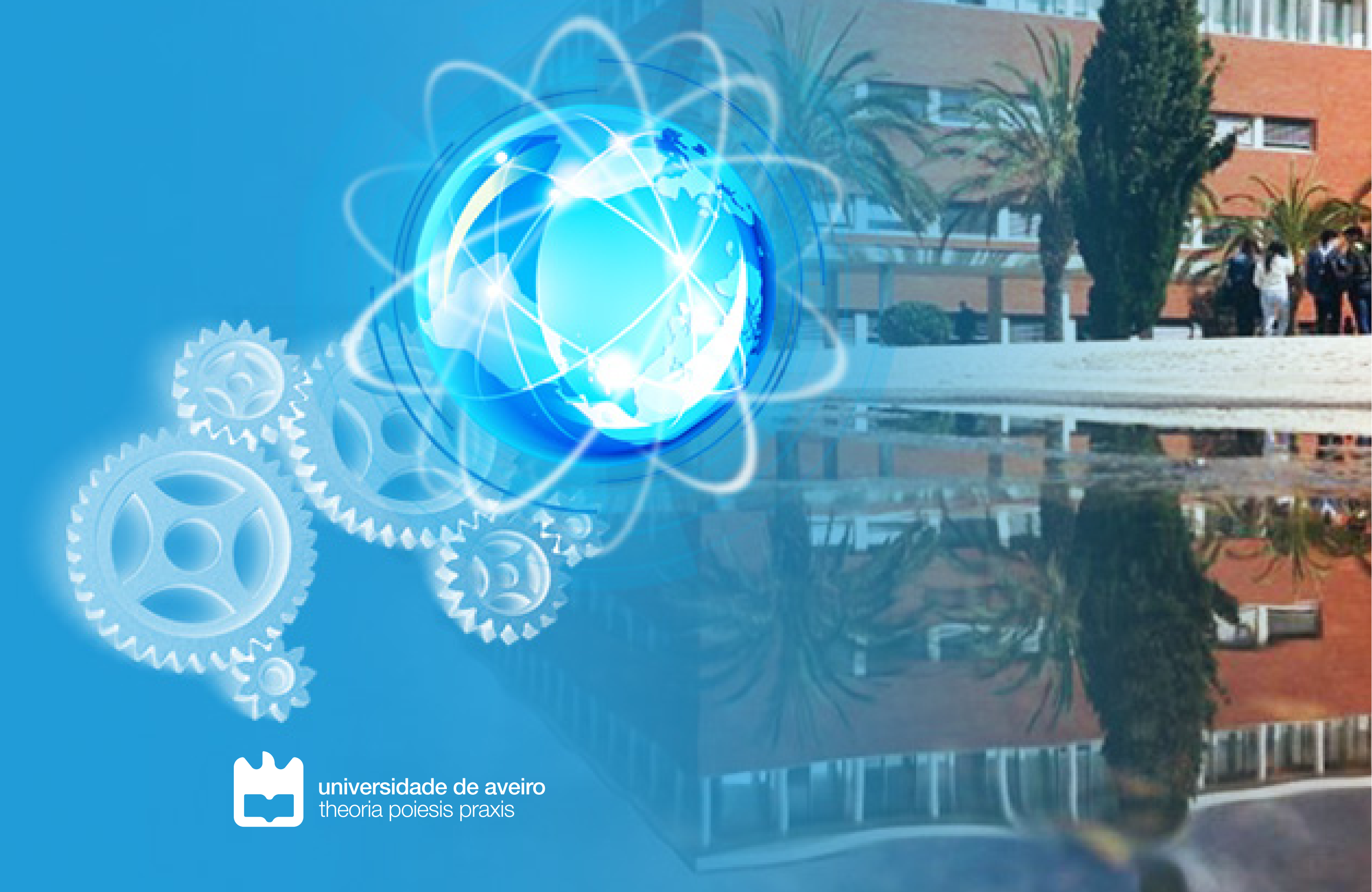
ENGINEERING SYSTEMS AND NETWORKS: The way ahead for industrial engineering and operations management

BOOK OF PROCEEDINGS
OF THE **ICIEOM-CIO-IIIE**
INTERNATIONAL CONFERENCE **2015**

Universidade de Aveiro, Portugal,
July 6th · 8th, 2015

XXI International Conference on Industrial Engineering and Operations Management
9th International Conference on Industrial Engineering and Industrial Management
(XIX Congreso de Ingeniería de Organización)
International IIE Conference 2015



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ENGINEERING SYSTEMS AND NETWORKS: The way ahead for industrial engineering and operations management
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Editors

Marlene Paula Castro Amorim
Leonor da Conceição Teixeira
Rui Jorge Ferreira Soares Borges Lopes
Carlos Manuel dos Santos Ferreira
José António de Vasconcelos Ferreira

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Foreword

We live in an interconnected world. Every day, increasing flows of goods, information and individuals strengthen the links among companies and nations. This scenario is reinforced everyday by the rising prosperity and participation of emerging economies, and by the dissemination of digital technologies. Aiming at an effective participation in todays' interconnected production contexts requires the development of specific knowledge that can inform managerial practice for taking full advantage of the existing opportunities. To this end academic conferences are privileged forums for the dissemination of the most recent and relevant research, theories and practices.

The ICIEOM-CIO-IIIE 2015, "XXI International Conference on Industrial Engineering and Operations Management", "9th International Conference on Industrial Engineering and Industrial Management" (XIX Congreso de Ingeniería de Organización) and "International IIE Conference 2015" called for contributions under the moto "Engineering Systems and Networks: the way ahead for industrial engineering and operations management". An impressive number of 353 submissions were received, addressing a multidisciplinary range of industrial engineering and operations management topics, and creating a rich setting for three Conference days of vibrant debate. A total of 200 of such submissions were selected for presentation at the Conference, after a rigorous process of selection, review and feedback to authors. This book presents 160 of these articles. A selection of 40 papers was gathered for publication in the series of Lecture Notes in Management and Industrial Engineering.

The Organizing and Scientific Committees of ICIEOM-CIO-IIE 2015 express their gratefulness to all the authors, invited speakers and to the members of the Program Committee who have generously committed their time and expertise in the rigorous process of revision of the submitted manuscripts, and provided key ingredients to set up a conference of very high standards, built on the experience of previous editions of ICIEOM, CIO and IIIE.

Marlene Amorim (Conference Chair)

Carlos Ferreira (Chair of the Scientific Committee)

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ICIEOM-CIO-IIIE International Conference 2015

This joint conference is a result of an agreement between ADINGOR (Asociación para el Desarrollo de la Ingeniería de Organización), ABEPRO (Associação Brasileira de Engenharia de Produção) and IIE (Institute of Industrial Engineers). In 2015 the Conference took place at the University of Aveiro (Portugal) from July 6th-8th.

The University of Aveiro was founded in 1973, and quickly became one of the most dynamic and innovative universities in Portugal. Ranked in top 50 young universities in the world, Aveiro offers an international environment, acknowledged for excellence in education and research, and appreciated for its welcoming culture.

The moto of ICIEOM-CIO-IIIE 2015 International Conference was "Engineering Systems and Networks: the way ahead for industrial engineering and operations management". The Conference aims to provide a forum to disseminate, to all branches of industry, information on the most recent and relevant research, theories and practices in Industrial Engineering, Management and Operations. To this end, ICIEOM-CIO-IIIE promotes links between researchers and practitioners from different branches, in order to enhance an interdisciplinary perspective of industrial engineering and management.

ICIEOM-CIO-IIIE 2015 received a total of 353 submissions, of which 200 were presented in the Conference after a rigorous process of selection, review and feedback to authors, therefore providing the key ingredients to set up a conference of very high standards, built on the experience of previous editions of ICIEOM, CIO and IIE conferences.

CONFERENCE AREAS

STRATEGY AND ENTERPRENEURSHIP
OR, MODELLING AND SIMULATION
LOGISTICS, PRODUCTION AND INFORMATION SYSTEMS
QUALITY AND PRODUCT MANAGEMENT
KNOWLEDGE AND PROJECT MANAGEMENT
SERVICE SYSTEMS
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Virgilio Machado
Wagner Lucato
Yuval Cohen

Keynote Speakers

The program of ICIEOM-CIO-IIIE 2015 included a set of plenary sessions that counted with the presence of acknowledged scholars, and the presentation of recent research results and debates in the field of Industrial Engineering and Management.
The keynote sessions provided moments of rich debate and prospective thought about the research challenges in the field, therefore contributing to the quality and excellence standards of the Conference.
The Scientific Committee of ICIEO-CIO-IIIE would like to express again its gratefulness to the invited speakers who generously joined the Conference, sharing their recent work development and warmly engaging in the academic discussion.

Prof. Jan Godsell (University of Warwick)

"Can OM Scholars Have It All?: The way ahead for scholarship in OM"

Professor Godsell's career has been split between both industry and academia, and she is currently a Professor of Operations and Supply Chain Strategy at WMG. She has worked for ICI/Zeneca Pharmaceuticals and Dyson, reaching the senior management level in both Supply Chain and Operations Management functions. She is a Chartered Engineer and Member of the IMechE. She is on the board and scientific committee of EurOMA (European Operations Management Association), the cabinet of the UK roundtable of CSCMP (Council of Supply Chain Management Professionals) and the manufacturing steering committee of the IMechE. She is on the editorial board of 3 journals, including the International Journal of Operations and Production Management, and she is an advocate for improving the uptake of STEM subjects by school children.

Prof. Rui Sousa (Catholic University of Portugal)

"Operations Management in the Digital Economy"

Rui Sousa holds a PhD from London Business School and is Professor of Operations Management at the Catholic University of Portugal, School of Economics and Management (Porto). His research has won several accolades and has been published in leading international journals, including the Journal of Operations Management, Production and Operations Management, Decision Sciences, International Journal of Operations & Production Management and the Journal of Service Research. Rui serves on a number of Editorial Review Boards (e.g., JOM, IJOPM) and is member of the Scientific Council of Social Sciences of the Foundation for Science and Technology (Portugal). In the School of Economics and Management, he is President of the Scientific Council, Director of the MSc in Service Management and Director of the Service Management Lab (SLab). He has taught at the London Business School, London School of Economics, the European Institute for Advanced Studies in Management (EIASM, Brussels) and several Portuguese business schools. His present research interests include service operations, digital economy and operations strategy.

Meet the Editors

The program of ICIEOM-CIO-IIIE 2015 included a set of plenary sessions that counted with the presence of editors from key journals in the field of Industrial Engineering and Management.
The Meet the Editors sessions provided an important opportunity to debate key aspects of the academic publication process. Thoughts were shared about the key areas for research and publication, as well as about the authoring and publishing processes and evolving requirements.
The Meet the Editors sessions offered important and enlightening moments that promoted a rich sharing of knowledge and practices among scholars.
The Scientific Committee of ICIEO-CIO-IIIE would like to express again its gratefulness to the invited Editors who generously joined the Conference, sharing their expertise and warmly engaging in the academic conversation.

Ron Askin

Ronald G. Askin is Professor and Director of the School of Computing, Informatics, and Decision Systems Engineering at Arizona State University. He received a BS in Industrial Engineering from Lehigh University, and an MS in Operations Research and a Ph.D. in Industrial and Systems Engineering from Georgia Institute of Technology. Dr. Askin is a member of INFORMS, SME, ASEE and a Fellow of the IIE. He was General Chair of the 2012 INFORMS Annual Meeting and currently serves as Editor-in-Chief of IIE Transactions. Dr. Askin has served as the Chair of the IIE Council of Fellows, Chair of the Council of Industrial Engineering Academic Department Heads and Chair of the INFORMS Manufacturing and Service Operations Management Society. He has authored over 120 publications on the application of operations research and statistical methods to the design and analysis of integrated production control systems. His awards include an NSF Presidential Young Investigator Award, the Shingo Prize for Excellence in Manufacturing Research, the Eugene L. Grant Award from The Engineering Economist, the IIE Transactions on Design and Manufacturing Best Paper Award (twice) and the IIE Transactions Development and Applications Award. He is also a two-time recipient of the IIE Joint Publishers Book-of-the-Year Award.

Alexandre Dolgui

Alexandre Dolgui is the Editor-in-Chief of the International Journal of Production Research–IJPR (Taylor & Francis). Professor of the École Nationale Supérieure des Mines de Saint-Étienne, received the distinction of Full Professor of Exceptional Class. Member of diverse professional associations like IIE, IFPR and AIM, Dolgui is Deputy Director of CNRS Laboratory LIMOS–UMR 6158 and of the Henry Fayol Institute, where is the Head of the MSc and PhD programs since 2011. Former Editor of IEEE Transactions (2005-2008), IJSS (2006-2009) and Omega (2010-2013). Member of Editorial Board of 18 international journals (e.g. IJPE, IJMTM and others).

Meet the Industry Professionals

The program of ICIEOM-CIO-IIIE 2015 included a set of plenary sessions that counted with the presence of Industry Professionals from leading companies, and with important expertise in the field of Industrial Engineering and Management.
The Meet the Industry Professionals sessions provided an important opportunity to bring together Industrial Engineering and Management Professionals and Academicians to share their views about the key areas for research and development of Industrial Engineering and Management Knowledge.
The Scientific Committee of ICIEO-CIO-IIIE would like to express again its gratefulness to the invited Industry Professionals who generously joined the Conference, sharing their expertise and engaging in a rich and vibrant debate with the community of researchers.

João Gunter Amaral

Board Member of **Sonae MC**

João has over 20 years IT experience working in different business sectors including Manufacturing, Services and Retail. After a four-year period as IT Director at Leica Camera AG in Portugal, leading the implementation of SAP at Leica's industrial unit in Portugal, João joined Sonae in 2001. After successfully managing several workstreams of Sonae's ERP implementation, João developed and managed Sonae's ERP Competence Center. In 2006 João was appointed Head of Innovation, role that he accumulated with his previous role of Business Partner for Sonae's food retail business leading the implementing of several innovation projects, in tight articulation with the different Business Units.
In 2013 João cumulatively assumed responsibility for Continuous Improvement at Sonae.
In 2014 João was nominated Board Member of Sonae MC assuming the responsibility of Logistics and Production Units.

Sandra Augusto

Logistic's Director-**Volkswagen Autoeuropa**

Born in Lisbon in 1971, studied Eletrotecnical Engineering in the ISEL. In April, 1994 started to work in the Autoeuropa. She started in the Production Planning as responsible for Investment Projects in equipment and infrastructure. In 1998 reached the first management position having gone through two years of coordination and supervision teams. I took that time responsibility for the Scheduling Department and Technical changes to the product in the Product Engineering. In 1999, Autoeuropa became 100% Volkswagen and the department began to be integrated into the logis- tics area with the name Pre Series. In 2000 embraced a new experience as Assistant to the Director of the Factory. In 2003 she finished her MBA and in 2004 returned to the Logistics Pre Series for the launch of EOS. In 2006 started to manage the Supply Chain and cumulatively since Nov. 2008 also the Internal Logistics. In March 2011 she took the current role.

The following papers presented at ICIEOM-CIO-IIIE 2015 were selected for publication in Lecture Notes in Management and Industrial Engineering (Springer)

STRATEGY AND ENTERPRENEURSHIP

SYSTEMATIC ANALYSIS OF ECONOMIC VIABILITY WITH STOCHASTIC APPROACH: A PROPOSAL FOR INVESTMENT
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LOGISTICS, PRODUCTION AND INFORMATION SYSTEMS

A DECISION SUPPORT FRAMEWORK FOR PRODUCTION FLOW COORDINATION USING SUPPLY CHAIN MANAGEMENT PRACTICES, ORDERING SYSTEMS AND MODELING TECHNIQUES
Wagner de Barros Neto, Laisa Caroline de Paiva Gomes, Maico Roris Severino and Moacir Godinho Filho

PRODUCTIVITY IMPROVEMENT, CONSIDERING LEGAL CONDITIONS AND JUST IN TIME PRINCIPLES IN THE MIXED-MODEL SEQUENCING PROBLEM
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LEAN PRODUCTION SYSTEMS DEPLOYMENT AND MONITORING USING DISCRETE-EVENT SIMULATION
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EXPLAINING ALLIANCE SUCCESS FACTORS IN SPANISH FOOD & BEVERAGE SUPPLY CHAIN: CASE ANALYSIS
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PROPOSAL OF A FRAMEWORK FOR ASSESSING ENVIRONMENTAL PERFORMANCE OF SUPPLY CHAINS
Cristovao Silva, Luis Ferreira and Susana Azevedo

A REFERENCE FRAMEWORK TO DESIGN INVENTORY POLICIES USING A FILL RATE CRITERION IN LOST SALES CONTEXTS
Eugenia Babiloni, Ester Guijarro and Manuel Cardós Carboneras

A NONLINEAR INTEGER PROGRAMMING MODEL FOR WAREHOUSING SUSTAINABLE LOGISTICS
Francesco Boenzi, Salvatore Digiesi, Francesco Facchini, Giorgio Mossa and Giovanni Mummolo

ROOT CAUSE IDENTIFICATION OF EXISTING BARRIERS DETECTED BY PEOPLE WITH DISABILITIES IN AIR TRANSPORT
Ivan Garcia-Miranda and Alfonso Duran Heras

SUSTAINABLE SUPPLY CHAIN MANAGEMENT: A CASE STUDY
Cláudia Silva

INTEROPERABILITY FRAMEWORKS IN PUBLIC ADMINISTRATION DOMAIN: FOCUS ON ENTERPRISE ASSESSMENT
Alexandre Castro, Jose Cestari, Eduardo Rocha Loures, Edson Pinheiro de Lima and Eduardo Alves Portela Santos

USING BIG DATA FOR COMPETITIVE DIMENSIONS IMPROVEMENT IN A TELCO COMPANY
Rafael Novo and José Neves

MAIN FACTORS AFFECTING THE DEVELOPMENT OF INTERORGANIZATIONAL PARTNERSHIPS IN BIODIESEL SUPPLY CHAIN IN BRAZIL
Eliene Cristina Barros Ribeiro, António Carrizo Moreira, Luis Ferreira, Leonardo Leocádio Coelho de Souza and Aldara da Silva César

A MODEL THAT INTEGRATES DIRECT AND REVERSE FLOWS IN OMNICHANNEL LOGISTICS NETWORKS
Eva Ponce-Cueto, Javier Guerrero-Lorente and Edgar E. Blanco

DIFFERENTIATION OF THE DIFFICULTY LEVEL OF SUPPLY CHAIN MANAGEMENT INTEGRATION ACTIONS
Fernanda Arantes, Maria Leite and Antonio Cezar Bornia

VSM ANALYSIS OF NATURAL CORK STOPPERS INDUSTRIAL PROCESS
Tatiana M. Pinho, Daniel Campos, J. Boaventura-Cunha, Americo Azevedo and A. Paulo Moreira

OR, MODELING AND SIMULATION

QUALITY AND PRODUCT MANAGEMENT

STRATEGY AND ENTERPRENEURSHIP

BPMN for a Costing Model Conception

Araújo MB[1], Rodrigues Filho BA[1], Gonçalves RF[1]

Abstract: This study was conducted to map and model the business processes of the HEI (Higher Education Institutions). It aims to show the importance of business processes modeling as a precondition for information system design. It shows the concepts of Activity-Based Costing (ABC) and its update, the TDABC (Time-Driven Activity-Based Costing), to support the development of a costing system for public universities. For the modeling of business processes, it was used the BPMN (Business Process Management Notation). It can be conclude that public processes implemented in public services are both complex and bureaucratic, mainly due to regulations. A bidding procedure of acquisition materials or services demand eight sectors activities. The contribution of this study was the presentation of a business process modeling should be applied to public service for the optimization of resources. This research presents the normal flow of bids, but in practice there is some variation.

Keywords: business modeling, costing, business processes management, BPMN, TDABC.

1 Introduction

The responsibility of a public university comprises besides teaching, also research and extension activities. As part of the public administration, as other entities are under excessive rules and regulations, either in Brazil or in the United Kingdom, as shown by some researches (Andrews and Boyne, 2014).

In addition to legal enforcement, public expenditure control is necessary for a proper allocation of key resources in areas of the Brazilian government (Araújo, 2011). In Brazil, all spent conducted by the Public Administration needs to be approved by the legislature through an annual budget law.

Beyond control, it is necessary to analyze the quality of public spending. Therefore, institutions need to know the costs of their activities. Among the various methods of costing international public universities have adopted ABC (activity-based costing) (European University Association, 2008).

Before implementing a costing system in any organization, it is necessary to know and organize all processes and activities. The allocation of costs in areas with different products or services may lead the manager to a decision based on false information.

The present study aims to show the importance of understanding and the model of the business processes and how a business modeling tool can help to build a costing system model for public universities.

A case study was used to allow an exemplification of the processes to be modelled. Therefore, at the Federal Institute of Education, Science and Technology of São Paulo, we sought to understand bureaucratic complexity to the development of a costing system applied to public universities. We use in this paper the BPMN (Business Process Management Notation) to be the language adopted by the OMG (Object Management Group) as the standard language of business process modeling and adopted by many analysts (Recker, 2010).

This article is structured into 4 parts: Section 2 provides a literature review. Section 3 provides an overview of the methodology. Section 4 provide a modeling business processes and it establishes the requirements that were presented by the Dean of Administration for notation and the tool used to define business processes and presents an analysis for solutions to be implemented for the development of a costing system. Finally, Section 5 summarizes the work presented and draws some conclusions about its development.

1 **Marcelo Bernardino Araújo** (mbernardinos@gmail.com)
Bruno Amado Rodrigues Filho (bruno.amado.filho@gmail.com)
Rodrigo Franco Gonçalves (rofranco@osite.com.br)
Graduate Program in Production Engineering. Paulista University. Dr. Bacelar St. 1212, São Paulo, Brazil.

2 Literature review

Activity-Based Costing (ABC) is a costing system developed in 1988 by Robin Cooper and Robert Kaplan, in order to allocate indirect costs to objects through cost drivers. It highlights three rules for their use. First, the concentration of expensive resources. Second, the emphasis on resources whose consumption varies significantly by product and type of product. Third, the concentration resources whose demand patterns are uncorrelated with traditional measures of hand direct manpower allocation, with the material processing time (Kaplan and Cooper, 1998).

Kaplan and Cooper (1998) define the activity-based costing as an economic map of the expenses and the organization's profitability based on organizational activities. This costing system offers companies an economic map of its operation showing the existing and the projected cost of activities and business processes that, in turn, explains the cost and profitability of each product, service, and customer operation.

Cropper and Cook (2000) conducted a study on the implementation of the costing system based on activities in UK universities in the second half of the 1990's and concluded that the deployment occurred in a slow, even with pressure from donors and government.

The implementation of ABC involves time and resources. It requires organizational changes and employee acceptance. It also requires investments in information technology and materials for data collection. Even with all the human, material and physical implantation it does not guarantee satisfactory results in the short term (Roztocki et al, 2004).

TDABC simplifies the costing process, eliminating the need to interview employees and search for cost allocation of resources to activities before allocating them to cost objects (applications, products and customers). The new model assigns resource costs directly to the cost objects, using an elegant structure that requires only two sets of estimates, none of which is difficult to obtain (Kaplan and Anderson, 2007).

In a literature review were identified thirty-six empirical contributions using TDABC over the period 2004-2012. This costing methods was applied in logistics, manufacturing, services, healthcare, hospitality and services nonprofit with potential benefits (Siguenza-Guzman et al, 2013). Among other applications are identified in university libraries (Pernot et al, 2007; Siguenza-Guzman et al, 2014). There are also applications in private schools (Yilmaz et al, 2013). This shows the concern in offering products or services with quality and fair prices.

Whatever the cost methodology the company needs to know your business processes. In this context, Business Process Management (BPM) can assist in the process knowledge and documentation of all processes, activities and procedures of the organization.

BPM has two main intellectual antecedents. The first is research Deming (1952) and Shewhart (1986) on statistical process control, and the precursor of Six Sigma, improving and managements of processes. The other antecedent is the concept of reengineering business processes (Hammer, 1990; Hammer and Champy, 1993), which has positive and negative points, but interdependent.

BPM is a management discipline that integrates strategies and objectives of an organization with customer expectations and needs, by focusing on processes, end to end. This methodology encompasses strategies, objectives, culture, organizational structures, roles, policies, methods and technologies to analyze, design, implement, manage performance, process and establish governance processes (ABPMP, 2013).

A process model is a visual representation of the sequential flow and logic control of a set of activities or related actions. The process modeling is used to obtain a graphical representation of a current and/or future process within an organization (IIBA, 2009). The business analysis is a precondition for information systems design and development, in order that it can reduces amount of problems of misunderstanding between the business areas and the IT team. The Business Analysis Body of Knowledge (BABoK) presents many techniques to understand business needs, business requirements elicitation and business process modeling (IIBA, 2009).

There is several languages notation for modeling process: BPMN, Flowchart, EPC (Event-driven Process Chain), UML (Unified Modeling Language), IDEF (Integrated Definition Language) and VSM (Value Stream Mapping).

BPMN is a standard diagramming business processes created by the BPMI (Business Process Management Initiative), which was later incorporated into the OMG, a group which sets standards for information systems. This notation presents a set of symbols for modeling BPD (Business Process Diagram) of different aspects of business processes. As in most of ratings, the symbols describe clearly defined relationships, such as activity flow and order of precedence.

BPEL (Business Process Execution Language) is a workflow-oriented composition model that brings a central piece in the heavily modularized SOC (Service-Oriented Computing) model (Khoshkbarforoushha et al, 2014). The origins of BPEL come from the WSFL (Web Services Flow Language) and XLANG, IBM and Microsoft respectively. It is serialized into XML and points to a schedule following the programming approach on a large scale.

BPMN has long been used lately as it offers advantages over other forms of business process modeling. Modeling is the set of activities involved in creating representations of business processes. The purpose of modeling is to create a representation of the complete way process and needs of its operation (ABPMP, 2013). BPMN is a language that facilitates communication between the organization and its stakeholders.

BPMN, for example, successfully helps in mapping business processes (Torres et al, 2011) because the layout combines other elements like actors, events and results. It can be used for modeling, from simple processes such as in complex processes for any type of organization.

For García-Dominguez and Medina (2012) BPMN must be used for approval of detailed designs. It should be used in repetitive and process with little variation as well as the activity description. In their study, they concluded that that kind of layout can not model existing objects and their transitions. However, when an agility and iteration in the process design is required, suggest the use of Value Stream Mapping (VSM). This tool was designed to identify problems and also to improve to create plans for waste reduction.

3 Methodology

The research method uses case study approach combined with Business Analysis techniques from BABoK to modeling the business process for information system design.

The study of this paper object is to show the complexity of the bidding process in public service to purchase goods and services. We use through business process modeling technique by BPMN notation. Through knowledge of the process it can be reconfigured to optimize human, material and financial resources. This will calculate the cost of idleness and implementation of TDABC.

The case study approach, defined by Yin (2014) as a research strategy that seeks to examine, in deep, a phenomenon within its context, to identify the business needs related with the costing process.

Data collection was performed by participant observation, involved also interviews with employees and internal documents of the organization, to understand the process context. The documental analysis was based on material provided by the institution, through management reports, institutional development plan, as well as information available on the Federal Institute of Education, Science and Technology of São Paulo (IFSP) website. From the information collected it was possible to expose in detail the current flow mapped process. However, research *in loco* revealed some changes in the bidding flow of the studied institution.

4 Results

All Brazilian Public Administration entities are required by law to conduct bidding. This requirement comes from the Federal Law No. 8666, known as the law of tenders and contracts and Law No. 10,520, which introduced another form of bidding, the trading session.

To carry out any spending in the public sector is still necessary, the approval by the Legislature, materialized in an annual budget law. It is estimated revenues and fixed expenses for the following year.

A simple process of purchasing goods and services demand activities of eight different sectors in this organization. Followed the bureaucratic proceeding, we make the payment to the supplier or service provider, extinguishing the financial obligation. BPMN is a helpful, because it showed a versatility to model the different situations of the acquisition of goods and services. These modeling applications generate BPMS (Business Process Management Systems). They has allowed a proper programming of the costing system.

It was analyzed the convenience and the opportunity of purchasing a physical or a service, introducing yourself a bidding process, following the steps of the Figure 1 diagram:

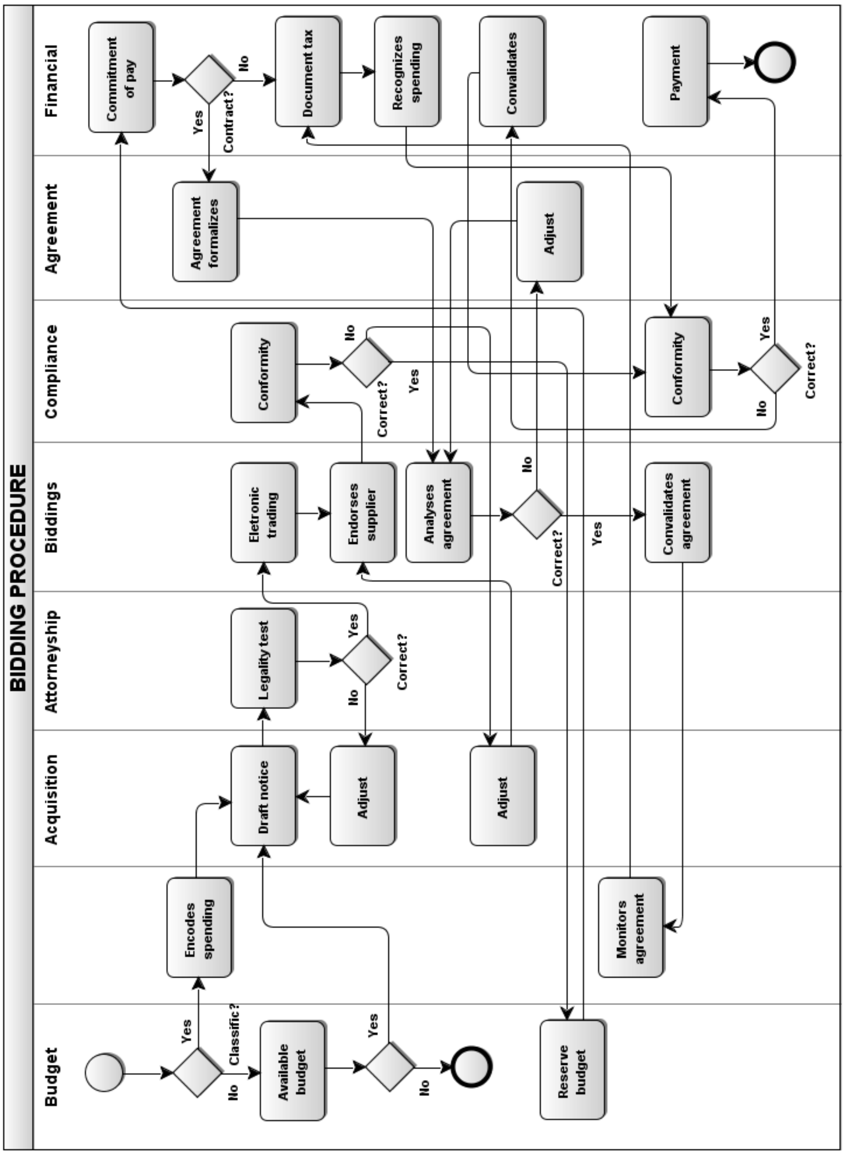

Fig.1
BPMN of bidding procedure.

The process of procurement of goods and services was modeled. From there, he was the use of at least seventeen employees. Each acquisition has a handheld unit cost of direct work of two hundred thirty-nine dollars in 2014. Table 1 shows the costs of each activity and the time spent, we ask in interviews, and salary queries:

Table 1
Direct labor cost.

Area	Resources	Unitary cost / h	Activity	Spending time (h)	Total USD
Budget	Worker 1	12.91	Available budget	1.0	12.91
	Worker 2	6.51	Reserve budget	1.0	6.51
Accountancy	Worker 1	7.55	Encodes spending	0.5	3.78
	Worker 2	14.21	Monitors agreement	0.5	7.10
Acquisition	Worker 1	8.86	Draft notice	1.0	8.86
Attorneyship	Worker 1	51.76	Legality test	1.0	51.76
Biddings	Worker 1	12.91	Eletronic trading	8.0	103.29
	Worker 2	6.01	Endorses supplier	0.5	3.00
	Worker 3	7.31	Analyses agreement	0.5	3.66
	Worker 4	6.51	Convalidates agreement	0.5	3.25
Compliance	Worker 1	9.50	Conformity	1.5	14.24
Agreement	Worker 1	8.86	Agreement formalizes	1.0	8.86
Financial	Worker 1	5.81	Commitment of pay	0.4	2.32
	Worker 2	6.97	Document tax	0.2	1.39
	Worker 3	6.97	Recognizes spending	0.3	2.09
	Worker 4	7.55	Convalidates	0.4	3.02
	Worker 5	14.21	Payment	0.2	2.84
Total	17	-	-	18.5	238.89

5 Conclusion

For both public and private HEI, resources are necessary to acquire efficiency. Therefore, they need to know their costs. The article has shown the importance of understanding the business processes for building a cost model for public universities. Therefore, we conducted a case study on the IFSP, where BPMN methodology was conducted to model their processes. TDABC is presented as a new form of funding, and more simplified applications in relation to ABC. Currently, we study the reduction of waste, whether of resources or time.

In case analyzed, a simple process of acquisition materials and services demand activities of eight different sectors. These factors are mainly due to internal rules and legal regulations. To know details of each of the processes of any organization is necessary to map them. Therefore, BPMN is a notation easy to understand. The contribution of this study was the presentation of a business process modeling should be applied to public service for the optimization of resources. This research has the limiting factor some variations in bidding flow of the studied institution. As a future work it will be continued in the definition of the systems requirements to perform the development of a costing software for HEI.

References

ABPMP (2013) BPM CBOK V3.0: Guide to business process management body of knowledge – Commom body of knowledge. Association of Business Process Management Professionals (ABPMP), Saint Paul

Andrews R, Boyne GA (2014) Task Complexity, Organization Size, and Administrative Intensity: The Case of UK Universities. Public Adm 92:656-672. doi:10.1111/padm.12078

Araújo MB (2011) A contabilidade de custos como instrumento de gestão no setor público. Conjunt Planej 170:42-49

Cropper P, Cook R (2000) Activity-Based Costing in Universities-Five Years On. Public Money Manag 20:61-68. doi:10.1111/1467-9302.00213

Deming WE (1952) Elementary principles of the statistical control of quality: a series of lectures, 2nd ed. Nippon Kagaku Gijutsu Remmei, Tokyo

European University Association (2008) Financially Sustainable Universities: Towards full costing in European universities (Working Paper). EUA Publications 2008, Belgium.

García-Domínguez A, Marcos M, Medina I (2012) A comparison of BPMN 2.0 with other notations for manufacturing processes. AIP Conf Proc 1431:593-600. doi:10.1063/1.4707613

Hammer M (1990) Reengineering work: don't automate, obliterate. Harv Bus Rev 68:104-112

Hammer M, Champy J (1993) Reengineering the corporation: A manifesto for business revolution. Bus Horiz 36:90-91

IIBA (2009) A guide to the business analysis body of knowledge (BABOK® guide) Version 2.0. International Institute of Business Analysis (IIBA),Whitby

Kaplan RS, Anderson SR (2007) Time-Driven Activity-Based Costing: A Simpler and More Powerful Path to Higher Profits. Harvard Business School Press, Cambridge

Kaplan RS, Cooper R (1998) Cost and effect: using integrated cost systems to drive profitability and performance. Harvard Business School Press, Cambridge

Khoshkbarforoushha A, Jamshidi P, et al (2014) Metrics for BPEL Process Reusability Analysis in a Workflow System. Syst J IEEE pp, 1-10. doi:10.1109/JSYST.2014.2317310

Pernot E, et al (2007) Time-Driven Activity-Based Costing for Inter-Library Services: A Case Study in a University. The J Acad Librariansh 33:551-560. doi:10.1016/j.acalib.2007.06.001

Recker J (2010) Opportunities and constraints: the current struggle with BPMN. Bus Proc Manag J 16:181-201

Roztocki N, Porter JD, et al (2004) A Procedure for Smooth Implementation of Activity-Based Costing in Small Companies. Eng Manag J 16:19-27

Shewhart WA (1986) Statistical method from the viewpoint of quality control. Courier Dover Publications, New York

Siguenza-Guzman L, et al (2013), Recent evolutions in costing systems: A literature review of Time-Driven Activity-Based Costing, Rev Bus Econ Lit 58:34-64

Siguenza-Guzman L, et al (2014) Using Time-Driven Activity-Based Costing to support library management decisions: A case study for lending and returning processes. Library 84:1-23

Torres V, et al (2011) Adapting BPMN to Public Administration, in: Business Process Modeling Notation. Springer, Berlin, pp. 114–120

Yilmaz M, Coskun A, Yilmaz S (2013) A Comparison and an Implementation of Time Driven Activity Based Costing and Activity Based Costing Methods in Private Schools, in: International Conference on Economic and Social Studies, 10-11 May, 2013, Sarajevo. International Burch University

Yin, RK (2014) Case study research: design and methods, 5th ed. Sage Publications, California.

The Importance of Cost Management in a Manufacturing Company of Hydroelectric Plants - a case study

Mello MF[1], Santos AB[2]

Abstract: Changes in the global market happen at all times and the update of the companies must be constant and rapid, thus it is necessary that managers are aware of the current status of the organization and its projects, mainly in cost sector. This paper aims to demonstrate the importance of cost managements and proposes a design methodology, through an applicative program for an appropriate management of costs in the studied company. The research occurred in the hydro sector on an assembly company of hydroelectric plants in the state of Rio Grande do Sul, Brazil. The survey results showed the importance of cost control in each project and this topic is part of the company financial policy. The results of this study show that a methodological structuring of cost control is vital for managers to have reports at hand in a proper sequence information, that is relevant to make decisions.

Keywords: Costs; Cost Management; Project Management.

1 Introduction

Currently, the market is increasingly competitive and companies that seek to be competitive need to improve and control their processes increasingly. According to Bornia (2010), to achieve this improvement in the productive system, the modern company has some peculiarities that distinguish it from the traditional ones, among them stand out the continuous process of improvement, combating waste and the implementation of the philosophy of total quality. As a result, companies must learn what they are doing, who they are working for and must also control how much they are doing. The quality and the control interfere directly in the success of the project.

The lack of a cost management system can affect profits and business processes. Thus, this study aims to demonstrate the importance of cost management as well as develop a methodology for the organization to better manage their projects and their cost structures. The company researched here is a company engaged in the provision of electro-mechanical assembly services in hydroelectric plants.

The management and costs are always factors that stand out in organizations because of the important role that they transmit and result. Increasingly, the highlight of these areas is growing and becoming important for the proper performance of the company. Practices that consider the alignment of these two terms need to be applied in organizations.

The study aims to show information relating to costs, cost management and project management, and may provide a basis for companies to develop strategies to have a more competitive profile market. The study also aims to provide information on the cost structure through the development of a specific applicative in the project of setting up hydroelectric power generation plants in the company researched.

1 **Mario Fernando Mello** (mariofernandomello@yahoo.com.br)
2 **Amanda Barbosa dos Santos**
Escola de Engenharia.
Universidade Luterana do Brasil – ULBRA.
99500-000 Carazinho, Rio Grande do Sul, Brasil.

2 Theoretical Fundament

This chapter contains a theoretical framework authors that supported the preparation of this article.

2.1 Costs

For the planning and execution of a project, the building company needs to have its costs well defined and delimited. Cost is the portion of the expense that is applied in the production or in any other function. Cost is the value accepted by the buyer for buying a specific good or is the sum of all aggregate values of a product since its acquisition until it reaches the marketing stage (Dutra, 2010).

The concept of costs need to be made explicit to everyone who is part of the project. Everyone needs to know that any expense applied in production or in any other function within the project is characterized as cost. The wrong quantification of costs can hurt and damage the project and its management. Setting costs is a serious and critical task within the project, as it may result in injury or increase the profit for the enterprise.

Since the studies of the draft paper, the characterization of the costs must be set. This categorization allows the understanding of how costs are divided and must be applied in the Project. The four (4) main cost settings are studied. They are the direct, indirect, fixed and variable costs.

The direct costs to Dutra (2010) are the ones that can be directly appropriate to each type of good or organ at the time of its occurrence, that is, it is connected directly to each type of good or cost function. The direct costs of a project, according to Barbosa (2009) can be easily identified and quantified from necessary resources to carry out the project activities. They are directly attributed to the work of the project and therefore do not require apportionment to be allocated to projects.

According to Dutra (2010), the indirect cost is unable to segregate the portion pertaining to each product or different service at the time of application of the cost. Such separation is performed later by a special criterium called apportionment. This cost can be apportioned in different ways and the adequacy of the same depends on the branch to which the company operates and its needs, so it is an analysis of the best cost allocation.

Fixed costs are those that are always present in the production but which do not have variations. These costs that do not vary with production, such as the location of the generators in the work, will not change, regardless of the type of service or the same schedule. This cost will be the same throughout the period of the work.

On the other hand, variable costs are characterized as those that vary with the volume produced or the performed activity. The variable cost increases as the production increases and decreases when the production decreases. It is directly proportional to project activities in a given period. An example of variable cost in a power plant assembly is the working force cost.

In plant assembly projects it is impossible not to have ownership costs, which is separation by cost center. To Kamada (2013), cost center is the categorization of costs. This categorization should be consistent with the budget. The categorization is intended to show where costs are being accumulated.

2.2 Management of costs

Companies are in constant pursuit of management and cost control, this is a primordial factor in competitiveness and in strategic positioning in the market. According to Wernke (2004), the strategic cost management should observe, identify and analyze the cost determinants, observe the factors that actually cause the costs, called cost drivers, providing the form that reflects the most precise reality of the situation. This concept is undoubtedly very important for the strategic management of any company, clearly showing that it is necessary to know the factors that cause losses.

According Shank and Govindarjan (2001), strategic cost management consists of these three pillars: value chain; strategic positioning and cost drivers. These factors contribute to the success of cost management in the project. The cost management should involve and give emphasis to projects that can consistently provide added and superior values to your customer, achieving these results by means of coordination and management of the cost flow. The same author also states that administrators need to monitor the performance of their companies and, therefore, must rely on relevant management information regarding to the costs and also reports that there are reliable sources of subsidies to optimize cost management. He recommends that, in order to facilitate the use and analysis of management information reports, the administrators must have available a proper sequence of information that is relevant to make decisions.

According to PMBOK® Guide (2008), cost management in a project involves three processes: estimating the costs, determining the budget and cost control. These three steps are closely linked, aiming to provide knowledge to analyze and to manage all the costs involved in the project.

2.3 Projects of management

The project management involves knowledge, skills, tools and techniques to carry out the project activities in order to achieve its goal and to meet the requirements (PMBOK, 2008). The project management is an essential part to achieve success in the project.

For Vargas (2009), the main features of a project are the individuality and staging of the project as well as the complexity and uncertainty. The project staging indicates the beginning and the end of the activity. It only happens when the end of the stated objectives are achieved. Each project creates a service or product that generates individuality. Several hydroelectric plants can be built with the same number of machines and the same generate capacity but each plant will be unique because each one is in different conditions, has a different complexity and the uncertainties and risks that surround each one are different. The effort of the work can be already known, the enterprise may already have well defined processes, but the individuality of the project, generates risks and uncertainties in the project practice.

The project is born with their particular life cycle. According to PMBOK® (2008), the life cycle of a project has four phases:

- Project start: it is the phase that involves the project beginning, the knowledge of the project scope.
- Organization and preparation: it is necessary, at this stage, to create the project management plan. At this stage, all the preparation in order to start the project happens, such as planning.
- Working and project execution: at this stage, everything that was planned is provided/delivered.
- Project closure: this is the phase of demobilization of all resources, it happens only when the goal has been achieved and every delivery documentation and project archiving is held.

The entire project foresees risks but with well aligned planning it is possible to minimize these risks by ensuring that quality assurance can happen to processes with methodologies and well-defined planning.

3 Methodologial Procedures

This work was carried out in three steps:

The first step was exploratory, where the determination of the study, the study of bibliographic references and construction of the project occurred. The second stage of is the fieldwork where we collected data, documents on the case and all possible and necessary information. In the third stage the analysis and interpretation of data, resulting in the submission of a report, was held.

The data collection in this research universe occurred through contact with employees, explaining the research objectives. Documents and company reports, needed for this work were obtained by direct contact with the responsible areas, when the research objectives and importance were explained.

The data were analyzed using content analysis technique, which according to Bardin (2009) is to deepen the understanding of the data collected. Thus, reports, documents or other documentation were treated as a basis for the presentation of results

The research was based on a service company, located in Passo Fundo, RS state, Brazil. The capital of the company is private and closed, with national origin, working in the hydromechanical assembly sector for hydroelectric plants.

4 Results

Five projects were analyzed within the company. For this work, the so-called projects C and D will be described.

The projects C and D were planned and carried out using the same river, and the two project characteristics, both physical space and facilities, nearly identical. Both projects are located by Uruguay River, near the town of Belém, in Pará state. Each plant has an installed capacity of 35 MW and its annual output is 180,057 MWh. These two projects have helped develop the city and the region's economy, influencing the Power supply for two more cities. Once they have nearly identical characteristics they were controlled together. These projects had the scope of two turbines, two generators and a substation. It was also in the scope of providing tools, supplies, labor and all the support to its employees. The total time was 13 months each project, but that deadline was extended to 17 months. The value of each project was US$ 2,000,000.00 (two million dollars). The data analysis of these two projects was carried out jointly because of their the similarities.

Demonstrating the company weakness in relation to cost management, these projects were controlled in only one worksheet where the costs of the two projects were released together. In these projects, it was identified that the greatest resource allocation was the largest investment that the company needs to take to complete a project, which is the labor. About 69% of which was invested by the company was in direct labor. This high value was obtained due to the high costs that the company needs to pay and the significant value in overtime paid to employees. Other costs include as a higher percentage for the two projects, the following categories: location of third party equipment such as cranes and trucks, food for breakfast, lunch and dinner and hosting indirect work employees. These categories contributed significantly to this percentage.

The other cost that had an influence on the final result was material consumption, which is widely used throughout the project. Materials with higher costs were categorized as: outsourcing, purchase of consumption material and the material used in weld. However, it was not possible to identify some of these categories as there was not much information in the worksheet. These two projects had a negative total result of 20.9% of the total value of the project because of the lack of a proper system of cost management.

One can see that after the analyzes that the major barriers faced in this company is the lack of financial control because, in every Project, the company started and finished projects with quality in its production and success in the assembly. The project is always finalized, even when lack customer support. This completion happens without analyzing what brings competitive and profitable advantages for the company. Even with the lack of control, you can see that the profitability of some projects is negative, dramatically undermining the financial health of the company.

To finish these analyses, an applicative in the software program Access was studied developed throughout the duration of that work. It can help control all costs involved in the project. The same was based on all the needs that a small or large project needs, and consists of a database in which all relevant project information are inserted.

4.1 Applicative program developed for the management of costs.

The application is composed of eight main interfaces requiring to be fed with the requested information. In five of these interfaces filling is only required when starting a new work after the start and the filling is not needed for the continuous feeding, making it easier for the user to complete the two other fields. The eighth field is for the generation of reports. This applicative can be used in various projects.

- Main menu: the main menu consists of eight buttons, the left side is composed of buttons Supplier, Customer, Cost and Cost Center and Report. These buttons are located on the left side because they use the same database for various works, once registered is in the applicative database, and when it is necessary to use it in other projects, it is already filled.
- Customer registration: all necessary information from the client to the control, as an encoding for the same, its corporate name, trade name and its company juridical number (CNPJ number, in Brazil) are in this icon. This detail of each client needs to happen because the same platform can control several projects of different customers. This registration also influences the release of data in other interfaces for better identification and organization.

- Providers: the vendor item contains: vendor code, Tax ID, Company Name, Trade Name, City and Contact. Center of costs: one of the basis for the success of this application, the Cost Center, contains: Cost Center Code, Level 1, Level 2, Level 3 and Description. The cost center is something in the application that should not be changed by the user because he needs to be aware of the cost centers, inserting the item correctly in the appropriate center. Along with this basis one can take the necessary information for future budgets and for the good result of the work control.
- Specification of the construction/project: in the item 'works', it is necessary to release all relevant information to the project like: work code, work number (this item is the number used in the entire company), customer, proposal number, contract number, total term, working time, time and date of commissioning and mobilization.
- Budget: this item includes the work number, cost center and the total amount budgeted for that cost center. The data for filling the budgeted item is based on the last budget by the commercial sector.
- Carried out: it must be released in the 'Carried out', the structure (cost center), plot number, value of the portion, invoice number and the supplier.
- Reports: this item demonstrates the visual project management. You can print individual reports for each cost center and a general report per project, to know the status of the project, making a comparison of what was budgeted with what was carried out.

So that the application can be used efficiently, it was created a list of technical instructions. These technical instructions contain information about each interface that the user will use and also provide information about cost centers, thus facilitating the use of the applicative. Thus, users will find it easier and have more knowledge at the time of filling of fields under their responsibilities.

5 Conclusion

At the end of this work, it is important that the evidence raised in the survey are in line with the overall objective of the study. The aim of this study was to design a cost control methodology that would assist in cost management and in the management of the company projects. Together with the creation of application demonstrated in this work, the main objective is achieved, as evidenced during the development of this work that the company needed this tool to improve its project management with an appropriate cost control.

The provision of information to sectors through reports using the visual management model will surely bring a contribution to the company because the trend is that employees become more involved with the processes, viewing points that may occur contributing cost rationalization in this way with a most appropriate magement of the costs in the projects.

In the step preceding the implementation, it is recommended the involvement of all the technical parts of the company to understand and to use the application, so that in this way, everyone can have access to the information generated by the applicative. It is also recommended for everyone to have access to information, make tables in the sectors involved with the fortnightly reports that the applicative generates. Increasing the purpose of the applicative is to improve the cost management and to develop visual management inside the company.

Is also important to note that the analysis of the results of this study shows that a methodological structuring of cost control is vital for administrators to have reports at hand in an appropriate sequence of information that is relevant for their decision makings.

Finally, even considering the limitations of this paper, it is evident the importance of an appropriate cost control system, helping improve the management process and also the company finance.

6 References

Barbosa, C. (2009) Gerenciamento de custos em projetos. 3. ed. Rio de Janeiro: Editora FGV.

Bardin, L. (2009) Análise de conteúdo. Lisboa, Portugal; Edições 70 LDA.

Bornia, A.C. (2010) Análise gerencial de custos: aplicação em empresas modernas. 3. ed. São Paulo: Atlas.

Dutra, R.G. (2010) Custos: uma abordagem prática. 7. ed. São Paulo: Atlas.

GUIA PMBOK®. (2008) Um guia do conhecimento em gerenciamento de projetos. 4. ed.

Kamada, S. (2013) Indicadores para a estabilidade produtiva. Disponível em: htttp://www.lean.org.br/artigos. Accessed 16 november 2013.

Shank, J. K.; GOVINDARAJAN, V. A revolução dos custos. Rio de Janeiro: Campus, 2001.

Vargas, R. (2009) Manual prático do plano de projeto: utilizando o PMBOK® Guide 4th ed. 4. ed. Rio de Janeiro: Brasport.

Wernke, R. (2004) Gestão de custos: uma abordagem prática. 2. ed. São Paulo: Atlas.

Integrated Management of Operations, Human Resources and Innovation: a Strategic Approach for Developing Sustainableand Competitive Business

Mejías AM[1], Pardo JE[2], Garrido N[3], Paz E[4]

Abstract: As a result of a broad analysis of the literature, the knowledge of three key management fields involved in sustainable development: operations/supply chain, human resources and innovations, is linked. This paper sets out to present a theoretical framework for contributing to answering the questions “what”, “who” and “how” should companies do to develop competitive and sustainable business. This framework is illustrated through the analysis of IKEA and INDITEX as exemplary case studies. Taking into account the individual and the comparative study of these companies, some lessons are drawn to promote an anticipatory or, even, an innovation-based sustainable strategic behaviour in SME companies, supported by human resources and operations management.

Keywords: Human resources, innovation; supply chain management; sustainable strategy; Sustainability.

1 Introduction

Since the concept of sustainable development was defined by the Bruntland report as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (WCED, 1987), the question of how to compete in changing markets while contributing to sustainable development is the most demanding challenge that all the companies must face.

From the academic perspective, there has been a growing body of research of sustainable operations management and, widely, of the interdisciplinary field of sustainable supply chain management. The application of the sustainability concept to the SCM (SSCM) is defined “…as the strategic, transparent integration and achievement of an organization’s social, systemic coordination of key inter-organizational business processes for improving the environmental, and economic goals in the long-term economic performance of the individual company and its supply chains” (Carter and Rogers, 2008, p. 368). In this framework, two more recent approaches have emerged in the literature. The first approach, related to the human resources field, has been labelled as sustainable human resource management and, widely, of the interdisciplinary field of sustainable supply chain management.

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1 **Ana M. Mejías** (mejias@uvigo.es)
Dpto. de Organización de Empresas y Marketing.
2 **Juan E. Pardo** (jpardo@uvigo.es)
3 **Nuria Garrido** (nuria.garrido@uvigo.es)
4 **Enrique Paz** (epaz@uvigo.es)
Escuela de Ingeniería Industrial. Universidad de Vigo. C/ Maxwell S/N, 36310 Vigo.

approach, related to the human resources field, has been labelled as sustainable human resource management (SHRM). The literature on SHRM has been developed over the last decade and explicitly acknowledges the impact of HRM on financial, social and ecological/environmental outcomes (Kramar, 2014). The second approach deals with the importance that companies give, especially small and medium size (SMEs), to directing their business activities toward sustainability through innovation (Innovation Management-IM) (Klewitz and Hansen, 2014).

In practice, increasing pressures from governments and other stakeholder groups have encouraged large firms to address the integration of sustainability into their strategy and management, as demonstrated by their public annual reports. However, the research into the extent to which companies are embedding the sustainable approach in their model business and what innovations are being developed by model firms for improving their sustainability performance, is still limited (Morali and Searcy, 2013).

This paper sets out to link this knowledge in order to answer the questions “what”, “who” and “how” should companies do to develop competitive and sustainable business. With this objective in mind, a theoretical framework is designed, linking the main elements that characterize sustainability in the three research fields (SSCM, SHRM and SIM). We then move on to illustrate this framework through the analysis of IKEA and INDITEX as exemplary case studies. Taking into account the individual and comparative study of these companies, some lessons are drawn to promote an anticipatory or, even, an innovation-based sustainable strategic behaviour in SME companies, supported by human resources and operations management.

2 Design of the Theoretical Framework

This section describes the methodology used in this research. We then synthesize the main issues that characterize sustainability in the research fields of management. Finally, the integrated theoretical framework is defined.

2.1 Methodology Research

The methodology research of this work is based on two lines. Firstly, this paper is based on a systematic literature review (Denyer and Tranfield, 2009) of papers which, in turn, have applied this methodology to analyze the relationships between SCM, the HRM and the IM, and sustainability. Secondly, the theoretical framework proposed is illustrated through the case study methodology. We thus build on Eisenhardt and Graebner (2007) to present the case study as a research strategy that creates theoretical constructs and/or midrange theory. For the case studies, a qualitative content analysis technique has been applied for generating valid and reliable findings of published reports in terms of two exemplary companies.

2.2 Sustainability and SCM, HRM and IM

In order to be as synthetic as possible, our literature review is illustrated by three condensing papers on the three fields of study. The research on sustainability and SCM is gathered from Garrido and Mejías (2014). In this paper, the authors identified and analysed 10 systematic literature reviews papers in the 2000-2013 timeframe. The main contribution of this paper is to collect the knowledge in the SSCM field in order to highlight the gaps and to identify future lines of research that allow for the development of the SSCM concept from a theoretical and practical point of view.

The research on sustainability and HRM is gathered from Kramar (2014). This author categorizes the literature on SHRM into three groups in terms of their outcomes. The group “Capability reproduction” focuses on the internal impacts of HRM policies; the group “Promoting social and environmental health” emphasizes external outcomes, including ecological and/or social and human outcomes; the group “connections”, the most interesting for our research, examines the interrelationships between management practices, including HRM and organizational outcomes, which include environmental and social outcomes.

The research on sustainability and IM is condensed in the systematic review by Klewitz and Hansen (2014). These authors identify two major building blocks in this field: the strategic sustainability behaviour (resistant, reactive, anticipatory, innovation-based and sustainability-rooted) and the sustainability-innovation practices and innovation types (process, product and organizational innovation). In this framework, they finally propose an integrated model specifically oriented towards SMEs. Table 1 shows the key ideas that characterize sustainability in the three areas of management analysed but, also, the ideas proposed in the literature of each area about the other one, i.e., the interaction between the areas in developing sustainability.

Table 1
Sustainability in SCM, HRM, IM and interaction between them.

Interaction	Sust. SCM	Sust. HRM	Sust. IM
SCM literature	Integration of the Triple Bottom Line (TBL) of sustainability into SC. Logistics is a critical area for improvements. Development of measures to explore and test sustainability across SC. SCM challenges: Costs, Complexity, Operationalization, Uncertainties and Mindset and cultural changes.	Connection between managerial components and sustainability efforts to better understand its influence. Top management must become committed. Visual picture of their SC, benchmarking each area of the SC against other firms. The role of SC relationships. A more multidisciplinary approach.	New approaches in linking knowledge to SSCM practices. Supplier involvement in sustainable new products development. To define the role of non-economic stakeholders on SC processes.
HRM literature	HRM is more than just managing employees. It also involves managing sub-contractors and people on non-employment contract. Also possibly managing other organisations in the production of goods and services.	The CEO provides legitimacy to HRM policies. Middle managers for the implement-tation of HRM policies and plans and for developing employee commitment. HR policies need to be perceived as fair and be understood by employees. Other factors: cultural and structural changes in developing effective HRM systems, employee involvement and making HRM departments accessible.	Sustainable HRM: a new approach to managing people, by identifying broader purposes for HRM, through its recognition of the complexities of workplace dynamics and the recognition of the need to avoid negative impacts of HRM practices.
IM literature	Process innovation: to redesign operations within the SC to produce goods and services by using less resources, managing non-product output effectively and increasing the eco-efficiency of production activities. Cleaner production. Product innovation: eco-design, life-cycle analysis, packaging, fair-trade and organic products, eco-label,…	Organizational structures (introduction of environmental/CSR depart-ments, teams or cross-functional units and committees), health and safety, code of conduct, employee development and training, employee engagement in sustainable/CSR activities, stakeholder management. Redesign of the company´s innovation process: integrating new innovation principles and interaction with external actors.	Strategic sustainability behaviour: Resistant (ignorance); Reactive (cause costs); Anticipatory (reduce costs); Innovation-based (contribute to market success); Sustainability-rooted (core business). Sustainable entrepreneurship.

2.3 The Theoretical Framework

Taking into account the main ideas compiled in Table 1, Figure 1 proposes a theoretical framework linking the main elements that characterize sustainability in the three research fields.

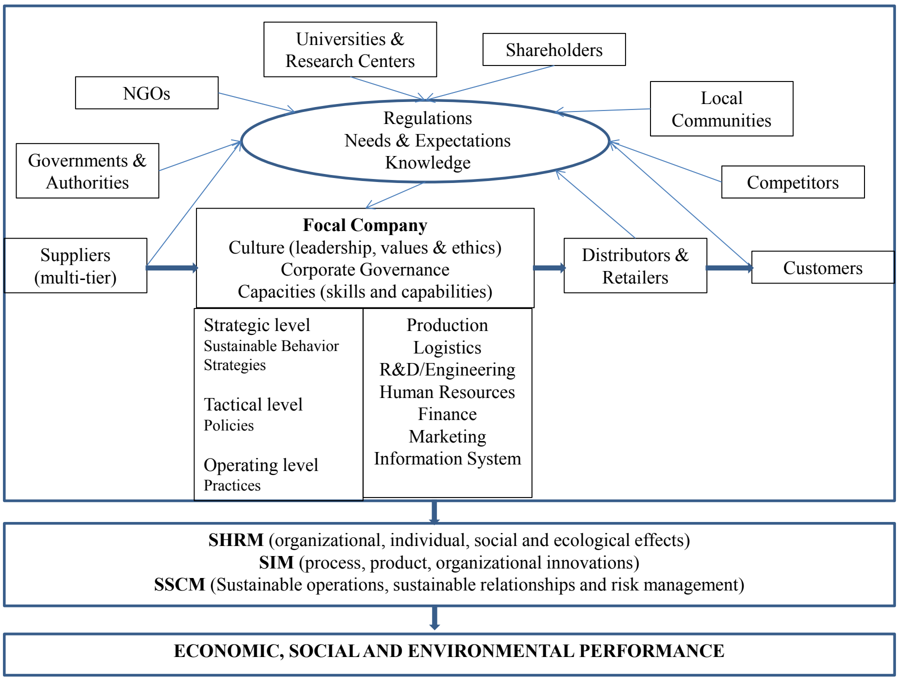


Fig.1
Integrated Sustainable Management of Operations,
Human Resources and Innovation.

3 The Case Studies

For this research, we selected the company INDITEX, one of the largest fashion retail groups in the world and the company IKEA, the largest furniture retailer group in the world. Both companies have a recognized high commitment to sustainability, which forms the basis of all their business decisions.

Based on their latest annual reports (2013), this is especially interesting because of the accessibility and the amount of information available, reflecting what top management in companies believes are the important corporate issues for stakeholders, and on this background, an individual and comparative analysis of the theoretical framework proposed has been developed and synthesized in Tables 2 and 3.

Table 2
The sustainable Model by INDITEX and IKEA (Part I).

Key elements	INDITEX	IKEA	Joint Assessment
Relationships with stakeholders Regulations Needs & Expectations Knowledge	Joint work with other companies, unions and the rest of civil society to mediate with governments on the modification of laws and practices that might breach human rights. Dialogue with and commitment to Stakeholders. Joint research and development programmes with universities and other stakeholders for improving sustainability.	Collaboration with governments in resources management supporting the introduction of regulations (i.e. forest conservation and by ensuring the legality of the timber used in Europe, USA, China…). Working and joining forces with other partnerships for sustainable resources. The IKEA Foundation as a projects framework.	High commitment in compliance with the regulations, but also promoters of changes and fair regulations. INDITEX: special emphasis on compliance with standards. Committees, auditors, monitoring groups for supporting and developing innovative programs (INDITEX: emphasizes the role of Universities; IKEA: the role of NGOs).
Culture, Governance and Capacities	Creating value beyond strict financial profitability. Transparency, information and regulations on Governance. Training and workers participation for capacity building.	The values are the foundations of the work. Team spirit and enthusiasm are key factors in its culture. Sustainable governance and management, business ethics and public policy. Learning as the process of developing competence.	Values and ethics on the basis of their business models. Transparency and sharing information. Clear principles of governance. Training (INDITEX) and learning (IKEA) for capacity building.
Strategies, Politics and Practices	Strategic plan for stable and sustainable SC 2014-2018. Politics involves all the functional areas. Continuous improvement and innovation in applying the best sustainable practices. New technologies as drivers.	People and planet positive strategy 2020. Politics involves all the functional areas. Continuous improvement and innovation in applying the best sustainable practices. New technologies as drivers.	Business strategies clearly based on sustainability (economic, social and environmental): sustainability-rooted behavior. INDITEX: main focus on activities; IKEA: special focus on the market ("inspire people to live a more sustainable life at home").

Table 3
The sustainable Model by INDITEX and IKEA (Part II).

Key elements	INDITEX	IKEA	Joint Assessment
SHRM	"To encourage the professional and personal growth of employees with the development of the business". Training, retention and promotion of talent. Prevention of occupational risks. Integration and equal opportunities. Volunteer force.	"We grow IKEA by giving all our co-workers the opportunity to develop, learn and take on challenging tasks". Talent management, leadership and diversity and inclusion, learning health and safety, workplace. Co-workers campaigns.	INDITEX: "ongoing development of teams´motivation", SHRM approach. IKEA: "a great place to work"; people management approach. A co-worker survey conducted by an independent organization.
SIM	Green design (sustainable fibres and ecolabel). The Ready to Manufacture programme is the first worldwide to prevent the inclusion or production of undesired substances during product manufacturing (consequence of the technological processes or the quality of chemical substances).	Understanding our customers' daily lives is important if we are to enable them to live more sustainably. The sustainability product scorecard: sustainable sources, renewable, reused and recycled materials, energy use in production…). Products that enable customers to reduce, water, energy and waste at home.	INDITEX, process innovation: Pioneering programs and standards through cooperative research programmes. IKEA, product innovation: solutions for a more sustainable life at home. Both, organizational innovation: structures, relationships with suppliers, understanding the role of all stakeholders.
SSCM	Efficient use of resources through the SC (water, energy, raw materials). Eco-stores and logistics. Risk management. Codes of conduct.	Idem: greening the processes (water, energy, wood, cotton…). Sustainable buildings and transport. Risk management. Codes of conduct.	Holistic approach of sustainability in SC operations. Important efforts for extending sustainability operations and codes of conduct to more than just direct suppliers.
Performance	TBL Indicators + GRI	TBL Indicators + GRI	Growth and welfare.

4 Discussion and conclusions

It is not easy to synthesize all the approaches, strategies, areas of activity, programmes and initiatives that explain the business models of the two companies analysed. We have tried to highlight the main elements of their extensive public reports in order to compare the models of both companies with the theoretical framework proposed. Both companies show a total concordance with the framework proposed, which integrated all the key findings in the sustainability literature research. Therefore, these companies allow us to develop theories and better understand the gaps and challenges proposed. However, undoubtedly, the main result of this analysis is to learn "what, who and how" these companies do for developing a successful and sustainable business. Both companies operate in difficult markets, where globalization, social and environmental impacts of their activities and the high amount of resources consumed, force these companies to work hard in order to respond to regulations, needs and expectations.

Inditex shows a great level of commitment, defining sustainability as the starting point of its decision-making processes. The stability and the support on sustainable standards (more of them developed by its collaboration) are strengths in its sustainable model of SC. The lack of an employee survey or the lack of perception of costumers about the sustainability of the company may be the main weaknesses. Ikea operates in more uncertain market conditions because of the economic crisis. But the company has focused its strategy on four cornerstones: growth, sustainability, people and lower costs. The philosophy: *With more than 680 million visitors to the IKEA Group stores worldwide and one billion visitors to IKEA.com, even the small changes that our customers make will add up to a big impact.* Integrated management of operations, HR and innovation is a strategic approach, but a common concern of the companies is to extend the sustainable principles to more than just direct suppliers.

5 References

Carter CR and Rogers DS (2008) A framework of sustainable supply chain management: moving toward new theory. International Journal of Physical Distribution and Logistics Management, Vol. 38 No. 5, pp. 360-387.

Denyer D and Tranfield D (2009) Producing a systematic review. In D. Buchanan & A. Bryman (Eds.), The Sage Handbook of Organizational Research Methods. Sage Publications, London.

Eisenhardt KM and Graebner ME (2007) Theory building from cases: opportunities and challenges. Academy of Management Journal, Vol. 50 No. 1, pp. 25-32.

Garrido N and Mejías AM (2014) The challenges of sustainable SCM through the systematic literature reviews. Book of Proceedings of the 8th International Conference on Industrial Engineering and Industrial management, XX International Conference on Industrial Engineering and Operations Management, International IIE Conference, pp. 221-228

Klewitz J and Hansen EG (2014) Sustainability-oriented innovation of SMEs: a systematic review. Journal of Cleaner Production, Vol. 65, pp. 57-75.

Kramar R (2014) Beyond strategic human resource management: is sustainable human resource management the next approach? The International Journal of Human Resource Management, Vol. 25 No. 8, pp. 1069-1089.

Morali O and Searcy C (2013) A review of sustainable supply chain management practices in Canada. Journal of Business Ethics, Vol. 117 No. 3, pp. 635-658.

WCED (1987) *Our Common Future*, World Commission on Environment and Development, Oxford University Press, Oxford.

Developing a Strategic Expansion Plan for the Manufacturing Industrial Sector in Kuwait

Nounou A[1]

Abstract: Developing the industrial manufacturing sector in Kuwait can be having several merits. It can offer employment opportunities, and accordingly reduce the burden of the social support, enhance other sectors of the economy, supply strategic commodities, and offer a room for applied research. Nevertheless, a well guided development of the industry needs to go through the phases of conceptualization, planning and realization in sequence. Based on a previous study of the conceptualization, the present study is focusing on the planning. The study overviews some of the important industrial figures in Kuwait and discusses the elements of the plan. A general scheme for the expansion plan is then presented. The study also presents improvements and changes that should be brought to these elements. Accordingly, a scenario of the expansion plan is presented based on the prioritization of the different manufacturing sectors regarding their strategic importance and performance. Finally, related discussions are conducted.

Keywords: Kuwait, Manufacturing Industry, Development, Strategic Expansion Plan.

1 Introduction

The development of the manufacturing industry in Kuwait can be significantly contributing to the overall development of Kuwait. Resulting employment opportunities can partially replace the need for public employment opportunities and might reduce the burden of social support costs. It can ensure the availability of strategic products, ranging from basic food commodities to defense products and can provide industrial equipment supporting other sectors like agriculture and construction. Moreover, it can collaborate with academia resulting in research and development activities that can be, themselves, among the drivers of the development of the manufacturing industry.

For the development of the industry to be well guided, it needs to go through the three sequential phases; conceptualization, planning and realization. In (Nounou A, 2015) it is focused on the conceptualization where a SWOT analysis for the manufacturing industrial sector is conducted and an industrial model for Kuwait is proposed. An industrial macro-model is interpreted in which the state is taking the lead, the Industrial Bank of Kuwait is the key player in the financial system and is aiming at evolving an industrial structure composed of growing industrial sectors composed of large companies as well as SMEs. In the same study an industrial micro-model (on an enterprise level) is proposed suggesting that industrial enterprises produce innovative licensed items (the product) using semi-automated processes (the process) for the regional market (the market). The present study is handling the planning phase and is benefiting from the aforementioned interpretations. The main objective is to come up with a general scheme for the industry expansion plan as well as a scenario illustrating its application.

1 **Amr Nounou** (amr.nounou@hotmail.com)
College of Engineering and Technology
American University of the Middle East, Egaila, Kuwait.

2 Overview of Important Industrial Figures in Kuwait

In the following, figures describing the size as well as the performance of the industrial sectors are presented. Table 1 identifies the size of the 8 industrial sectors in terms of number of industrial plants, investment and labor.

Table 1
The sizes of the industrial sectors in terms of number of industrial plants, investment and labor*

Sector		No. of industrial plants	Investment (mn KWD)	Labor
1	Food, Beverages & Tobacco	91	455	22,788
2	Textiles, Clothing & Leather Products	21	24	1,868
3	Wood & Wood Products, Furniture	64	38	3,884
4	Paper, Paper Products, Printing & Publishing	68	207	6,972
5	Chemicals, Petroleum Products, Coal, Rubber & Plastic	167	1,981	18,585
6	Non-Metallic Minerals Except Petrol	160	463	13,061
7	Metal Products, Machinery & Equipment	204	1,043	31,688
8	Other Manufacturing Industries	16	72	1,942
	Total	791	4,283	100,788

*: data based on (Public Authority for Industry, 2013).

In the following it will be referred to the sector by numbers from 1 to 8 as shown in Table 1. In the strategic expansion plan, it will only be focused on sectors 1 to 7 due to the variety of industries in sector 8. Table 2 is presenting the data for the profit rate, the ratio of investment to labor, percentage of idle capacity and percentage of exports in production which can be considered as parameters reflecting the performance of the sectors.

Table 2
Data for four selected performance indicators*

Sector	Profit rate (%)	Ratio of investment to Labor (KWD/Labor)	Idle capacity in 2010 (%)	Percentage of exports in production (%)
1	2.6	11,339	59.4	35.6
2	33.7	11,369	43.7	32.8
3	40.4	9,136	42.9	4.2
4	52.8	26,280	34	13
5	69.2	94,170	46.7	54.4
6	48.7	38,608	42.2	12.8
7	40.8	26,595	34.5	11.1
8	61.1	41,531	58.3	37.8

*: data from (Kuwait University and Public Authority for Industry, 2011).

3 Developing a General Scheme for the Strategic Expansion Plan

The development plan will involve three elements; expansion of the manufacturing industrial sectors which represents the physical growth, improvement of the global ranking of the competitiveness criteria which represents the development of the industrial environment and reducing the idle capacity of the existing plants which focuses on the utilization of the current capacities. Meanwhile, the plan will be based on the annual targeted investment of KWD 505 mn in the manufacturing sector as per the governmental development plan 2010/2011- 2013/2014 (Supreme Council for Planning and Development, 2010).

3.1 The Expansion of the Manufacturing Industrial Sectors

Based on Table 1, the average investment in a facility is KWD 5 mn with average labor of 127. For an annual investment budget of KWD 500 mn, 100 new plants are to be established resulting in 500 plants each 5 years. A labor force of 12,700 would be required annually accounting for 63,500 each 5 years. These figures can be used for a general expansion plan based on averages. Based on data in (Kuwait University and Public Authority for Industry, 2011) and assuming average plant sizes for the size ranges in Table 3, the weighted average plant size is approx. 6,000 m². Consequently, the space required each year is 600,000 m² and 3,000,000 m² each 5 years. Establishment of industrial zones can be based on the above with a ratio of industrial plot sizes as in Table 3.

Table 3
Numbers, percentages and ratios of industrial plants sizes*

Size of industrial plant (m²)	< 1,000	1,000 - 5,000	5,000 - 10,000	> 10,000
Assumed average size m²	500	2,500	7,500	15,000
Number of industrial plants *	52	480	94	123
Percentage (%)	7	64	13	16
Approximated ratio	1	9	2	2

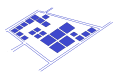
*: data based on (Kuwait University and Public Authority for Industry, 2011)

If the ratio of space acquired by industrial plots to the total space in an industrial zone is 1:2, then one new industrial zone would have a space of 6,000,000 m². An average industrial plant and a typical industrial zone needed each 5 years are represented in Table 4.

Table 4
An average industrial plant and a typical industrial zone.

An average industrial plant

Investment	KWD 5 mn
Labor	127 employees
Space	6,000 m²



A typical industrial zone for five years plan

Total space	6,000,000 m²
Industrial space	3,000,000 m²
Ratio of number of plots	
< 1,000 m²	1
1,000 to 5,000 m²	9
5,000 to 10,000 m²	2
> 10,000 m²	2

3.2 Improving the Global Ranking of the Competitiveness Criteria

It is suggested to focus in the plan on the criteria; starting a business, registering property, getting credit, trading across borders and dealing with construction permits. These criteria are based on World Bank ranking of competitiveness of a country out of 189 countries (Global Finance, 2015). It is proposed that improving the rank of these criteria to be targeted and to be a part of the expansion plan.

3.3 Reducing the Idle Capacity of the Existing Industrial Plants

While expanding the industrial sector and adding new facilities, utilization of the existing capacities stays to be a necessity. Table 2 is presenting the percentage of idle capacity for the industrial sectors in 2010. It is proposed that target minimum attainable values for this parameter should be set and included in the plan.

4 A Scenario for the Strategic Expansion Plan Based on Prioritization of Industrial Sectors

In the following a scenario of the expansion plan based on prioritization of the industrial sectors according to their strategic importance and performance is presented.

4.1 Prioritization of the Individual Existing Sectors

The strategic importance and the performance parameters in Table 2 are the criteria used for prioritization of the sectors. Regarding the strategic importance, the sectors 1 and 5 were ranked as highest (3), sectors 6 and 7 medium (2) and the rest as lowest (1). The values of the criteria are divided by the highest value and multiplied by 5 to have a score out of 5 (for the idle capacity, through dividing the lowest value by the individual values and multiplication by 5). An overall performance score is calculated as an average of the four performance criteria. In Table 5 an overall score is calculated as an average of the strategic importance and the overall performance scores then leveraged values of the industrial sectors were calculated through multiplying the potential sectors (above 2.5) by 2. Based on the sum of the leveraged values, the share of each sector in the expansion plan is identified and finally the sector expansion budgets are calculated by multiplying these percentages by the assumed annual investment of KWD 500 mn.

Table 5
Overall performance scores and calculation of the expansion budgets.

Sector	Overall score	Leverage of potential sectors	Share in the expansion budget	Annual sector Expansion (mn KWD)
1	3.4	6.7	20%	98
2	2.1	2.1	6%	30
3	1.8	1.8	5%	26
4	2.3	2.3	7%	33
5	4.8	9.7	28%	140
6	3.0	6.0	17%	87
7	2.9	5.9	17%	85
		Sum	Total	Total
		34.4	100%	501

4.2 The Expansion of the Manufacturing Industrial Sectors

Based on the data in Table 1, the average investment per plant for each sector and the number of added plants and their labor and space requirements are calculated as in Table 6. The annual expansion in terms of number of plants, total space and total labor needed are calculated. The same parameters for a five-year expansion plan are calculated through multiplication by 5 as represented in Figures 1 to 4.

Table 6
The annual expansion of the industrial sectors.

Sector	Investment /industrial plant (mn KWD)	No. of industrial plants (rounded)	Labor per industrial plant (rounded)	Space per industrial plant	Space required per year	Labor required per year
1	5	20	250	5,838	114,231	4,892
2	1	30	89	3,717	113,073	2,707
3	1	26	61	3,181	84,107	1,613
4	3	11	103	3,937	43,407	1,136
5	12	12	111	5,985	70,028	1,299
6	3	29	82	5,116	148,557	2,381
7	5	17	155	4,793	81,884	2,648
	Total	145		Total	655,289	16,676

4.3 Reducing the Idle Capacity of the Existing Industrial Plants

The minimum attainable value for the idle capacity is proposed to be 10% for all industrial sectors and to be achieved stepwise with equal increments each five-year plan. The target values for the five-year plans are presented in Figures 1 to 4.

4.4 Improving the Global Ranking of the Competitiveness Criteria

It is proposed to improve Kuwait's rank for the selected criteria in the global ranking to be at the edge of the best 25% (rank 47 out of 189 countries) by the year 2035 also stepwise with equal increments of improvement each five-year plan.

The scenario for the strategic expansion plan based on prioritization of industrial sectors is presented in Figures 1 to 4.

5 Discussions

The previous discussion focused on the existing industrial sectors meanwhile other manufacturing opportunities should be identified and studied. The strategic expansion plan, presented in Figures 1 to 4, projects the increase in industrial plants, labor force and industrial zones as well as the improvement of the global ranking of the competitiveness criteria and the reduction of the idle capacities in terms of five-year plans. Accordingly, the number of industrial plants is to reach 3,241 and the labor force is to amount to 434,308 employees by 2035.The structure of the strategic expansion plan offers unlimited planning opportunities and allows further interpretations. It lays out the needed infrastructural investments and helps in interpreting labor needs for each sector. This can help in forecasting the academic and vocal educational needs with relevance to the expansion of the different sectors. Targeting improving the global ranking of the competitiveness criteria is to focus on the strategic and procedural related issues and aim at resolving them. Based on the challenges the industry would face, research programs can be planned on a long term. In addition to the planning aspect, the strategic expansion plan can be considered a tool for monitoring and control where the values shown in the plan can be used as KPIs guiding the implementation (realization) phase.

6 Conclusions

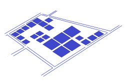
In the study, an overview of the important industrial figures in Kuwait is conducted. A general scheme for strategic expansion plan is then suggested followed by a scenario based on prioritization of the industrial sectors according to their strategic importance and performance. Finally, possible further interpretations based on the strategic expansion plan were discussed.

2015-2020

Investment in industrial plants = KWD 2.5 bn

Added	Total
725	1,516

Added	Total
83,380	184,168



Added
1

Competitiveness criteria	Ranking out of 189 countries
Starting a business	126
Registering Property	79
Getting credit	109
Trading across borders	96
Dealing with Construction Permits	112

Sector	Idle capacity (%)	Added investment (mn KWD)
1	47	489
2	35	152
3	35	132
4	28	165
5	38	702
6	34	436
7	**28**	**427**

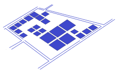
Fig.1
The expansion plan 2015-2020.

2020-2025

Investment in industrial plants = KWD 2.5 bn

Added	Total
725	2,241

Added	Total
83,380	267,548



Added
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Competitiveness criteria	Ranking out of 189 countries
Starting a business	100
Registering Property	69
Getting credit	89
Trading across borders	80
Dealing with Construction Permits	90

Sector	Idle capacity (%)	Added investment (mn KWD)
1	35	489
2	27	152
3	26	132
4	22	165
5	28	702
6	26	436
7	22	427

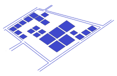
Fig.2
The expansion plan 2020-2025.

2025-2030

Investment in industrial plants = KWD 2.5 bn

Added	Total
725	2,966

Added	Total
83,380	350,928



Added
1

Competitiveness criteria	Ranking out of 189 countries
Starting a business	73
Registering Property	58
Getting credit	68
Trading across borders	63
Dealing with Construction Permits	69

Sector	Idle capacity (%)	Added investment (mn KWD)
1	22	489
2	18	152
3	18	132
4	16	165
5	19	702
6	18	436
7	16	427

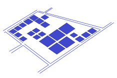
Fig.3
The expansion plan 2025-2030.

2030-2035

Investment in industrial plants = KWD 2.5 bn

Added	Total
725	3,241

Added	Total
83,380	434,308



Added
1

Competitiveness criteria	Ranking out of 189 countries
Starting a business	47
Registering Property	47
Getting credit	47
Trading across borders	47
Dealing with Construction Permits	47

Sector	Idle capacity (%)	Added investment (mn KWD)
1	10	489
2	10	152
3	10	132
4	10	165
5	10	702
6	10	436
7	10	427

Fig.4
The expansion plan 2030-2035.

7 References

Global Finance (2015) Kuwait https://www.gfmag.com/global-data/country-data/kuwait-gdp-country-report. Retrieved 14 Feb 2015

Kuwait University and Public Authority for Industry (2011) Results and recommendations of Field Industrial Scanning Project for The Industrial Sector in the State of Kuwait for the Year 2011

Nounou A (2015) Proposing an Industrial Model for the Manufacturing Industrial Sector in Kuwait. KINETIC 2015, Kuwait

Public Authority for Industry (2013) Industrial Guide, 3rd Edition.

Supreme Council for Planning and Development (2010) Medium Term Development Plan 2010/2011 – 2013/2014, February 2010.

Social Behavior of Brazilian Organizations: An analysis of isomorphism mechanism

Bogo, Adelaide M[1], Schmitt, Alan C[2], Henning, Elisa[3], Menegotto, Margarete LA[4]

Abstract: Man's behavior is determined by variables that are commonly understood as needs and motives. Human behavior is closely related to motivation to meet needs and, according to Maslow, these needs are built on a hierarchy composed of five groups, which are physiological, safety, love/belonging, esteem and self-actualization. Based on the above, this study aims to analyze the social behavior of Brazilian organizations and the existing isomorphism in these practices. The sample consists of companies listed on the ISE-BOVESPA stock market and the data were collected in the 2012 Sustainability Reports. Is use Content Analysis technique and descriptive statistics. The results indicate a concentration of actions on the need for safety and the existence of coercive and normative isomorphism in social activities.

Keywords: Isomorphism; Human Needs; Corporate Social Responsibility.

1 Introduction

Brazil is a large country with social problems still to be solved (IBGE, 2013), this the brazilian social environment is characterized by great economic inequality between individuals, with a large portion of society living in poverty and misery (Griesse, 2007), this causes the humanitarian reasons are the main impulses to the adoption of social practices by organizations (Reis, 2007). The behavior of organizations concerning the choices of social actions to be performed can originate from an institutionalized environment which in turn can lead to the homogenization of social practices, as explained by Meyer and Rowan (1977). Furthermore, DiMaggio and Powell (1983) explain that the concept that best captures the homogenization process among organizations is isomorphism.

Considering that man's behavior is motivated by the fulfillment of five basic needs, which are physiological, safety, love/belonging, esteem and self-actualization (Chiavenato, 2003; Hersey & Blanchard, 1988; Maslow, 1987), and organizations undertake social actions to meet those needs, it's possible to identify in what kind of need the actions are concentrated and also the existence of institutionalized isomorphism in the environment. Based on the above, this study analyzes the social and isomorphic behavior of Brazilian organizations with regard to their social actions. By social behavior, we mean the set of actions that aim to fulfill basic human needs, which raises the following question: How has the social behavior of Brazilian organizations been performing relative to the homogenization of social practices? This study is empirical, exploratory research, with a qualitative approach and using Content Analysis to and descriptive statistics to analyse data.

The population includes all companies listed on the ISE/BOVESPA (BOVESPA, 2014), for a total of 40 organizations. The data will be taken from the Sustainability Reports (SR) for 2012.

This study may contribute to new directions of social actions, new ways to organize themselves in order to achieve higher goals in a country or even understand why strategically organizations develop social actions. It can also contribute in research aimed to management controls, the image of the organization, accountability and Institutionalism Theory. This article is structured into seven sections. The first section

1 **Bogo, Adelaide M.** (adelaide.schmitt@udesc.br)
Department of Chemistry, Technological Sciency Center (CCT/Joinville), UDESC, Brazil.
2 **Schmitt, Alan C.** (alanudesc@gmail.com)
Department of Production Engineering, Technological Sciences Center (CCT/Joinville), UDESC, Brazil.
3 **Henning, Elisa.** (elisa.henning@udesc.br)
Department of Mathematics, Technological Sciences Center (CCT/Joinville), UDESC, Brazil.
4 **Menegotto, Margarete L. A.** (margamenegotto@hotmail.com)
Universidade de Caxias do Sul/PPGA/Brazil.

introduces corporate social responsibility. The second addresses isomorphism. The third presents Maslow's hierarchy of needs. The fourth presents the current Brazilian scenario and corporate social responsibility practices by organizations. The fifth section explains the methodological process, the data and the data analysis. The sixth section presents the discussion and the seventh has the conclusion.

2 Corporate Social Responsibility

The notion that companies should be socially responsible has its origin in the idea that today we live in a world where 20% of the rich own 86% of the gross national product, a single country consumes 23% of the world's energy supply and the U.S. and Europe account for 65% of the world's wealth creation (Blowfield & Murray, 2011). Corporate Social Responsibiliy (CSR), which can be understood as a continuous process of the organization that aims to constantly monitor the environment (social, political, economic and legal) in which the organization operates and its relations with this environment (L'Etang, 1995). CSR is based on the premise that the organization needs to behave in a socially responsible way (Asif, Searcy, Zutshi, & Fisscher, 2013; Schaltegger & Wagner, 2006) and Carroll (1979) defines social responsibility as obligations of the organization and should involve four three-dimensional categories of business performance integration: economic, legal, ethical and discretionary. It can also be seen with a clearly articulated set of policies and practices that are well communicated and reflect corporate responsibility for some of the great benefits to society (Falck & Heblich, 2007; Matten & Moon, 2008), and increasing corporate image and meeting accountability (Gray, Owen, & Maunders, 1988), or as an ideological movement to consolidate the power of organizations (Banerjee, 2008). Culture, another kind of motivations to organizations practices social responsibility, correspond a set of rules that guide the behavior and attitudes of most interest and meaning to people in the organization (Alvesson, 1993; (Hofstede, 2003; Schein, 2004). So we can understand CSR as social behavior of the organization that is aimed at fulfilling basic human needs and which results from some conditions of the environment.

3 Isomorphism in Social Practices

Institution (Burns & Scapens, 2000), is a prevalent and permanent form of thought or action which is involved in the habits of a group or the customs of a person. As such, when organizations realize that they have an institutionalized environment, they tend to homogenize their organizational practices because they understand that this mechanism allows them to increase their chances of survival (Fennell, 1980; Meyer & Rowan, 1977).

The homogenization process stems from the need to legitimize the organization (DiMaggio & Powell, 1983; Kondra & Hurst, 2009), and the concept that best captures the homogenization among organizations is called isomorphism (DiMaggio & Powell, 1983). Isomorphism is driven by the survival instincts of organizations leading them to strategic and/or operational changes (Fennell, 1980; Meyer & Rowan, 1977). The isomorphic process among organizations happens based on three mechanisms: coercive, mimetic and normative (DiMaggio & Powell, 1983). The coercive process stems from political influence and legitimacy problems, the mimetic behavior comes from the standardization of behavior as well as responses to environmental uncertainties, and the normative mechanism comes from the professionalization of the environment (DiMaggio & Powell, 1983).

Considering that each organization operates in its own business sector, organizations end up adopting the CSR practices of its environment and these are perceived and appropriated by their target audience (Aerts, Cormier, & Magnan, 2006; Shah, 2011). Campbell (2007) found that socially responsible behavior has a strong relationship with the level of competition. To summarize, we can see that the business sector, society, the local community and the country itself where the organization is based exert pressures on the organization that may compromise its survival (Meyer & Rowan, 1977).

4 Human Needs

Maslow (1987) stating that the individual is an integrated being, an organized whole and that motivation is of the individual and not of a part of him. In turn, Hersey and Blanchard (1988) state that behavior is usually motivated by a desire to achieve some goal. The individual is motivated from needs created by him, consciously or unconsciously, and that when one need is satisfied, another one emerges (Maslow, 1987).

The needs identified by Maslow (1987) comprise five hierarchical groups, which are physiological, safety, love/belonging, esteem and finally self-actualization. Hartley (2010), based on Maslow, presents the needs in five ordered groups according to their power, with physiology being first, the second is the need for safety, the third is the need for love and sense of belonging, the fourth self-esteem and finally self-actualization.

The physiological needs relate to two principles, homeostasis and appetite (Maslow, 1987), safety needs include situations that give security and stability, livelihood, family and assets, threat protection and escape from danger. The social needs include association, participation, acceptance, friendship, affection, love and family. Esteem needs are related to the way the individual is seen and evaluated, and involve self-assessment, self-confidence, social approval, respect and status, among others. Finally, self-actualization needs are related to the realization of one's own potential and continuous self-development (Hartley, 2010; Maslow, 1987). Some social studies that seek to find the satisfaction of the needs of individuals and the community, such as enabling people to take advantage of their own abilities, are the object of as yet unresolved issues (Dover, 2011). In short, the social actions that organizations conduct may not yet completely fulfill the needs of the human being, and we should have some thoughts on the social behavior of organizations.

5 Social Reality in Brazil

Brazil is a country with great social inequality (Barros, Henrique & Mendonça, 2000). Even with a wealth of natural resources and potential for development, its growth has been uneven and unequal, a factor that takes part of its population into poverty (Griesse, 2007). Based on this characteristic of social inequality, some NGOs have emerged in order to help Brazilian organizations with their social actions (Griesse, 2007).

An interesting feature about the fight against poverty in Brazil is the participation of the government, community groups and private organizations, which together can build a new model of actions (Young, 2004). Because of the multidimensionality of poverty and inequality, actions and policy implementations that improve the living conditions and well-being are necessary (IBGE, 2013). There is a range of unresolved situations in Brazil involving access to public health, low quality of education, access to housing, populations concentrated in large cities, social inequality, violence and social exclusion that end up aggravating Brazilian social problems (Francisco, 2014). Given the above, it is clear that social problems in Brazil remain, and that social inequality still exists even with the dedication of private organizations and community groups.

6 Methodology

This empirical study is exploratory and brings a qualitative analysis of the social actions of Brazilian organizations. We intend to identify in which human needs social actions are concentrated and to know whether there is homogeneous behavior between organizations in order to find which isomorphic mechanism is most prevalent. The analysis techniques used in this study include content analysis (Bardin, 2014) and descriptive statistics to identify isomorphism practices and relate them to coercion, mimetic and normative mechanisms (DiMaggio & Powell, 1983).

a) Population and Sample - organizations listed in the ISEBOVESPA, 37 organizations were selected. Some organizations were excluded from the sample, either for not having disclosed the 2012 SR, or because the organization was part of a conglomerate with other companies already included, and therefore the SR was the same (BOVESPA, 2013).

b) Data - taken from the 2012 Sustainability Report. Was analyzed the nature of social actions disclosed in the groups Labor Practices and Decent Work (LPDW), Human Rights (HR) and Society (SO), whose categories are listed in the GRI (GRI., 2011)

c) Description of the methodological process - Initially, the categories were organized as parent and child categories (Bardin, 2014). Parent categories were defined based on the GRI Technical Manual (GRI, 2011), so three parent categories were created: Labor Practices and Decent Work (LPDW), Human Rights (HR) and Society (SO). Responsibility for the Product was excluded from the group since the information had no consistency or homogeneity in the reports.

Then, for each of the parent categories, child categories were built adopting the same structure of human needs presented by Maslow: physiological, safety, social, self-esteem and self-actualization. The data were recorded as follows: a) To analyze the most prevalent isomorphic mechanism (which are reported in Table 02); b) To analyze the actions that fulfill human needs, participation in the group (which is reported in Table 01). Table 01 shows the relative frequency of the actions by parent category and sub-categories.

6.1 Analysis of Results

As indicate above, in the Table 1 will be analyzed the actions realized of human need by sectors and in the Table 2 will be analyzed the prevalent isomorphism mechanisms.

a) Labor Practices and Decent Work - There is a concentration of actions for the need for safety. But for the physiological needs no organization dedicated any attention, just as with self-actualization. However, for the social and self-esteem needs, there are few investments. For safety, the programs/projects are directed toward family health and education. For social needs, the focus is on social inclusion, adaptation of the individual in society after retirement and sports activities outside the company. And self-esteem actions are geared towards valuing the individual through awards.

Analyzing from the perspective of isomorphism, based on Table 01 and considering the types of actions carried out by organizations with their workforce, there is a predominance of the coercive mechanism. The normative and mimetic mechanisms are present, however, to be certain which of the two has prevalence is only possible if we enter into the decision-making process.

The most common coercive actions identified in the included analytical research on LPDW, concerning the employment relationship, involve the employment contract or civil service admission exam, internal safety activities in accordance with the workplace safety group, meetings regarding workplace safety and programs such as the emergency brigade. There are also actions regarding workplace health resulting from occupational health programs such as hearing conservation, PPE, respiratory protection programs, biosafety and ergonomics.

The most common normative and/or mimetic actions involve training and education for employees focused on technical and professional qualifications, at the three levels of education: technical, undergraduate and graduate, either in the classroom or through distance learning. Most undergraduate and graduate programs receive financial assistance from the organization, in the form of a scholarship. There are also programs aimed at internships, apprenticeships and trainee programs. Whether or not they come out of the PCMSO, there are programs focused on workers' health and they are usually extended to include their dependents. Most of them deal with physical and mental health, smoking, alcohol and drugs, chronic diseases, women's health, pregnancy, healthy eating, sex and visual and/or hearing impairment.

In the areas of career and employee compensation, there are also normative aspects in the behavior of the organizations. It was found that it is common practice among organizations to establish meritocracy programs to do employee promotions, usually with performance evaluation programs that link the progression and compensation to performance. Some companies use profit sharing as an additional form of compensation and in some cases link this to job performance, as is the case at the management and executive levels. It is also a common practice to establish the job and salary plan, independent of any evaluation for performance or merit.

Table 01
Actions and Relative Frequency by Organizations.

ACTIONS GROUP	SITUATION	FREQUENCY	PERCENTAGE
LPDW Physiological	No	37	100
LPDW Safety	Yes	37	100
LPDW Love/belonging	Yes	8	21,6
LPDW Esteem	Yes	2	5,4
LPDW Self-actualization	No	37	100
HRPhysiological	Yes	1	2,7
HRSafety	yes	2	5,4
HRLove/belonging	yes	2	5,4
HREsteem	No	37	100
HRSelf-actualization	No	37	100
SOPhysiological	yes	10	27
SOSafety	yes	36	97,3
SOLove/belonging	yes	21	56,8
SOEsteem	yes	1	2,7
SOSelf-actualization	No	37	100
LPDW - Labor Practices and Decent Work			
HR - Human Rights			
SO - Society			

b) Human Rights - There are actions for safety and social needs, both with 5.4%. For isomorphism, based on Table 01, it was not possible to identify the predominant mechanism since the sample has a small number of actions done in this social aspect. In this social aspect in human rights, the actions focus on gender diversity, ethnicity, age, religion, sexual orientation and people with disabilities. There are also programs aimed at vaccination, wellness, youth entering the job market, recognition of the struggle for land and respect for indigenous peoples and traditional communities, this last one including the resettlement of land.

c) Society - There is a focus on actions aimed at safety, with 97.3%, followed by social actions, with 56.8%, then physiological actions, with 27%, and self-esteem with 2.7%. In isomorphic terms, in Table 01 we see mimetic behavior between organizations. Viewed analytically, the actions may not represent mimetic behavior because this study did not do research on decision-making in the choice of actions. However, if we look at the industry's behavior as well as companies listed on the ISEBOVESPA, it appears that there is mimetism between organizations, since all focus their actions on safety and social needs. Few investin in physiological and almost none invests in self-esteem and self-actualization. The actions aimed at safety involve primary education programs, technical courses for young people, participation in social programs like apprenticeships, digital inclusion, entrepreneurship, sports, arts, theater, volunteering, training, underprivileged communities, blood donations, support for adolescents and children with cancer, environmental education, supporting social organizations, technical coopera-tion, financial education, undergraduate and graduate scholarships, accessibility, support/donations to youth councils, support for projects and reintegration into society. For social needs, actions are geared towards the arts, cinema, theater, traditional festivals, music, cultural events, restoration work, citizenship, volunteering, biking, sports competitions, contests with prizes and social gatherings. Actions to meet physiological needs mostly include food donations to social organizations, pediatric cancer care programs, infant feeding, vaccination, blood donation and examination campaigns, Christmas campaigns, emergency programs, pediatric and family health and cooperative actions. The Table 02 present by sector the action groups in which organizations carry out their social responsibility.

Table 02
Participation in Social Actions by Sector.

SECTOR	LPDW					HR					SO				
	P	S	l-b	E	S-a	P	S	l-b	E	S-a	P	S	l-b	E	S-a
Industrial Goods/Machines and Equipment		x					x	x							
Industrial Goods/Transport Materials		x										x			
Non-cyclic Basic/Processed Foods		x										x	x		
Non-cyclic consumption/Prod. Personal Cleansing		x	x	x			x	x				x	x		
Construction and Transport./Constr. and Engineering		x									x	x			
Construction and Transportation/Transport		x										x	x		
Non-cyclic consumption/Health		x									x	x	x		
Finance and Others/Financial Intermediaries		x	x	x							x	x	x	x	
Finance and Others/Insurance		x										x			
Finance and Others/Miscellaneous Financ Services		x									x	x	x		
Basic Materials/Wood and Paper		x									x	x	x		
Basic Materials/Mining		x				x					x	x			
Basic Materials/Chemicals		x										x	x		
Basic Materials/Metallurgy		x										x			
Telecom/Land-line Telephony		x	x								x	x	x		
Telecom/Mobile Telephony		x	x								x	x			
Public Utilities/Water and Sanitation		x									x	x	x		
Public Utilities/Electrical Energy		x	x									x	x		
Percentage results	0%	100%	29%	12%	0%	6%	12%	12%	0%	0%	53%	94%	65%	6%	0%
LPDW - Labor Practice and Decent Work	P - Psycological								E - Esteem						
HR - Human Rights	S - Safety								S-a- Self-actualization						
SO - Society	L-b - Love/belonging														

Table 02 identifies the social behavior of the sectors. Analyzing vertically, we can see that the 'Safety' item receives the most attention from the organizations, where in LPDW, 100% of the sectors have actions and in 'Society', 94% of the sectors have actions. The other need worth mentioning is the physiological which has a total of 53% of sectors investing in this need. Analyzing this table horizontally, it appears that the sectors with the greatest diversity of actions in the SO parent category are 'Non-Cyclical Consumption/ Personal Products' and 'Cleaning, Financial and Other/Financial Intermediaries' with a concentration in 'Safety,' 'Social' and 'Self-esteem' in three parent categories (LPDW, HR and SO).

The sectors 'Telecommunications/Land Lines' and 'Public Utilities/Water Sanitation' are concentrated on actions aimed at meeting physiological, safety, social and self-esteem needs and are concentrated in the 'Society' parent category.

The 'Public Utility/Electrical Energy' sector has actions to meet safety and social needs and they are concentrated in the parent categories LPDW and SO. In other sectors, there is a concentration of actions aimed at meeting the needs of safety, then social needs. They are concentrated only in the SO parent category. It was also found that all sectors except Industrial Goods/Machines and Equipment have social actions aimed at safety needs. Analyzing the isomorphic behavior of the sectors, we can see homogenization in 'safety' in both LPDW and SO. In LPDW the isomorphism can be coercive and can have origin in the strong work legislation in the country and in the SO the isomorphism can be mimetic and can have origin in institutionalized practice.

7 Discussion

In order to analyze the social and isomorphic behavior of brazilian organizations regarding the social actions carried out in view of basic human needs, the initial question that was defined was 'How has the social behavior of Brazilian organizations been presented regarding the homogenization of social practice?' The data indicate that, in terms of fulfilling human needs, the highest concentration of actions is found in the 'Safety' item, then comes 'Social' item followed by 'Physiological' needs. The other part of the question regarding the homogenizing characteristics, observed in Table 02, is the coercive isomorphism in the actions geared toward the safety need in the LPDW parent category in 100% of the organizations. In the HR parent category, there is insufficient evidence to support the isomorphic mechanism as predominant. And in the SO parent category, there is an indication of the mimetic mechanism. It can be observed that 94% of the sectors have actions in 'Safety,' 65% in 'Social' and 53% in 'Physiological.'

As shown in Table 02, there is a concentration of actions in 'Social' and 'Safety' and this may happen due to the social characteristics of the country which, as the IBGE shows, still has many social problems to be solved. Thus, the concentration of actions in these two needs may indicate mimetic behavior motivated by the current situation in Brazil. We noticed that only a few sectors have actions in the physiological need, which are transport, non-cyclical consumption, financial, basic materials, telephony/telecommunications and water and sanitation.

Considering that one of the objectives of this work is to identify isomorphic aspects in activities of social responsibility in brazilian organizations, it was found that isomorphism is present in the behavior of organizations both in the activities for internal audiences and external audiences. For internal audiences, the behavior is expressed most prominently in safety activities in LPDW. This characteristic may occur due to the strongly established regulatory pressure in the country. For external audiences, the behavior is expressed more intensely in the safety activities in SO and this feature can occur due to the social reality of the country. The concentration of activities in safety and social needs may reflect a maturing of organizations and society, and the fact that some actions are conducted in partnership can also reflect a major advance in the concept of organized teamwork.

8 Conclusion

Considering the goal of this research, the data collected from the Sustainability Reports allow us to assume with a relative safety margin that there is isomorphism in brazilian organizations, particularly in the coercive and normative aspects of social activities for internal audiences. In actions aimed at external audiences targeted to meet human needs, there was a concentration of safety and social items, and this behavior may represent a practice of mimetism in the organizations. We identified a difficulty in understanding whether every action stems from a normative pressure or it is a question of the organization opting for mimetism, given that the research did not enter into the internal processes of decision-making.

The difficulty of accurately understanding the difference between an action that meets the physiological need or the safety need, or between safety and social is a limitation of the research. The difficulty in understanding the nature and its essence may be related to the multidisciplinary quality of corporate social responsibility (Aguinis & Glavas, 2012), or even a short description of the project, or a project including actions that meet more than one need. From the evidence in this study, it can be assumed that organizations can reflect on the effectiveness of their actions if they look at society holistically. They can, based on this view, organize themselves together to effectively meet the needs of human beings. They can make intensive use of management accounting and, because of this, organize themselves differently than they do today, in a way that is more appropriate for transparency and comparative analyses. The dynamic process of organizing society assumes constant change and adaptation and for this reason, studies that shed light on social issues can be helpful.

New research can be developed based on this study, such as understanding why actions for physiological needs are still done in a country like Brazil, or why organizations focus their actions on safety. Another option for further study could be to understand the reasons for the decisions of the organizations in the choices of actions, how the accounting is done in internal procedures for corporate social responsibility, how social issues are embedded in the organization's strategy or in management controls. Finally, an ethnographic or etymological study could be performed, or a history of the actions to verify their evolution, both by organizations and sectors in Brazil.

9 References

Aerts, W., Cormier, D., & Magnan, M. (2006). Intra-industry imitation in corporate environmental reporting: An international perspective Journal of Accounting and Public Policy, 25, 299–331.

Aguinis, H., & Glavas, A. (2012). What We Know and Don't Know About Corporate Social Responsibility: A Review and Research Agenda Journal of Management, 38(4), 932-968.

Alvesson, M. (1993). Cultural Perspectives on Organizations. New York: Cambridge University Press.

Asif, M., Searcy, C., Zutshi, A., & Fisscher, O. A. M. (2013). An integrated management systems approach to corporate social responsibility Journal of Cleaner Production, 56, 7-17.

Banerjee, S. B. (2008). Corporate Social Responsibility: The Good, the Bad and the Ugly Critical Sociology, 34(1), 51-79.

Bardin, L. (2014). Análise de Conteúdo. Lisboa: Edições 70.

Barros, R. P., Henrique, R., & Mendonça, R. (2000). Desigualdade e Pobreza no Brasil: retrato de uma estabilidade inaceitável. Revista Brasileira de Ciências Sociais, 15(42), 123-142.

BOVESPA. (2013). ISE - Indice de Sustentabilidade Empresarial. Retrieved 15 nov., 2013, from https://www.isebvmf.com.br/index.php?r=site/conteudo&id=1

BOVESPA. (2014). Índice de Sustentabilidade Empresarial - ISE. from BM&FBOVESPA http://www.bmfbovespa.com.br/indices/ResumoIndice.aspx?Indice=ISE&Opcao=0&idioma=pt-br

Burns, J., & Scapens, R. W. (2000). Conceptualizing management accounting change: an institutional framework Management Accounting Research, 11, 3-25.

Campbell, J. L. (2007). Why Would Corporations Behave in Socially Responsible Ways? An Institutional Theory of Corporate Social Responsibility Academy of Management Review, 32(3), 946–967.

Carroll, A. B. (1979). A Three-Dimensional Conceptual Model of Corporate Performance. Academy of Management Review, 4(4), 497-505.

Chiavenato, I. (2003). Teoria Geral da Administração: uma visão agrangente da moderna administração das organizações (7a. ed.). Rio de Janeiro: Editora Campus.

Dimaggio, P. J., & Powell, W. W. (1983). The Iron Cage Revisited: Institutional Isomorphism and Collective Rationality in Organizational Fields. American Sociological Review, 48(2), 147-160.

Dover, M. A. (2011). Human Needs. Cleveland: Oxford.

E Francisco, W. d. C. (2014). Problemas sociais nas cidades do Brasil. Retrieved from http://www.mundoeducacao.com/autor/wagner-de-cerqueira-e-francisco

Falck, O., & Heblich, S. (2007). Corporate social responsibility: Doing well by doing good. Business Horizons, 50, 247-254.

Fennell, M. L. (1980). The Effects of Environmental Characteristics on the Structure of Hospital Clusters Administrative Science Quarterly, 25(3), 485-510.

Gray, R., Owen, D., & Maunders, K. (1988). Corporate Social Reporting: Emerging Trends in Accountability and the Social Contract. Accounting, Auditing and Accountability, 1(1), 6-20.

GRI. 2011. G3.1-Guidelines-Incl-Technical-Protocol [Online]. Global Reporting Initiative. Available: https://www.globalreporting.org/Pages/default.aspx [Accessed 22 abril 2014].

Griesse, M. A. (2007). The Geographic, Political, and Economic Context for Corporate Social Responsibility in Brazil. Journal of Business Ethics, 73(1), 21-37.

Hartley, D. (2010). Understanding Human Need: Social Issues, Policy and Practice. Bristol: Policy Press.

Hersey, P., & Blanchard, K. (1988). Management of Organizational Behavior (5th ed.). Englewood Cliffs (New Jersey): Prentice-Hall.

Hofstede, G. (2003). Culturas e Organizações - compreender a nossa programação mental (A. Fidalgo, Trans. 1a. ed - 2a. reimp. ed.): Edições Sílabo.

IBGE. (2013). Síntese de Indicadores Sociais: uma análise das condições de vida dos brasileiros. Rio de Janeiro: Instituo Brasileiro de Geografia e Estatística.

L'Etang, J. (1995). Ethical Corporate Social Responsibility: A Framework for Managers Journal of Business Ethics, 14, 125-132.

Maslow, A. H. (1987). Motivation and Personality (3th Ed.). New York: Harper & Row.

Matten, D., & Moon, J. (2008). "Implicit" and "Explicit" CSR: A Conceptual Framework for A Comparative Understanding of Corporate Social Responsibility. Academy of Management Review, 33(2), 404–424.

Meyer, J. W., & Rowan, B. (1977). Institutionalized Organizations: Formal Structure as Myth and Ceremony. American Journal of Sociology, 83(2), 340-363. Retrieved from http://www.jstor.org/stable/2778293 website:

Reis, C. N. d. (2007). A Responsabilidade Social das Empresas: o contexto brasileiro em face da ação consciente ou do modernismo do mercado? Revista de Economia Contemporanea, 11(2), 279-305.

Schaltegger, S., & Wagner, M. (2006). Managing sustainability performance measurement and reporting in an integrated manner - Sustainability accounting as the link between the Sustainability Balanced Scorecard and sustainability reporting Eco-Efficiency in Industry and Science (Vol. 21, pp. 681-697).

Schein, E. H. (2004). Organizational Culture and Leadership (3rd ed.). San Francisco: Jossey-Bass.

Shah, K. U. (2011). Strategic organizational drivers of corporate environmental responsibility in the Caribbean hotel industry Policy Sci, 44, 321–344.

Young, R. (2004). Dilemmas and advances in corporate social responsibility in Brazil: The work of the Ethos Institute. Natural Resources Forum, 28(4), 291-301.

Strategic decisions: an approach to the implementation of the Production Strategy in farms producing soybean

Leitner CP[1], Sznitowski AM[2], Baggenstos S[3], Perini A C[4], Oliveira T S[5]

Abstract: The content of the production strategy includes certain levels of planning, where are observed the competitive priorities and on this basis, two types of decisions: the structural and infrastructural. It was with scope on these decision levels that the study was developed having as object farmers who grow soybeans of the Campo Novo dos Parecis City (Brazil). For this was done field research with application of questionnaires to the farmers on their decision process involving structural and infrastructural decisions in the past four years. With the questionnaire it was sought to: understand the operation of the farm, identify the profile of rural properties, and identify in which factors of structural and infrastructural decisions the farmers spent more efforts in the period 2010 to 2014. The results showed that in recent harvests, when compared to investments in structure, farmers did more investments in infrastructure, which enables them to sustain the competitiveness of rural enterprises.

Keywords: Farmers; Rural properties; Structural Decisions; Infrastructural Decisions.

1 Introduction

In today's world the Brazil stands as agricultural barn. Has 22% of productive land in the world, makes use of high technology and agribusiness sector efficient and competitive internationally. The state of Mato Grosso in the national context is the state with the highest profit sharing obtained by the production chain of grains, such as quotes Mato Grosso Economy Agricultural Institute (IMEA, 2012). According to the Ministry of Agriculture, Farming and Supply (MAPA, 2014), increased productivity is associated to technological advances, the management and efficiency of producers and market guarantee, mainly because soybeans are an essential component in manufactured of animal feed, and their increasing use in food. For Pozzobon (2006) the evolution of the agricultural sector performance is the result of modernization of rural activity, but the changes resulting from that modernization led to new requirements in the management of agricultural properties. He also mentions that the farms make little use of question practical and coherent strategies for the agricultural market.

There are several studies of strategic decisions in several areas, but there is still a shortage of studies on strategic decisions geared specifically to soy production. With this stresses the need to know what the pro-soy producers take into account in formulating its strategic decisions. Thus, the main objective of this study was to identify which elements of structural and infrastructural decisions were no major financial expenditures and efforts of farmers established one of the largest soybean production tors municipalities in the state of Mato Grosso - Campo Novo do Parecis.

1 **Camyla Piran Leitner** (camyla.piran@gmail.com)
2 **Adelice Minetto Sznitowski** (adeliceadm@gmail.com)
3 **Salli Baggenstoss** (salli@unemat-net.br)
4 **Aline Carla Perini** (aline.perini@ibest.com.br)
5 **Tatiane de Souza Oliveira** (tatioliveira_bbu@hotmail.com)
Dpto. Administração
Universidade do Estado de Mato Grosso. Rodovia MT - 358, Km 07,
CEP 78300-000 Tangará da Serra/Mato Grosso-Brazil.

2 Strategy of Production

According Batalha (2008) was from the 1960s that theorists began to highlight the importance of strategies for companies to manage their strengths and weaknesses and achieve their goals. Chase et al (2006), indicate that the production of the Strategy can be seen as part of a planning process that coordinates the goals / operational targets with the objectives more extensive of organizations. Moreira (2006) adds that production strategy is the rational planning of production activities in order to use them as a competitive weapon.

According Sciuto (2012), the establishment of production strategy by companies begins with the definition of competitive strategies according to the market they serve. Then run to determine the competitive priorities that should be displayed by the production function, according to the strategic aspects defined in competitive strategy. After this step, should be performed in decision making, which will support the range of competitive priorities elected through a coherent set of decisions.

Decisions can be grouped according to their nature, into two groups: structural and infrastructural. They are subject to change due this linked to the market and the desire of customers, and shall be consistent and well-defined, since the entire function of the production company will shape these decisions. The structural decisions are divided into installations, capacity, technology and vertical integration, which are characterized by being costly decisions, long term and difficult to reverse (HAYES AND WHEELWRIGHT, 1984). For Nogueira (2002), the areas of infrastructural decisions are considered more tactical because they involve continuous decisions that are related to more operational aspects of the business. Among them are: human resources, quality management, planning and production control, organization.

Observe the following descriptions about the structural and infrastructural decisions.

2.1 Structural Decisions

According to Paiva, Carvalho and Fensterseifer (2004), the facilities are related to decisions about geographic location, type of production process, volume and lifecycle. Hayes and Wheelwright (1984) complement facilities relating to the size of the plant, its mix of products, production processes and the degree of specialization / targeting of production resources.

The capacity is related to the premises decisions and determined Standing her area, equipment and human resources, according to Paiva, Carvalho and Fensterseifer (2004). Capacity analysis is relative to what will be produced and tam well as will be produced, marked out in terms of market need and technological possibility available (HAYES AND WHEELWRIGHT, 1984). Yet for Hayes and Wheelwright (1984), decisions inherent in this category are intima-mind related to market demand and, therefore, companies have to decide whether to work with their ability above, below or keeping pace with demand.

The implementation technologies include factors such as choices of new equipment, automation and integration in the production process (HAYES and WHEELWRIGHT, 1984) and the adoption of information systems for the management of manufacturing (PIRES, 1995).

Those relating to vertical integration decisions are mainly related to internal transactions that the company will realize that goods and / or services will acquire from third parties and which will adopt purchasing policy. In essence it is a question between manufactures the products or provides service, or buys them from others. Although they are based on the analysis of the profitability of make or buy, these decisions are largely strategic in nature (Karloff, 1994).

2.2 Infrastructural Decisions

Are elements that category decisions concerning Human Resources, Quality Management, Planning and Production Control Organization (PIRES, 1995) among others, depending on the company profile. The human resources strategies act on the defined policies and existing enterprises, thus seeking to achieve the goals set by the organization (PAIVA; CARVALHO; FENSTERSEIFER, 2004). Barros Neto (1999) complements asserting that decisions to human resources is related as a recruitment, selection, hiring, training, promotion, compensation, motivation, evaluation, transfer, dismissal. Human resources are competitive differentials between companies (PIRES, 1995).

The quality management of management should be guided by the definition of goals and ways to control the quality of products and processes of the company and should be assigned responsibilities, define what are the tools and system but to be used, set training programs be instituted (PIRES, 1995).

Production Planning and Control is the way to how the company organizes in terms of forecasting and scheduling of resources in production. Are the decisions concerning the way of acting on the means of production to increase efficiency and to see that production targets are achieved (HAYES AND WHEELWRIGHT, 1984).

Decisions concerning the organization mainly involve the organizational structure, hierarchical levels and the organization of work in the company. Oliveira (1998) states that the organizational structure is an important tool in the development and implementation of the organizational plan of the companies, for both, it must be designed in accordance with the objectives and strategies of settled.

3 Methodology

Research in its initial design was quantitative and exploratory. We chose to de-fine your search by using the register of the farmers in Association of Soy and Corn Grower of Mato Grosso (APROSOJA), which in the municipality of Campo Novo do Parecis - MT corresponds to 225 producers. Considering the rate of return accepted by Malhotra (2006), which is 20% for type survey surveys, the sample was considered valid 24 respondents. The quantitative nature of the research directed the use of structured questionnaire with questions close of following the standard Likert for the answers. The questionnaire was divided into three parts: 1) profile of properties, 2) competitive priorities 3) questions on the areas of structural and infrastructural decisions based on Hayes and Wheelwright (1984), which brought to light the decision areas structural or infrastructure with more investments. The data obtained from this group of farmers were analyzed qualitatively.

4 Results and Discussions

All the surveyed farms, besides the size - are large properties - have in common the main product soybeans grown via tillage. This form of planting is typical of large areas. Besides soybeans (main activity of summer) and corn (second crop, starting after planting soybeans be harvested), are planted in lesser amount sunflower and popcorn. These properties, the number of employees varies depending on the size of the property. However, the majority (45.8%) are between 01 and 10 employees who are hired on demand services that change depending on the periods as after planting and after harvest. As for the size properties, the most studied (87.5%) have large areas (up to 3000 acres). The size of the property is one of the 1st characteristics observed by producers for crop planning, since it is from the size of the property that other decisions are made (as numbers of employees, machines etc.). Land ownership is also taken into account in the planning of the harvest, given the increasing demand for soy producers can choose to purchase, lease or other forms. In this sense one can see that in the 2013/14 crop, the majority (54.2%) of the area was property of them.

The grains harvested are marketed through the main existing customers on the market, namely the trading companies, cooperatives, brokerages and garners. The research group sells its production via trading companies establishing certain requirements for the purchase of products. One requirement to be satisfied is related to the type of soybean. It was observed that the type of soybean planted is called conventional, which is more accepted for export; already transgenic (genetically modified) is sold domestically. It was found that most (54.2%) have some sort of certification, especially related to infrastructure characteristics of the property (people management, quality management).

Decisions taken by the farmers surveyed are distributed into structural and infra-structural decisions. The structural decisions are subdivided in capacity, facilities, technologies and vertical integration that will be discussed in the sequel. As regards investments involving structural decisions, in particular, about capabilities (such as expansion of the planted area), it is seen that smaller number of farmers (66.5%) did not invest in this regard. However, those who invested, the values were significant, with values above 10 million to 8.4% of producers. As for leased areas, the highest values were in up to three million. A higher percentage of farmers invested in recruitments of employees, which is directly related to the acquisition and leasing of areas, investment value by up to 500 thousand. About investment category, it was found that most New Field of farmers Parecis-MT did not invest in facilities in the Mato Grosso state (58.2%), or out of state (87.4%), or in silos and warehouses on their farms (54.1%). Of those who did, there are the acquisitions made in warehouses and silos, however a very deficient factor.

The survey data show that all producers have invested in some kind of technology. The largest investments were generally in technology them for pest control (87.4%) and machinery and equipment for harvesting (100%). The values for the first group of technologies were between R$ 500.000 to R$ 300.000.000. For the group second values between R$ 500.000 to R$ 10.000.000. The last item considered within the structural decisions is vertical integration. The data show that some of the investigated soybean producers (33.3%) purchase products directly from the manufacturer. Concerning the extension of silos and / or warehouses 41.70% claim to have never expanded. Also, 41.70% sporadically outsource collection.

The following data will be presented on infra-structural decisions. In item Quality Management, factor that involves setting standards for inspection of inputs, 29.2% of farmers indicate that invested rarely, 16.6% invest often, 12.50% always invested and only 12, 50% of producers have not invested. The preventive maintenance of machinery and equipment, the majority (66.6%) did investments. With regard to the technical standards (manuals, data sheets, crop planning) at planting and harvest, 45.8% of farmers invested. About the inspection of the final product (rank) always occurred investments. As regards the management person was found that 37.5% of the producers always invest ram in health and safety. About reward system based on crop productivity, the majority (41.7%) of producers has invested without pre-invest in skills and training (37.50%), and the benefit programs (29.20 %). About planning and control of production, the largest investments were in the planning of planting activities, treatment plants and harvest (87.5%). On this criterion, 79.2% of producers invested always; 83.4% also always invested in managing the purchase of inputs for crops in the period 2010/11 to 2013/14. Still 58.3% always made investments in inventory control. Regarding the organization of farms, the change in style of lead showed a mixed response. For this question, 50% of said producers sometimes change, while 20.80% is frequently changing. Already 12.50% of said always change and 12.5% said they never change and 4.2% rarely.

Finally, it presents the information about the relationship of farmers with suppliers. It was identified that the greater the amount of inputs acquired, the greater the advantages offered by the vendors. The data showed that 37.5% of producers are given incentives from suppliers to development to new products and support to improve crop productivity. About courses and training provided by suppliers, 37.5% reported receiving sometimes these incentives and 20.9% reported receiving frequently or always. The actions related to quality management, planned and executed by suppliers, are also offered to farmers. However, 37.50% of the farmers stated that rarely receive and 20.90% never received. Regarding the financing of the land to be planted, 25% of producers always use financing of input suppliers, while 20.90% do not use often. In the crop financing by trading companies it was found that 79.3% do not use, while 20% of producers often use.

Data from the study allowed evaluating the types of relevant structural and infrastructural decisions adopted by farmers. It was evidenced that 62% of producers consider being of low importance the investments in capacity and also in plants (88%). Already the technology factor for most farmers was considered of great importance (70%). About vertical integration, for most farmers (55%) are of great importance, and also quality management for 80% is of great importance. Decisions aimed at managing people were considered indispensable for 66% of the farmers and planning and control of production was also perceived as very important by 80% them. Moreover, it is plausible that decisions about the organizational structure are very important for the majority of farmers (80%) and also the relationship with suppliers is of great importance for 45% of farmers.

5 Final Thoughts

For the objective of this study that was to identify which structural and infrastructural decisions are considered by soybean producers in the municipality of Campo Novo Parecis - MT, it was found that both the structural and infrastructural decisions are taken into account by farmers, being these interdependent in the decision-making process. However, higher investments relate to infrastructure decisions.

The study permitted enlarges the understanding of the functioning of rural property in relation to decision making on factors inherent in soy production. It was also possible to identify the profile of the rural properties that grow soybeans. The factors considered in deciding on the planning of crops involving structural decisions and infrastructure still were analyzed. In relation to limitation to the study, it is possible mentioned that it involves a single municipality, may expand future research for larger areas. And it is suggested that in addition to soybeans, other types of cultivars within the state can be studied, considering that Mato Grosso is the largest producer of grains (soybeans) and there is also facing shortage for the production units "within the gate". Thus, this pilot study may be useful for the purposes of correlation / comparison with future studies, allowing understand and analyze strategic decisions of other production units or others locations.

6 References

APROSOJA. Projeto Referencia. Disponível em: http://www.aprosoja.com.br/projeto/projeto-referencia/. Acesso em: 03/05/2014.

BARROS NETO, J. P. Proposta de um modelo de formulação de estratégias de produção para pequenas empresas de construção habitacional. 1999. 326p. Tese (Doutorado em Administração) – Universidade Federal do Rio Grande do Sul, 1999.

BATALHA, Mario Otavio / organizador. Introdução à engenharia de produção. – Rio de Janeiro: Elsevier, 2008.

CHASE, R. B.; et al. Administração da produção para vantagem competitiva. 10 ed. Porto Alegre, RS: Bookman, 2006.

HAYES, R. H.; WHEELWRIGHT, S. C. Restoring our competitive edge: competing through manufacturing. New York: John e Wiley, 1984.

IMEA. Agronegócio em Mato Grosso. Cuiabá - MT, Brasil. 2012. [s.n.]. Disponível em: www.imea.com.br/upload/pdf/.../2012_09_13_Apresentacao_MT.pd....´

MALHOTRA, N. K. *Pesquisa de Marketing: Uma Orientação*. [S.l.]: Bookman Companhia Ed, 2006. Disponível em: http://books.google.com.br/books?id=FtdIFOgTP8UC

MAPA. Exportação Soja brasileira 2013.[s.n.], 2014. Disponível em: http://www.agricultura.gov.br/dwagrostat/seg_dwagrostat.principal_dwagrostat.

MOREIRA, D. A. Administração da produção e operações. São Paulo: Thomson Learning, 2006.

NOGUEIRA, E. (2002) - Empresas Fabricantes de Revestimentos Cerâmicos e a Gestão de seus Sistemas Produtivos: A Proposição de um Modelo. Tese de Doutorado, FGV/EASP. São Paulo, 2002.

OLIVEIRA, D. de P.R. de. Sistemas, organização e métodos: uma abordagem gerencial. 10. ed. São Paulo: Atlas, 1998.

PAIVA, E. L., CARVALHO JR., J. M.; FENSTERSEIFER, J. E. Estratégia de produção e de operações: conceitos, melhores práticas e visão de futuro. Porto Alegre: Bookman, 2004.

PIRES, S. Gestão Estratégica da Produção. Piracicaba: Editora UNIMEP, 1995.

POZZOBON;, D. M.; LÖBLER;, M. L.; SILVEIRA;, V. C. P. O processo de estratégia em empresas agropecuárias: proposição de uma metodologia de formulação e implementação. 2006, Fortaleza - CE: [s.n.], 2006. p. 1–20. Disponível em: http://www.ufsm.br/extrural/vicentepp/arquivospdf/o processo de estratégia.pdf

SCIUTO, Joseleine Maria. Estratégia de produção enxuta: estudo de caso em uma grande empresa metal mecânica. 2012. 119p. Dissertação (Mestre em engenharia de produção), Universidade Federal de São Carlos, São Carlos, 2012. Disponível em: http://www.bdtd.ufscar.br/htdocs/tedeSimplificado//tde_busca/arquivo.php?codArquivo=5183. Acesso em 12/04/2014.

Communication Adaptation Decisions Considering Cultural Differences between Brazilians and Americans

Marcon A[1], De Medeiros JF[2], Cruz CML[3], Marcon É[4]

Abstract: This article sought analyzing the adaptation decisions of McDonald's when communicating with distinct markets. Thus, the institutional communication actions performed by the company in Brazil and in the United States of America were analyzed in order to describe the macro environmental variables that exert influence over the brand management, as well as, identifying, in light of Hofstede's Theory, the adaptation decisions under the aspects of individualism, masculinity, power distance and uncertainty avoidance. Regarding the method, the research was characterized as qualitative and exploratory, using the approach of content analysis of the commercials in both countries of the sample. As the results, it was observed that McDonald's adapts its communication compound to the Brazilian culture both in the macro environmental aspects and in the subjective aspects mapped by Hofstede's Theory.

Keywords: International Marketing; Adaptation; Culture; Communication.

1 Introduction

After the 80's, with the increasing academic discussion regarding the globalization of markets, two theories gained space concerning the orientation for the ideal commercial approach to be employed by the organizations willing to insert their brands in new territories: (i) standardization theory and (ii) adaptation theory. For the standardization theory (i), the tendency for markets is to converge to global similarity (Levitt, 1983), whereas, for the adaptation theory (ii), the insertion in distinct territorial markets requires environmental sensitivity, that is, it must recognize that there are specific cultural needs for specific markets (Keegan and Green, 2003).

In this article the scope of analysis centers on the adaptation theory, and it has, as the focus of analysis, the adaptations performed by McDonald's in its communication activities. The study is justified by the inherent need to develop and deepen the specific knowledge concerning marketing communication in markets distinct to the ones native to the company (Churchill, 2010).

2 Literature Review

2.1 Marketing Moderating Variables

Accepting culture as an influential factor in the marketing decisions, Motta (2004) states that companies are not self-sufficient, thus, every company needs to interact with the environment to which it is inserted, in this way, they need a systemic vision of the surrounding environment. The author states that it is common to divide such marketing environment into two: the competitive environment (i) and the macro environment (ii).

1 **Arthur Marcon** (121137 @upf.br)
2 **Janine Fleith de Medeiros** (janine@upf.br)
3 **Cassiana Maris Lima Cruz** (cassiana@upf.br)
4 **Érico Marcon** (119497@upf.br)
Faculdade de Ciências Econômicas, Administrativas e Contábeis.
Universidade de Passo Fundo. Passo Fundo, RS, Brasil.

The (i) competitive environment involves the variables that can be manipulated by the company, whereas the (ii) macro environment is characterized by the variables that are not controlled by the company and are, still, equally important in the decision-making process. The six variables that make up the macro environment, according to Kotler and Keller (2013) are: the demographic (i) which includes indicators such as growth rate, predominant ethnicities, gender, age and income; the economic variable (ii) that involves factors as inflation, purchasing power and interest rates; the natural variable (iii) involves issues related to the preservation of the ecosystems, the scarcity of raw material and pollution; the technological variable (iv) concerns the technological innovations and their impact on people's daily lives; the political variable (v) includes, fundamentally, laws and policies determined by the governments and, finally, the socio-cultural variable (vi) involves cultural values that define attitudes and behaviors.

2.2 Culture

Authors from the consumer behavior field mention that it is not possible to comprehend people's choices without considering the context in which they were made. This context comprises the knowledge, beliefs, customs, laws and any other habits and capabilities acquired by the individuals as beings that participate in society (Hawkins et al, 2007).

Accordingly, Hofstede (1983) states that culture works as mental programming shared by a community and it is, per se, durable and engraved in the realizations and in the institutions of a certain group, enabling the distinction of different groups of persons. Hofstede's theory will be used in the data analysis of this article (item 2.2.1).

2.2.1 Hofstede's Theory

In his research, Hofstede developed a theory to describe culture, based on data collected in fifty countries with more than a hundred and sixteen thousand questionnaires. By means of the research, it was possible to identify that four dimensions describe national cultures:

> 1. Individualism *versus* Collectivism: in this dimension the author points out that individualism happens when the ties between individuals are loose. In collectivist cultures, people are born inside social groups, which can be family groups, their tribes or their villages.
>
> 2. Power Distance: the main topic here, according to the author, concerns "how society deals with the fact that people are unequal […] in their physical and intellectual capabilities."
>
> 3. Uncertainty Avoidance: for the author, the main issue involved in this dimension concerns the way society deals with the fact that time runs only one way.
>
> 4. Masculinity *versus* femininity: this dimension is limited to the division of roles in society. Once that, according to the author, the only activities that are strictly determined by the sex of a person are those related to procreation which are described by the author as biological sexual division, which differ from the social sex roles that concern this variable.

3 Methodology

The research's approach to the problem was exploratory and qualitative. Concerning the study's sample definition, it was composed of electronic commercials advertised in the Brazilian market and in the American market from March 2011 to May 2014. It is important to emphasize that the sample was composed of institutional and promotional commercials. Still, it is highlighted that this sampling is characterized as judgmental once that the criteria of period and message type were defined by the authors. The analysis road map for the electronic advertisements was elaborated based on the researched theory exposed throughout item 2 of this article. Operationally, the analysis was developed through the 4 steps necessary, which, according to Bardin (2011), are: pre-analysis, material exploration and processing and interpretation of the results.

4 Presentation and Discussion of the Results

4.1 Analysis of the Commercials Based on Hofstede's Theory

By means of the methods described in the methodology chapter, five McDonald's campaigns advertised in Brazil and five campaigns advertised in the United States were selected. The analysis was, initially, done in an individual way in order to, subsequently, through Hofstede's Theory, gather the variables observed in the advertisements of the sample within the categories determined by the author.

1. Individualism versus Collectivism:
   - Brazil: it was possible to perceive the use of social groups, family groups and groups of friends, much more than the use of characters in solitary scenes, even though it occurred. It is also important to highlight the use of scenes in which families and groups of friends have their meals together.
   - United States: Despite being ranked as an extremely individualist society according to Hofstede's research, the commercials analyzed presented a large frequency of groups of friends consuming the product, what may suggest the brand's encouragement for such practices.
2. Masculinity versus Femininity:
   - Brazil: In Hofstede's ranking, Brazil was analyzed as a country in an intermediate stage concerning the masculinity factor. Such fact was confirmed by the analysis, once that, in the majority of the commercials, there is similar appearance of men and women. Regarding subjectivity, a more feminine society was perceived, once that values like caring for others, concern for quality of life, cooperation between the characters and modesty were observed.
   - United States: Because the United States has a more masculine graduation, there is a constant presence of men, more than women in the commercials, even though some commercials show a similar frequency of both. As to the subjectivity, masculinity was the most frequent, which is justified in values such as: statement of personal success and the importance of work. However, in some cases it was possible to identify feminine values as well.
3. Uncertainty Avoidance:
   - Brazil: Because Brazil is ranked as having relatively high rates in this variable, the need for rules and regulations that reduce the uncertainty avoidance was perceived. Still, it was possible to denote the use of family moments and affective expressions between the characters, factors that are also common for societies with high rates in this variable.

- United States: Even though American scores were below the average, the use of formal rules was perceived in the dialogues and the scenes, as well as displays of affection. These facts diverge from Hofstede's research, however, the authors consider it worth mentioning that, perhaps, the company uses these scenes to incentive the consumption of the products among friends and family and, in order to create affective connections with the consumer.

4. Power Distance:

- Brazil: It was observed the use of status symbols and hierarchy in the commercials, by showing people in formal clothing and denotative roles of mother and father. It is necessary to highlight that the power distance variable was the less common in the commercials.
- United States: Reiterating what was mentioned in the Brazilian analysis, here it was possible to identify the same reduced occurrence of power distance in the commercials. Nonetheless, in the commercials in which this factor appeared, it was presented in both the figures of family hierarchy and working hierarchy.

4.2 Systemic Analysis of the Macro Environment and of the Cultural Adaptation

In this item, a synthetic joint analysis of the macro environmental variables along with the analysis of Hofstede's variables is presented.

4.2.1 Commercials Advertised in Brazil

GPPP8 Simplesmente Inacreditável - Advertisement for the "Pequenos Preços McDonald's" campaign – March 2011 - In the period the commercial was advertised, Brazil had a majority of white and mixed-race people. The country, then, had ¼ of its territory under environmental protection, though the CO_2 emission was high. Collectivism is apparent in groups consuming the product. Masculinity and femininity occur with the same frequency. Emotions and feelings are noticeable by body language. Status symbols are also present in people formally dressed.

GPPP9 Simplesmente – Advertisement for the "Pequenos Preços McDonald's" campaign – June 2011 - The macro environmental scenario is the same as in the first commercial, though, it is important to reiterate the feminine predominance, and the share of black people in the statistics, totalizing 7,61% of the population. Collectivism is, once more, highly present, although individualism was still perceived. Objectively, men appear as much as women in the commercial, however, subjective feminine values were present like caring for others. Again, in the uncertainty avoidance variable, the characters use body language and display feelings and emotions.

Simplesmente Família – Happy Meal Advertisement – August 2011 - In this commercial, it is important to highlight the concern for sustainability through the permanent grazing areas in the natural variable. Still, 1/3 of the population had personal computers in this period. In this commercial it was possible to assess both the predominance of femininity in the objective variable and in the subjective variable by values like quality of life and modesty. The appearance of characters in family groups in the collectivist variable was frequently observed. Concerning the power distance variable, the display of family status (hierarchy) was frequent.

Escolhas 30' – Promotion of salad as a side dish – October 2011 - In the last commercial of 2011, the female predominance was identified in the macro environment. Still, the authors considered relevant the continuous importance given to the environment and to CO_2 emission rates, as previously mentioned. In this advertisement, the subjective presence of femininity was observed, in values like cooperation and quality of life.

McD Sempre Especial – Institutional – February 2013 - Lastly, by identifying the subjective variable in the commercial, it is important to mention the Human Development Index, which was of 0,744 in Brazil. The concern with healthy eating habits and the concern with others characterized the feminine subjective variable as the most frequent in this commercial. Yet, concerning the collectivist variable, the use of family groups was constantly perceived.

4.2.2 Commercials advertised in the United States

McDonald's Lettuce Supplier, Dirk Giannini – Institutional – January 2013 – In the period the commercial was advertised, the United States had a population of 322.583.006. Analyzing the population two years earlier, it was observed that men represented 49,4% of the population. Still, given the commercial's context, it is necessary to highlight that the territory under environmental protection in 2010 was equivalent to 13,66% of all the United States territory. The lack of display of emotional expressions or feelings is evident in the commercial regarding the uncertainty avoidance variable. Besides that, society's masculinity could be assessed through the analysis of the expressions of personal success and the factors of "living for the job," characteristic of societies where masculinity is stronger.

McDonald's Apple Supplier, Leo Dietrich Sons "Generations" – Institutional – January 2013 - Following the same context of the first commercial, in this item of the sample it is emphasized the CO_2 emission index, which in 2010 was of 5.433,057 kg/ton. Power distance was observed in this commercial through the description of the work hierarchy. Yet, regarding the individualism variable, the observed in the commercial differed from Hofstede's research, once that the commercial presents frequent scenes with groups. In the masculinity variable, the virtually exclusive use of male characters was perceived, as well as the statement of personal success. Even though the country's score was not high in the uncertainty avoidance variable, the commercial describes the requirements McDonald's makes and how they must be fulfilled, perhaps, intending to demonstrate the company's concern with the processes and the quality of the products.

McDonald's: Dollar Menu & More – Hot New Playlist – Promotion of the Dollar Menu & More campaign – April 2014 - Because the commercial shows black people, it is important to reiterate the share of this ethnic group that represented 7,93% of the American population in 2010. Despite Hofstede's research showing the USA as an individualist country, the commercial presents a pair of friends having fun together.

McDonald's Fish Supplier, Kenny Longaker "The Last Frontier" – Institutional – April 2014 - In the penultimate commercial of the American sample, it is worth mentioning that the Human Development Index of the USA in 2013 was 0,914. Finally, it is necessary to mention the labor costs related to the American legislation, once that the commercial shows employees at work. In this way, in the United States, a worker costs 8,84% of extra costs to the employer, almost six times less than in Brazil. Concerning the individualism, the main character is alone in most of the commercial and refers back to himself many times throughout the commercial. Nonetheless, the advertisement also presented scenes of collective work, even though in a small proportion.

McCafé Mornings with Jessica – McCafé Promotion – May 2014 - In the last commercial of the American sample, it is important to mention that the average income of the population in 2010 was US$ 3.472,82, a high index when compared to Brazil. Still, in the economic variable, the American GDP/capita in 2012 was of US$ 51.163/year, once again higher than the Brazilian index. Femininity was evident in the commercial through the concerns with quality of life and the use of female characters in the commercial. The predominance of individualism was perceived, once that the character appears alone through most of the commercial. Finally, in the power distance variable, it is possible to denote the clear family hierarchy.

5 Final Considerations

Observing the results obtained through the analysis, it is understood that, despite being considered a global brand, McDonald's adapts the brand to the Brazilian market, in both the macro environmental aspects and in the subjective cultural aspects of Hofstede's Theory. Finally, despite reaching the objectives set, the research was limited to a sample of two countries and one company, thus, further researches could include more countries to the sample, as well as replicate the analysis to more companies of the sector. Still, future studies could assess the consumer perception regarding the commercials, enabling the validation of the hypothesis described in the theories that support the analysis in this article.

6 References

Churchill Jr, Gilbert A (2010) Marketing: criando valor para clientes, 3rd ed. Saraiva, São Paulo

Hawkins DI, Mothersbaugh DL, Best RJ (2007) Comportamento do Consumidor: construindo a estratégia de marketing. Elsevier, Rio de Janeiro

Hofstede G (1983) The cultural relativity of organizational practices and theories. Journal of International Business Studies, Available via JSTOR. http://www.jstor.org/stable/222593?origin=JSTOR-pdf. Cited 05 Jan 2015

Keegan W J, Green M C (2003) Princípios de marketing global. Saraiva, São Paulo

Kotler P, Keller K L (2013) Marketing essencial: conceitos, estratégias e casos, 5th ed. Pearson Education do Brasil, São Paulo

Levitt T (1983) The globalization of markets. Harvard Business Review, Vol. 61 No. 3

Motta SLS (2004) Ambiente cultural como elemento modelador das decisões de marketing global, paper presented at the 28th Encontro Anual da Associação Nacional de Pós-graduação e Pesquisa em Administração, September 2004, Curitiba, available at: www.anpad.org.br/diversos/trabalhos/EnANPAD/enanpad_2004/GIN/2004_GIN165.pdf

An approach to Islamic Finance in Spain

Garrido C[1], Rodríguez-Monroy C[2]

Abstract: Islamic finance systems are a new way of raising funds for families, companies and public institutions. This kind of system has its origin in the Middle East and Asia, but it is gaining customers all over the world due to the growth of Islamic economies and the problems of traditional financial systems in Western countries. Therefore, having into account the problems to get credit by SMEs in Spain Islamic Finance is a new open way for entrepreneurs, as well as for corporations and the whole society. This new financial resource has strict principles based on the Sharia'a, the Muslim law that regulates the transactions in Arab society. This fact could be a key point in order to develop a business structure in Spain, as a conse-quence of the spoiled reputation of traditional banks.

Keywords: Islamic Finance, SME, Spain, Banking

1 Introduction

The Financial crisis, developed after the Lehman Brothers' collapse in 2008, has reduced the instruments and opportunities for funding in most Western countries. Obtaining money by credit is one of the main problems in countries of the Eurozone. This is one of the principle reasons why many SMEs in Spain had to leave their business once liquidity in their statements started to disappear. However, the European Parliament and governments in the European Union have applied different measures in order to expand the credit. These measures have always followed a path in which banks were the connection between the financial sources and the final customer. Those stimuli did not get at the same magnitude from the banks to the customers as it did from the governments to the banks because some of the banks needed liquidity in order to increase their capital ratio due to the Basel 2 treaty. Thereby, the result is that European banks are stronger than before the crisis because of those reforms, but SMEs still have difficulties to obtain funds according to the Basel 2 treaty rating system, in which SMEs show a riskier profile due their shorter history, lack of information and high elasticity to market condictions, comparing them to big corporations, (Shiyab, 2014).

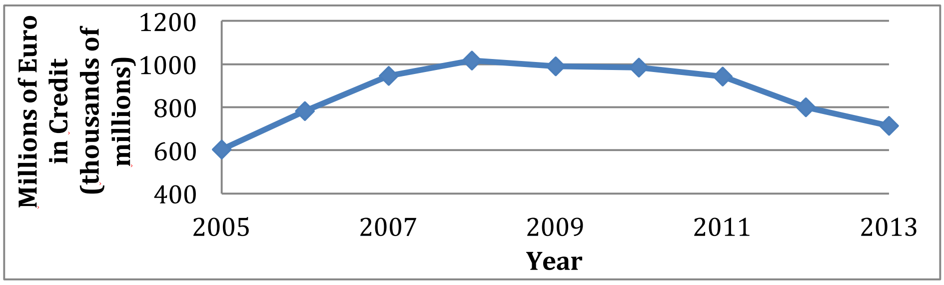


Fig.1
Evolution of Credit in Spain.
Source: Bank of Spain (BdE).

1 **Carlos Garrido Camino** (carlos.garrido.camino@alumnos.upm.es)
Dpto. de Organización de Empresas. Escuela de Ingenierías.
Universidad de Málaga. C/ Dr. Ortiz Ramos S/N, 29071Málaga.

2 **Carlos Rodríguez Monroy** (crmonroy@etsii.upm.es)
Dpto. de Organización de Empresas.
Escuela Técnica Superior de Ingenieros Industriales.
Universidad Politécnica de Madrid. C/ José Gutiérrez Abascal 2, 28006Madrid.

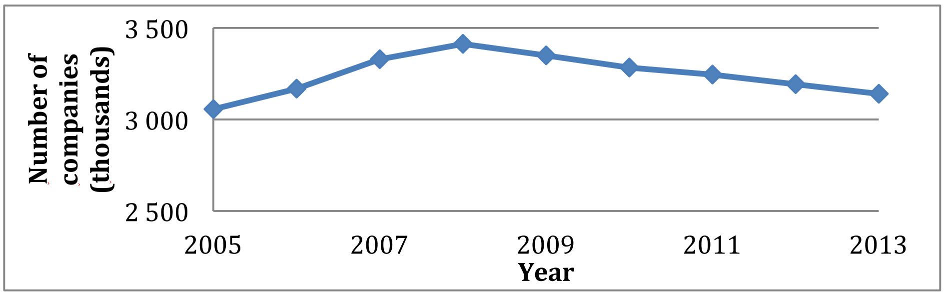


Fig.2
Evolution of the number of companies with less than 200 employees in Spain.
Source:Spanish Statistical Office (INE).

As it has been already mentioned, one of the main problems for SMEs is the access for external financial resources (Lehmann & Neuberger, 2001), even when they play a key role for growth and employment creation across any country of the world (Wagenvoort, 2003). The principal source for obtaining funds for SMEs is banking financial products (Montoriol, 2006), however, actually they face credit rationing when trying to develop their operations. This credit rationing is the existence of any kind of restriction on the access to financing sources, without taking into account the real risk of the project, being directly related to the size of the company, the previous relationship with the financing institution or other characteristics of the company that seeks for credit sources (Larrán, García-Borbolla, & Giner, 2008).

In Europe, the problem has been bigger than in any other part of the world. The Euro currency avoids the countries of the Euro-zone to apply monetary policies and national exchange rates. In the special case of Spain, the credit from financial institutions has been historically focused on real estate and construction sector. Furthermore, real productivity was not competitive comparing to other economies of the world. These facts made Spanish economy very vulnerable to external monetary flux restrictions. Thereby, when this happened in 2008, Spanish economy was hardly hit, what implied a credit restriction and a lag on public sector payment (Mendizabal Zubeldia, Lertxundi Lertxundi, & Garmendia Ibáñez, 2011). That is why all kind of companies in Spain were forced to stop their business and to reduce their personnel.

Facing this credit restriction, SMEs in Spain tend to increase the relative weight of commercial credit in contract to banking credit (Fischer, 2005). To sum up, commercial credit is the natural substitutive for banking credit when the latter is restricted, being higher the cost of the former when not using discounts for prompt payment discount. Here is where Islamic Finance methods can offer Spanish SMEs a new method for external source for finance.

2 Islamic Finance

The Islamic world has lived a great development during the second half of the twentieth century. The discovery of vast oil reservoirs in Middle East together with the huge demand of petroleum from the Western countries, enhance the rapid growth of countries such as Qatar, United Arab Emirates, Saudi Arabia, etc. Due to this fact, these countries have millions of dollars per capita. However, crude oil reservoirs will not last forever, and that is why Middle East countries started to invest in other type of industries in order to diversify their economy. Therefore, the rapid growth of the economy, the population growth in Islamic countries, and the restrictions imposed by the Islamic culture on economic and social aspects of life, encouraged to create what is known as Islamic Finance.

Islamic Finance is based on the Sharia, the law the Islamic world is ruled by. This fact is the one that makes this industry quite different to Western Traditional Banking. The objectives and the activity is basically the same in both industries, but in the Islamic Finance every operation must follow the Sharia. There are five main differences that Sharia introduces to Islamic Banking (Beck, Demirgüç-Kunt, & Merrouche, 2013):

- The investment purposes must not be related to gambling, alcohol, porn, sale of pork or weaponry.
- The assets exchanged in the contract must be tangible.
- Speculation and uncertainty are not allowed.
- The contracts must not be charged with interests, or riba in Arab.
- The operations must be based on risk sharing.

Interest is the basic tool for western banking industry. However, Islamic Banking does not allow using interest as it is considered to be unethical. It is seen as an unjustified capital growth, avoiding any effort to earn that money. Apart from those facts, there cannot be a fixed return for the lender coming from the operations, which is the reason why the risks are shared. The returns come from the profits that the wealth growth created by the operation gives (Castro, 2013).

3 Main Islamic Financial Products

In Order to give the reader a general view of how products look like in Islamic Finance, this part of this paper deals with the main products that any customer can find in the market. The first type of products is the ones that give a fixed income to the banks (Castro, 2013).

- *Sukuk*: This product is the so called Islamic bond. This term means participation certificate. They are rather liquid bonds. *Sukuk* generally cannot be tradable in secondary markets, although if they are, liquidity level is increased. At the expiry date, the seller pays a donation, or *hiba*, that represents a nearly fixed productivity of the *sukuk*, and buys again the asset. However, the *sukuk* cannot represent debt, as it is forbidden to trade with debt, so they have to represent a property of an asset, thereby, connecting *sukuk* value to the underlying asset value.

- *Ijara*: In this product the bank leases an asset to the customer. This contract fixes a rent and a period for the leasing operation. All the costs associated to the use of the asset are responsibility of the client. When this contract comes to an end, there is a possibility for the customer of purchasing the asset. This must be done on a separate contract. When the asset is shared by different banks or investors, the rentals are shared according to the percentage of property of each owner.

- *Murabaha*: This is the form that Islamic banking uses to credit asset buying operations of their customers. Under this kind of contracts, the bank buys the asset the customer needs. The customer is given a price with a surplus, according to the profit that the bank estimates as fair. Once the contract is signed, the bank delivers the asset to the customer, who pays in a fixed period of time by instalments. All the income from the penalties given in deferred payment of the instalments by the customer must be spent on charity, according to sharia.

- *Salam*: This contract is used to finance activities related to commodities. The bank buys the commodity in advanced to the producer, whoobtains liquidity in order to produce the goods. Then, when production is finished goods are sold to the bank at pre-fixed price. As a regular practice, the bank usually enter into a parallel Salam contract in which another party buys the assets.

- *Istisna*: Similar to Salam. One difference is about the asset underlying the contract. These assets are manufacturing goods. The second difference is that the payment can be in advanced or in a future moment. This type of contract is used for building houses, plants, projects or public infrastructure.

Apart from the previous, there are two other widely used products which do not guarantee any income to the financial institution.

- *Musharaka*: This kind of product works as a joint enterprise. The customer and the bank enter in this contract where they prefix a share of the profits earned, while the losses are shared according to the capital contribution of each party. This capital can be either cash or assets, and the financial institution can help with its expertise on the sector by giving managing advice.

- *Mudaraba*: Similar to *Musharaka* but in this case the losses are only supported by the capital provider. This product is very useful for high skilled people with a weak economic situation, where capital provider has no managing rights over the business.

4 Opportunities and Challenges for Spain and Islamic Finance

As already seen in the second part of this paper, one of the main problems for the development of SMEs in Spain is the access to external financing sources. Thereby, in order to fill this gap, one of the solutions is to seek for finance from other countries where liquidity can be found easily. In table 1 there is a brief summary in which one of the main indicators for excess of liquidity is shown, the current account balance, BoP. As it can be observed in the table, Islamic economies are the ones that reached the best positon according to their BoP. The main countries in this group are Saudi Arabia, Kuwait, Qatar, Iraq, Libya, Malaysia and Algeria. These countries account for almost the 28% of the positive BoP of the whole world, making them one of the main possible sources for financing.

Table 1
Positive current account balance (BoP, current US$).
Source: IMF.

Country or Zone	Millions of US Dollars
Main Islamic Economies	403,645.76
Germany	240,743.21
China	193,139.15
The Netherlands	72,732.98
Norway	72,609.01
Russian Federation	72,015.71
Japan	60,859.46
Switzerland	53,913.74
Singapore	51,437.24
South Korea	43,335.10
Others	181,940.88
Total	1,446,372.25

Following this reason, European countries like the United Kingdom, The Netherlands, France, Luxembourg or Germany have applied different measures in order to attract Islamic investment. The UK was one of the first countries to introduce fiscal and legal reforms in order to diminish natural walls against Islamic finance. In fact, the UK is the ninth country in the world according to the amount of assets. In France, in 2010 under the sign of Christine Lagarde as Minister of Economy and Finance, some regulatory changes took place in order to develop different Islamic products such as *murahabah, sukuk or ijara*.

Thereby, Spain should adapt their fiscal structure to let Islamic financial products to be competitive enough. Indirect taxes like VAT or tax on patrimony transfer should be modified in order to avoid the penalty it implies to Islamic products. Furthermore, direct taxes on *sukuk* revenues should be equal to the taxes for revenues from fixed-income products like traditional bonds, as well as recognizing *sukuk* as debt for companies in order to be deductible facing the corporation taxes (Kessler Rodríguez, 2012).

Apart from this, the reputation of traditional banks in Spain has decreased due to different situations in which some managers abused of their positions or there was a lack of ethical business operations (Hedgecoe, 2014). There are several theories establishing that reputation, especially on banks, has a great influence on situations where a customer has to decide whether to sign a contract with a bank or a different financial institution (de Obesso Grivalvo, San Martín Gutiérrez, & Jiménez Torres, 2012). The strict principles that rules financial contracts on Islamic Financial Systems make this new financing source in Spain a strong possibility for gaining an important market share.

What is more, several non-Muslim like the UK decided to enter in the sukuk market. Other governments like Hong Kong, South Africa and Luxembourg did the same, in order to fed the bond-hungry situation of Islamic investors who were looking for products where they could find a good return. For example, the UK sold ₤200m sukuk when investors demanded ₤2bn, and Luxembourg's 60% of its €200m sukuks went to Middle East investors (Wigglesworth, 2014). Seeing this investment-appetite from Islamic investors, governments set a benchmark for other companies to enter the sukuk market. Therefore, this could be a new approach for Spanish government and SME's to get liquidity in a different way.

Finally, products like *musharaka* and *mudaraba* can allow SMEs to solve their funding problems, especially to those at the very beginning of their life. The key advantages of venture capital in business development are (Nisar, 2010):

1. It is more attractive for companies in their early stage, too small to raise funds in public markets or from conventional banks;

2. Technology advancement;

3. Increase in job creation and innovation, like some years ago did Google, Amazon, Apple and Intel among many others.

The Islamic commercial principles, that is profit and loss sharing, prohibition of interest-baring loans and transactions, and avoidance of speculative transactions, will enhance equity financing rather than debt-based financing (Hj. Nawawi, 2009). In order to regulate venture capital financing for SMEs the *Guidelines and Best Practises on Islamic Venture Capital* of the Securities Commission Malaysia would serve as a good model (Oseni, Hassan, & Matri, 2013).

6 Conclusions

Giving the actual environment in which financing sources are difficult to achieve by SMEs and big corporations, both from banks and in the markets, the Islamic Finance Systems offer a new alternative for raising funds.

In order to introduce Islamic Finance in Spain, a first approach would be to enter into a niche market at this time. Previous experience shows that if focused on a niche market, like SMEs could be in this country, the yield is higher than a full-scale introduction for an alternative financing system (Salavou & Avlonitis, 2008).

Countries like the UK, Germany and France, due to the high number of immigrants from Islamic countries, have taken the lead in reforming their fiscal and legal systems. However, only the UK has made a real difference. Thereby, Spain has a great opportunity to make a difference in the Euro-Zone, apart from the fact that Spain has an important influence from the Arab culture, it has a numerous population of Muslim people, especially in places like Ceuta and Melilla.

Anyway, reforms in both fiscal and legal systems are the further steps to be taken in order to make Islamic Finance attractive by eliminating double taxation situations. Transparency and accountability, added up to fairness should guide the development of Islamic financial products in Spain, something that already underlies in Spanish legal and fiscal systems. In fact in the last months some important events related to Islamic Finance have taken place in Spain, due to the great interest that has aroused in entrepreneurs, like the International Halal Congress in the city of Cordoba. In this Congress, José María Fuentes, Investment Director of Kernel Investment Group in the USA said that "Because of our strategic location, good relationship with Arab countries and our tradition, Spain has to become the hub for Islamic Finance in Latin America (…) and Mediterranean countries, (Abascal, 2015). Also in this conference, Ángel José del Río, Aresbank Commercial Division, highlighted that his bank did not offered Islamic products in Spain because its legal framework did not allow financial entities to do it.

7 References

Abascal D (2015) Yo, PYME española, no me puedo permitir un impago. In: Atalayar. Available via DIALOG. http://www.atalayar.com/content/%E2%80%9Cyo-pyme-espa%C3%B1ola-no-me-puedo-permitir-un-impago%E2%80%9D. Cited 28 Apr 2015.

Beck T, Demirgüç-Kunt A , Merrouche O (2013) Islamic vs. conventional banking: Business model, efficiency and stability. Journal of Banking & Finance, Issue 37, pp. 433-447.

Castro C (2013) Islamic Banking. Procesos de Mercado: Revista Europea de Economía Política, X(1), pp. 275-287.

de Obesso Grivalvo AM, San Martín Gutiérrez S, Jiménez Torres NH (2012) El papel de la reputación, el boca-oreja, la confianza y la incertidumbre en la contratación de un banco. Investigaciones Europeas de Dirección y Economía de la Empresa, Issue 18, pp. 190-199.

Fischer KH (2005) Acquisition of Information in Loan Markets and Bank Market Power: An Impirical Investigation. Chicago, Federal Reserve Bank of Chicago.

Hedgecoe G. (2014) Distrust and anger at Spain's bungling banks. In: AlJazeera. Available via DIALOG. http://www.aljazeera.com/indepth/features/2014/05/distrust-anger-at-spain-bungling-banks-201452014312125946.html. Cited 30 Dec 2014.

Hj. Nawawi R (2009) Islamic Law on Commercial Transactions, Kuala Lumpur: CERT Publications Sdn. Bhd..

Kessler Rodríguez A (2012) Finanzas Islámicas: Una Oportunidad para España. Boletín Económico de ICE, Issue 3022, pp. 25-34.

Larrán M, García-Borbolla A , Giner Y (2008) Empresa Familiar y Racionamiento de Crédito. Revista Internacional de la Pequeña y Mediana Empresa, Issue 1, pp. 15-39.

Lehmann E, Neuberger D (2001) Do Lending Relationships Matter?: Evidence from Bank Survey Data in Germany. Journal of Economic Behavior & Organization, 45(4), pp. 339-359.

Mendizabal Zubeldia A, Lertxundi Lertxundi A, Garmendia Ibáñez J (2011) Análisis del Impacto de la Crisis sobre el Racionamiento de Crédito de las Pyme en España. Anales de Estudios Económicos y Empresariales, Volumen XXI, pp. 59-73.

Montoriol J (2006) Relationship Lending and Small Business Finance: Empirical Analysis of Cost of Capital, Credit Rationing, and Firm Performance, Barcelona: Universitat Pompeu Fabra.

Nisar K (2010) The Role of Venture Capital Model in an Islamic Economic System. Islamic Finance News, VII(23), p. 12.

Oseni UA Hassan MK , Matri D (2013) An Islamic Finance Model for The Small and Medium-Sized Enterprises in France. Journal of King Abdulaziz University: Islamic Economics, XXVI(2), pp. 153-180.

Salavou H , Avlonitis G (2008) Product Innovativeness and Performance: a Focus on SMEs. Management Decision, XXXXVI(7), pp. 969-985.

Shiyab S (2014) Sukuk - An alternative funding method for the SME sector?. In: Islamic Finance Info. Available via DIALOG. http://www.islamicfinanceinfo.co.uk/uk-leads-the-way/sukuk-an-alternative-funding-method-for-the-sme-sector. Cited 28 Apr 2015

Wagenvoort R (2003) Are Finance Constraints Hindering the Growth of SMEs in Europe?. EIB Papers, Issue 8, pp. 22-50.

Wigglesworth R (2014) Non-Muslims tap sukuk market. Financial Times, 13 October.

Integrated Framework for Sustainability Management in Project Environment

Ozmehmet Tasan S.[1]

Abstract: Proactively or reactively, companies are looking for ways to integrate ideas of sustainability in their marketing, corporate communications, annual reports and in their actions. Since projects are often implemented as a means of achieving an organization's strategic plan, executives are imposing the usage of sustainability concept in projects. Unfortunately, there is little consensus on exactly what do to respond to these demands that project managers take action. Specifically, this study focuses on to fill this research gap on how to integrate sustainability and what concepts of sustainability to include in Project Management approaches as well as the knowledge areas of PMBOK. In the proposed integrated approach, a new knowledge area "Project Sustainability Management" is proposed. This study, which includes a preliminary proposal, will be most helpful to practitioners and researchers while managing a project by developing a structured guided framework.

Keywords: Project Management; Sustainability; Integration; PMBOK.

1 Introduction

It is widely accepted that projects has an essential influence in increasing competitive advantages of firms. Since projects are undertaken at all levels of the organization, they are often used to complement and achieve an organizational strategic plan. Consumption the natural resources and creating pollution are the main environmental problem caused by project activities. Additionally, project managers have been faced with increasing costs and creating adding value for customers. Moreover, these conditions bring the need to change the conventional cost orientation paradigms to competition adding value while project managers are trying to effectively apply project management (PM) approaches and tools. Along environmental concerns, competitive market conditions and firm's strategic goals, using the resources efficiently has always been the core issue for projects. Under these circumstances, the interest to manage the projects in a sustainable way has ever increased. Sustainability can simply be defined as meeting the needs of the present without compromising the ability of future generations to meet their own needs. With this widespread acceptance, sustainability became one of the most important challenges of our time.

Today, a strategy focusing on solely on shareholder value has not been enough for company survival. Hence, the pressure on companies to broaden their reporting and accountability from economic performance for shareholders, to sustainability performance for all stakeholders has increased which resulted extending their organizational strategic plan to include sustainability. Results of the about corporate sustainability survey conducted by Boston Consulting Group & MIT Sloan Management Review in 2010 showed that almost 60% of companies said that their investments increased as a result of sustainability spending (Ramirez, 2012).

Since, projects are often implemented as a means of achieving an organization's strategic plans, the companies' executives specifically acquires the attention of project managers to integrate this concept into projects. Doing sustainability projects is not enough; there is a need to integrate sustainability in PM. Today, there is an increasing awareness of sustainability issues within projects. Unfortunately, the sustainability issues were only handled conceptually, since there is no standard direction or no recipe for integration sustainability into PM.

1 **Seren Ozmehmet Tasan** (seren.ozmehmet@deu.edu.tr)
Dept. of Industrial Engineering. Dokuz Eylul University. Izmir, 35160, TURKEY.

Today, for PM mostly used and accepted facto standards are USA based Project Management Institute's Guide to Project Management Book of Knowledge (PMBOK) 5th edition and UK based Projects IN Controlled Environments (PRINCE2). Neither PMBOK 5th ed. nor PRINCE2 integrated sustainability related issues in their approaches. Specifically, this study focuses on to fill this re-search gap on how to integrate sustainability and what concepts of sustainability to include into the knowledge areas of PMBOK. In the proposed integrated approach, a new knowledge area "Project Sustainability Management" is proposed. This study will be most helpful to practitioners and researchers developing a structured guided framework.

The structure of the study is as follows: section two provides better understanding regarding the terms sustainability. Section three includes the information about PM, its standards regarding to PMBOK 5th edition and investigates the understanding of sustainability in PM and PMBOK. Section four contains the proposed integrated framework for sustainability management for projects and discussions about various integration concepts. Finally, the findings are discussed and concluded in section five.

2 Sustainability

The concept of sustainability and sustainable development was first mentioned in the report of World Commission on Environment and Development (WCED) (UN, 1983). The fundamental objective of sustainability is to sustain human life and keep planet in a way that every generation can live. The concept of sustainability and sustainable development has evolved considerably since first arising during the 1980s. Sustainability is frequently conceptualized as consisting of three typical distinct dimensions; i.e environment, society and economy, which are often called triple-P-pillars of sustainability; profit, people and planet. The relationship between these aspects can be shown graphically by using different conceptual representations. In this study, we are going to use a holistic approach to address sustainability concept (see Figure 1) (Lozano, 2008).

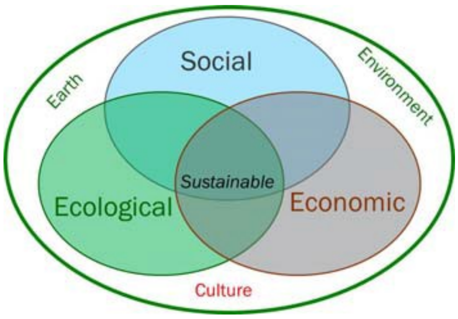


Fig.1
Pillars of sustainability: Holistic Overlapping Triple-P.

The connection between sustainability and projects was already established by the World Commission on Environment and Development (1987). However, two decades later that the standards for project management "fail to seriously address the sustainability agenda" (Eid, 2009). Association for Project Management (past) chairman Tom Taylor recognizes that "the planet earth is in a perilous position with a range of fundamental sustainability threats" and "Project and Programme Managers are significantly placed to make contributions to Sustainable Management practices". Later in 2008, Project Management Association (IPMA)'s Vice-President Mary McKinlay stated in the opening keynote speech that "the further development of the project management profession requires project managers to take responsibility for sustainability". Her plea summarized the development of project management as a profession as she foresees it.

3 Project Management, PMBOK and Sustainability

The Project Management Institute's Body of Knowledge – PMBOK – is perhaps the most widely acknowledged and popular project management standard in existence. Presently in its fifth version (2013), PMBOK contains the ten areas of knowledge and five process groups which find application over the project life-cycle (see Figure 2). The PMBOK Guide defines the important aspects of each Knowledge Area and how it integrates with the five Process Groups. A Knowledge Area represents a complete set of concepts, terms, and activities that make up a professional field, project management field, or area of specialization. There are a total of 47 project management processes identified in PMBOK (PMBOK, 2013).

Fig.2
The structure of PMBOK 5th ed.

Hence, Guide to PMBOK is one of the most widely used standards in PM, there have been no usage of sustainability concepts in the guide. The present 5th edition of the guide only mentions sustainability briefly in three places but it does not define sustainability concepts nor does it provide tools or techniques to focus on sustainability issues. The following two mentions were generally given as background information.

In section 1.4 Relationships among Portfolio Management, Program Management, Project Management, and Organizational Project Management

- …Organizational Project Management is a strategy execution framework utilizing project, program, and portfolio management as well as organizational enabling practices to consistently and predictably deliver organizational strategy producing better performance, better results, and a *sustainable competitive advantage.*

In section 1.5 Relationship between Project Management, Operations Management, and Organizational Strategy: 1.5.2.2 The Link between Project Management and Organizational Governance

- …e.g., if an organization has adopted policies in support of *sustainability practices* and the project involves construction of a new office building, the project manager should be aware of *sustainability* requirements related to building construction.

The following mention was given in Integration Management knowledge area.
In section 4.2 Develop Project Management Plan: 4.2.1.3 Enterprise Environmental Factors

- The enterprise environmental factors that can influence the Develop Project Management Plan process include, but are not limited to:
  Organizational structure, culture, management practices, and *sustainability*;

3 Integrated Framework for Project Sustainability Management

In the current project management methodologies, the management of projects is dominated by the 'triple-constraint' variables time, cost and quality. And although the success of projects is most often defined in a more holistic perspective, this broader set of criteria doesn't reflect in the way projects are managed. The triple-constraint clearly puts emphasis on the profit 'P'. The social and environmental aspects may be included as aspects of the quality of the result, but they are bound to get less attention. Additionally, the life cycle of whatever result the project realizes and also the life cycle of the resources used in realizing the result. Integrating the concept of sustainability in project management therefore stretches the 'systems boundaries' of project management (Silvius & Schipper, 2010).

In this study, to deal with this issue, an integrated approach is proposed. The foundations of this approach are illustrated in Figure 4.

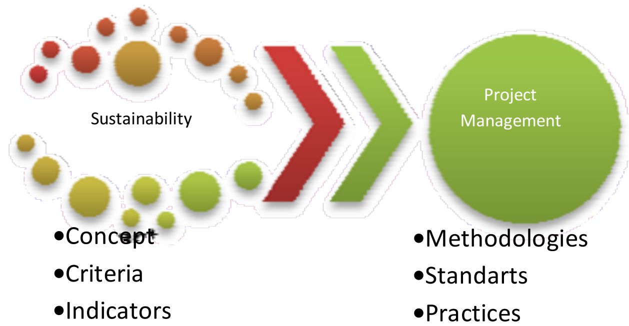


Fig.2
Integration Framework.

The primary idea behind this project is to reflect sustainability in methodologies, standards and practices during PM. Specifically; one can easily stretch PM boundaries to meet sustainable implementations. This framework can be easily applied to several PM approaches and restructured to meet the specific needs of various projects.

This framework integrates the sustainability within process groups and knowledge areas of PMBOK. Currently, there are 10 knowledge areas. With this integrated framework, a new knowledge area "Project Sustainability Management (PSM)" is formed. This new knowledge area is somewhat has similar characteristics as integration management knowledge area, which has strong relationships with other 9 knowledge areas.

In the PSM knowledge area, the procedures for achieving/maintaining sustainability is defined, the methodologies and standards for maintaining sustainability are included. The sustainability indicators are should be used during Monitoring & Control process group. Relevant sustainability indicators should be selected according to the specific needs of a project

In this study, PMS is defined as follows;

Project Sustainability Management includes the processes needed to identify, define, combine, unify and coordinate the sustainability concepts in the project process groups. Integration of sustainability is crucial for project completion, meeting stakeholder expectations and needs, making choices where to concentrate resources over time, dealing with issues and coordinating project activities.

In this study, five processes proposed for PSM are Define Sustainability, Plan Sustainability Management, Create a Sustainability Assessment Plan, Manage Sustainability, and Monitor & Control Sustainability.

Define Sustainability concepts during the Initiating process group:

This process in essential in Initiating process group and should be performed before "developing project charter" in Integration Management knowledge area. In this process, sustainability concepts should be defined together with minimum sustainability standards.

Plan Sustainability Management during the Planning process group:

This process defines how to conduct sustainability management activities for a project and ensures that all projects are screened and approved using minimum sustainability standards; with higher sustainability targets negotiated whenever possible

Create a Sustainability Assessment Plan during the Planning process group:

This process includes the selection of the appropriate sustainability indicators together with sustainability assessment methods. Sustainability assessment can be defined as self-assessment for an organization in the direction of their economic, social and environmental responsibilities.

Since there are numbers of sustainability assessment tools exists and many of them have developed in order to present better applications and case study experiences, it is also necessary to provide a categorization of sustainability assessment tools to develop the broader understanding and wider interpretation of sustainability (Ness, Urbel-Piirsalu, Anderberg & Olsson, 2007). Based on the temporal focus of the assessment tools along with the object of focus of the tool, Ness et al. (2007) proposed a framework shows the temporal focus, which is either retrospective (indicators/indices), prospective (integrated assessment) or both (product-related assessment). The object of focus of the tools is either spatial, referring to a proposed change in policy (indicators/indices and integrated assessment), or at the product level (product-related assessment).

Sustainable is abstract concept for many researchers but it is quantified in many studies to be workable by determining indicators. United Nations (UN) defined indicators for sustainable development considering sociological field of development problems as well as the physical problems (United Nations, 2007). United Nations Commission on Sustainable Development (UNCSD) grouped indicators according to the four pillars of sustainable development; social, economic, environmental and institutional considering 44 sub-themes related to fields such as poverty, governance, health, education, demographics, natural hazards, atmosphere, land, oceans, seas and coasts, freshwater, biodiversity, economic development, global economic partnership, consumption, and production patterns. According to the concept of the project, relevant sustainability indicators should be selected. For example, if the project is related to manufacturing sustainability indicators related to manufacturing should be selected. Sustainability indicators for manufacturing are evaluated in three differently named groups such as product, process and management (Raizer-Neto et al., 2006), or social, environmental and economic (Krajnc & Glavic, 2003).

Manage Sustainability is performed during the Executing process group:

This process makes sure that the other processes in Executing process group perform according to the sustainability concepts that are defined.

During this process, the indicators chosen in the previous process are used. Additionally, some composite indicators can be employed multiplying indicator values. Aside composite indicators, one can use linkage indicators where two pillars of sustainability are linked together in an indicator such as labor productivity, where social and economic pillars are treated together.

Monitor & Control Sustainability is performed during the Monitoring & Controlling process group:

This process monitors and controls sustainability throughout the entire project lifecycle to ensure the sustainability goals of the project stakeholders are met. Aside controlling and monitoring the sustainability indicators, one can also use sustainability control lists. In 2010, IPMA has generated a control list for economic, social and environmental aspects of PM.

4 Conclusion and Discussions

The concept of sustainability has grown in recognition and importance in PM research area. Unfortunately, there is little consensus on exactly what do to respond to these demands that project managers take action. Since doing sustainability projects is not enough, this study meets the urgent need to integrate sustainability in PM by developing a structured framework for integration. Besides, this framework can be easily applied to several PM approaches and restructured to meet the specific needs of various projects. The proposed integrated framework is a generic one which needs to be structured around the specific needs of a project. So if the project includes manufacturing activities, the sustainability indicators related to manufacturing should be used.

Also, the reader must bear in mind that PMBOK limits decision making solely to project managers, making it difficult for handing over aspects of the management to other parties and senior managers. With PMBOK, the project manager can seemingly become the primary decision maker, planner, problem solver, human resource manager and so on. So the decision about sustainability solely relies on project managers. Another issue need to be discussed is that the costs need to dealing with sustainability issues. Organizations often see these costs as being incremental to business costs. Though, they often doesn't acknowledge of their benefits in long terms.

Aside ideas from above discussions, possible future research works include the implementation of this integration idea into other PM facto standards such as PRINCE2 and Agile and risk-sustainability composite concept. Since risks and sustainability are inseparable, these composite concepts should be further investigated.

5 References

Eid R (2009) Factors affecting success of world class manufacturing implementation in less de- veloped countries. J Manuf Technol Manag 20:989–1008

Krajnc, D., & Glavic, P. (2003). Indicators of Sustainable Production. Clean Techn Env Pol, 5, 279-288.

Lozano, R. (2008) Envisioning sustainability three-dimensionally. J of Cleaner Prod, 16(17): 1838-1849.

Ness, B., Urbel-Piirsalu, E., Anderberg, S., & Olsson, L. (2007). Categorising tools for sustainability assessment. Ecological Eco, 60, 498-508.

PMBOK (2013), Project Management Institute: PMBOK® Guide - Fifth Edition, Project Management Institute.

PRINCE2 (2009).Directing Successful Projects with PRINCE2 & Managing Successful Projects with PRINCE2, TSO, Office of Government Commerce.

Raizer-Neto, E., Mariotte, M. T., & Hinz, R. T. P. (2006). Indicators to measure sustainability of an industrial manufacturing. Innov in Life Cycle Eng and Sust Dev, 18, 111-122.

Ramirez, G. A. (2012). Sustainable development: paradoxes, misunderstandings and learning organizations The Learning Org: An Int J, 19(1): 58-76.

United Nations. (December 19, 1983). Report of the World Commission on Environment and Development: Process of preparation of the environmental perspective to the year 2000 and beyond / General Assembly Resolution 38/161.

United Nations. (1987). Report of the World Commission on Environment and Development: Our common future.

United Nations (2007). Indicators of sustainable development: Guidelines and methodologies (3th ed.). New York: UN Publication

Silvius AJG, Schipper R (2010) A maturity model for integrating sustainability in projects and project management, 24th World Congress of the IPMA, Istanbul-Turkey.

Using cost-volume-profit to analyse the viability of implementing a new Distribution Center

Etges APBS[1], Calegari R[2], Cortimiglia MN[3], Rhoden MIS[4]

Abstract: Firms are constantly improving their activities in order to become more competitive. With the diffusion of international competition and easier access to global markets, effective logistic and inventory management strategies become essential to all players. In this sense, there is a clear tradeoff between inventory costs and service level. A common strategy to address this issue is to locate distribution centers (DC) near key markets. However, the decision to build new DCs must be supported by clear and convincing analysis. In this context, this paper reports the use of cost-volume-profit analysis to assess the viability of establishing a new DC by a real company that manufactures radiopharmaceutical products. The researchers collected and analysed detailed financial information from the company and compared the current scenario with potential future scenarios using the cost-volume-profit technique. Next, expected firm profitability is compared for two scenarios: with and without the new DC.

Keywords: Cost-volume-profit; decision making; logistic costs; radiopharmeceutical distribution.

1 Introduction

The main objective of the logisitic function is to provide a firm's customers with the right product, at the right place and right time, according to pre-determined conditions (Ballou, 1999). In this context, a few key logistic activities are considered strategic, especially in a country of continental dimensions like Brazil. For instance, it is essential that logistic activities such as transportation and inventory management operate with efficiency so that product delivery is not hindered (Fernandes et al., 2011).

However, given the complexity inerent to the logistic processes, it is difficult to estimate optimal transportation and warehousing costs (Engblom et al., 2012). According to Yoshizaki (2002), the higher the availability of material (which results in a higher service level), the higher the inventory carrying costs. On the other hand, increased availability reduces opportunity costs related to sales lost because of stockout. The same author posits that as the number of warehouses increases, service level improves and delivery costs decrease, but at the expense of increased (fixed) warehousing costs. Thus, a complex tradeoff in distribution management is evident. A common approach to address this tradeoff is to build distribution centers (DC) close to key markets in order to improve the service level perceived by the customer, reduce lead time and logistic costs, increase market share, and, eventually, facilitate entry in new markets and achieve higher competitiveness levels (Hill, 2003).

However, even if the variable part logistic costs are reduced with this strategy, it is important to analyse the remaining cost components (Waller and Fawcett, 2012), given that a company must aspire to reduce the total logistic cost, and not only local costs (Stock and Lambert, 2001). Waller and Fawcett (2012) explored the complexity that charcterizes the decision to build a new distribution center and concluded that distribution costs are not usually known *a priori*, even if cost modelling techniques are used, since models can be affected by numerous endogenous and uncertain variables, many of which are not static.

1 **Ana Paula Beck da Silva Etges** (anaetges@produca.ufrgs.br)
2 **Rafael Calegari** (Rafael.calegari@gmail.com)
3 **Marcelo Nogueira Cortimiglia** (cortimiglia@producao.ufrgs.br)
Dpto. De Engenharia de Produção. Escuela de Engenharia.
Universidade Federal do Rio Grande do Sul. Porto Alegre, Av. Osvaldo Aranha, 99, Brasil.
4 **Marisa Ignez dos Santos Rhoden** (marisa.rhoden@ufrgs.br)
Escola de Administração. Universidade Federal do Rio Grande do Sul.
Porto Alegre, Av. Washinton Luís, 855.

Among the techniques used to analyse production objectives that enable cost recovery and the onset of profitability, the cost-volume-profit (CVP) method stands out. CVP analysis is already established in comparative studies of a firm's relationship with the external environment (Ravichandran, 1993). To Horngren et al. (2000), CVP analysis provides a comprehensive financial picture of a given scenario and helps to estimate how revenues, costs, and profits behave as business activities, product prices or fixed commercialization costs change. Among the benefits associated with CPV, Moraes and Wernke (2006) cite the support to decision-making about which specific items should be offered for sale and if any productive segment should be abandoned during the evaluation of alternative scenarios of promotions and price reductions. CVP analysis also allows a better understanding of safety margins, which consist in excess sales above the point of equilibrium (Bornia, 2010). Consequently, it is possible to estimate how much the sales can decrease without real harm to the firm's long term financial viability.

In this context, this paper reports the use of cost-volume-profit analysis to assess the viability of building a new DC by a Brazilian company that manufactures radiopharmaceutical products. The firm operates in the city of Porto Alegre and evaluated the opportunity to establish a DC in São Paulo. Initially, the researchers collected financial data to support a CVP analysis that determined the minimum sales level required to support the new DC. Thus, it was possible to estimate the financial effects of establishing the new DC, enriching firm managers' decision-making.

2 Sustainability

In order to achieve the research objective, which requires a detailed investigation of a single setting, a case study research strategy was employed. The research is applied, since it aims to generate useful solutions for all involved. Besides, a hands-on, easy-to-use methodological approach was chosen, which can be easily transferred to practitioners at the company studied.

In order to investigate the viability of establishing a new DC, a three-step empirical study involving financial analysis tools was conducted. During the study, the researchers maintained constant contact with the studied company. This facilitated data collection and validation of every single step in the analysis and provided the firm with instant feedback.

The first step in the empirical research involved a comprehensive analysis of the firm structure, strategy and operations. It also involved the understanding of the peculiarities of the market where the firm operates, with special attention dedicated to transportation activities. This was done through a series of interviews with top and middle-level managers responsible for the following areas: quality control, R&D, warehousing, accounting and auditing, procurement, financial planning and strategic management. The semi-structured interviews took place during two days; on average, the interviews were 45 minutes long.

The second step in the empirical research was the collection and analysis of financial data, sales forecasting, past sales data by geographical region, and regulatory compliance data. This data was collected partially during the aforementioned interviews, but also through analysis of firms' documents and records. This data substantiated the financial analysis using the CVP technique that defined the minimum sales level for each product that would justify, from a financial point of view, the establishment of the new DC in São Paulo.

Given the financial criteria obtained in step two, the third step in the empirical research involved the decision-making, by the firm top management, supported by the analysis of the possible effects of a new DC. Finally, the results were compilled and presented to the firm managers.

3 Results and Discussion

3.1 Case description

The firm investigated is ten years old and is member of a university technology park, where the management offices and production line are located. The firm also has a commercial office in São Paulo, which is responsible for approximately 25% of the total sales revenues. It manufactures and distributes radiopharmaceutical products, a high-value supply for medical imaging diagnosis systems such as PET scans. The firm has two main business lines: products and services. Most revenues come from products: the firm has a portfolio of nine products, but 73% of the overall revenues come from a single product. The very specific nature of the firms' products require significant R&D, production, distribution, and sales capabilities.

It must be noted that the Brazilian radiopharmaceutical industry is very peculiar, especially because it is characterized by a very low number of participants. In fact, the studied company is the only private firm that operates in the Brazilian market. Moreover, radioactive tracers are subjected to strict regulatory oversight and constant monitoring by the Federal agency that deals with drugs and medications.

It is also important to highlight the studied firm's declared innovation-oriented strategy, which translates to substantial investments in R&D activities, especially in partnership with foreign players. Since its inception, the firm has established a large network of foreign partners such as universities, research institutes, and similar companies operating in international markets. The studied firm is the undisputed leader in the radiopharmaceutical Brazilian market. Thus, it can be noticed that the firm is a strong advocate of internationalization, as most of the firms' products are national versions of products already commercialized in other countries.

3.2 Interviews

Considering this step as the starting point to understand the setting, three researchers spent two whole days embedded in the company. Interviews were conducted with middle and top managers responsible for the following areas: quality control, R&D, warehousing, accounting and auditing, procurement, financial planning and strategic management.

Specifically regarding the R&D team, the researchers investigated the strict regulatory setting that impacts the firm. Among these, a specific financial cost was identified: the firm must keep a trained pharmacist at the new DC to comply with regulatory requirements. Another example of unforeseen costs involves transportation within São Paulo. Instead of vans or cars, the firm has explored the option of hiring motocycle drivers. However, the regulatory agency requires that these professionals must be specifically trained and certified to handle the radiopharmaceutical products; the estimated cost of such training was added to the analysis. It was also pointed out that the DC has to be equipped with refrigeration facilities.

The warehousing team, on the other hand, emphasized the need for a detailed study to design the layout of the potential new DC. The space should be adequate to the product volumes to be handled but should also comply with regulatory guidelines for warehousing health commodities. These include minimum volume and space requirements for staging and storing commodities, special racking systems and material handling equipment, and a certified warehouse management system. Eventually, even interchangeable shipment and receiving staging areas could prove necessary. These requirements were factored in the financial analysis.

Additionally, the financial team provided the researchers with full access to firm's balance sheets, whereby it was possible to structure the CVP analysis. The financial team also explained the current financial management strategy and its operational directives, particularly regarding cost estimation methods and the working definition of fixed and variable costs used by the company.

Finally, the top management was fully available to explain the firm's general strategy and its deployment in short-term operational plans. The top management was able to aggregate valuable qualitative information such as a critical appraisal regarding current and prospective key clients (and their locations), goals for shortening delivery time, company relationship with regulatory agencies, universities, research institutes, competitors and customers, and financial availability for the prospected new DC. The top management team also promptly questioned and validated most of the non-financial premises behind the CVP analysis.

3.3 CVP Analysis

The CVP analysis was conducted in order to estimate the sales volume, for each product, necessary to justify the establishment of a DC in São Paulo, one of the key markets for the company. The premise for a new DC is that it can reduce variable logistic costs, but at the expense of higher fixed logistic costs associated with an expanded physical infrastructure.

The first step in the CVP analysis was to assess how each product contributes to overall revenues and the main customers (along their geographical location) for each product. It was found that the product portfolio contains 9 items, whose sales are distributed as follows: 22% in the Southern region (RSU), 26% in São Paulo (RSP), 23% in the other Southeaster states, that is, MG, RJ and ES (DRSE), and 28% distributed in the remaining regions.

Next, the researchers listed the price of each product and estimated variable costs associated with each product based on past sales from January to November 2014. The average price for each product was calculated for that period and used in the calculations as the product price. Variable costs considered the price of raw materials for each product, the direct labour costs associated with the production of each product, and the estimated logistic cost for each product. The estimation of logistic costs required the calculation of the average sizes of shipped lots: the global expenditures with logistic activities for each product were summed up and, considering the period under analysis, divided by the average number of products shipped per order per region was calculated and rounded up to the next whole number. All partial results were validated with the company. Then, the difference between variable costs required to keep the logistic activites in Porto Alegre only and the estimated variable costs for establishing the new DC in São Paulo were analysed. This difference will impact the Unitary Contribution Margin and the Equilibrium Revenue for products in both regions.

At this point in the analysis, given that the studied firm has a diversified product portfolio and both the share of revenue for each product at each region and Equilibrium Revenue, the Unitary Contribution Ration for the two scenarios was calculated: 0.79 for the current situation and 0.82 for the scenario with the new DC in São Paulo.

The analysis followed with the compilation of current fixed costs and the estimation of the costs associated with the establishment of the necessary physical infrastructure for the new DC. The costs for the current structure were obtained directly from the firms' balance sheets, and amounted to R$ 5,669,044.60. The expense items associated with the new DC were estimated as follows: monthly rental for a medium-sized warehouse with cold and clean storage facilities in different industrial districts in São Paulo, labour costs for a pharmacist and warehouse staff trained to operate health supplies, monthly logistic costs for shipping products from the manufacturing center (in Porto Alegre) to the new DC, one-time construction costs to adapt a common warehouse to handle health supplies in compliance with local regulatory guidelines. The fixed costs for the new DC amounted to R$ 558,045.84 for the same period (January-November), of which R$ 32,000.00 amount to one-time investments, while the rest represent monthly expenses of R$ 50,731,44. Is interesting to note that the current fixed structure in Porto Alegre would remain, and this additional amount to the current fixed cost. Then the total fixed cost for the new DC amounted R$ 6,259,090.44.

From the data calculated to each product in both scenarios, the Equilibrium Point for sales that would enable the São Paulo DC was calculated, as well as the current Equilibrium Point. These results were then compared with past sales from January to November 2014, in order to assess profitability with the DC in Porto Alegre versus the establishment of the new DC. Table 1 shows these results.

Table 1
Profitability analysis using Equilibrium Point.

Profit POA	RSU	RSP	DRSE	DRB	Profit
A	R$ 439.400,94	R$ 752.245,61	R$ 728.474,98	R$ 732.041,97	R$ 2.652.163,50
B	R$ 46.437,53	R$ 21.142,95	R$ 26.632,06	R$ 17.196,37	R$ 111.408,90
C	R$ 7.335,11	R$ 7.272,65	R$ 975,77	-R$ 2.803,69	R$ 12.779,84
D	R$ 11.801,44	R$ 5.124,12	R$ 9.066,98	R$ 5.179,89	R$ 31.172,42
E	R$ 9.646,00	R$ 9.513,91	R$ 4.673,89	R$ 5.563,87	R$ 29.397,68
F	-R$ 3.949,90	R$ 1.101,99	-R$ 4.609,53	-R$ 6.227,95	-R$ 13.685,38
G	R$ 20.055,62	R$ 40.310,42	R$ 26.017,44	R$ 94.504,29	R$ 180.887,78
H	R$ 165.608,28	R$ 42.330,83	R$ 18.566,51	-R$ 1.498,13	R$ 225.007,48
I	R$ 374,91	-R$ 137,98	R$ 249,38	-R$ 1.676,35	-R$ 1.190,05
					R$ 3.227.942,17
Profit SP	**RSU**	**RSP**	**DRSE**	**DRB**	Profit
A	366.808,25	R$ 678.238,08	R$ 658.765,21	650.359,82	2.354.171,36
B	43.565,27	R$ 21.639,78	R$ 26.490,41	19.751,39	111.446,84
C	7.573,08	R$ 9.851,23	R$ 3.980,81	2.128,68	23.533,80
D	11.052,79	R$ 6.671,46	R$ 11.008,04	7.799,74	36.532,04
E	8.891,40	R$ 13.800,81	R$ 5.147,79	8.473,26	36.313,27
F	- 3.445,17	R$ 498,32	-R$ 2.775,42	- 3.666,39	- 9.388,66
G	14.839,01	R$ 36.833,78	R$ 21.561,60	93.414,07	166.648,46
H	160.325,93	R$ 37.728,13	R$ 13.221,77	- 8.620,58	202.655,25
U	495,76	R$ 157,06	-R$ 159,31	- 241,30	252,20
					R$ 2.922.164,56

According to Table 1, the firm's profit is estimated to decrease R$ 305,777.61 with a DC in São Paulo. Evidently, the financial analysis cannot be the sole motivation for top management decision making, but it provides a significant starting point for strategic considerations.

4 Conclusions

Logistic costs usually have a stron impact in a firm's cash flow (Ballou, 1999), without adding value to the products, and are considered one of the key wastes of the lean philosophy (Womack *et al.,* 1992). Thus, managers and decision makers should pay close attention to the elements that influence, either positively or negatively, these costs, as they can be a significant source of variation of the firm's profitability. Besides, depending on the specific industry wher a firm operates, market positioning strategies can be considered key strategic actions that drive the business towards better customer service.

In this context, the present paper reports a viability analysis for the establishment of a new DC for a company operating in the Brazilian radiopharmaceutial industry. The results include the minimum sales volume for each product and each region in order to financially justify opening a DC in a key market. The key result is the difference between the current profits and the estimated profits with the new DC, which can be used as a starting point for strategic decision making. Improved revenues from new customers due to the improved service level were not factored in the financial cost analysis, for instance.

The study also highlighted the importance of using cost analysis techniques, such as the CVP method, to study the financial impacts of logistic decisions. In particular, the case study reported in this paper illustrated how the expansion of logistic infrastructure impacts fixed costs, on the one hand, while provides a better position to reduce variable costs, given the closer proximity with selected customers.

Future research in this area of inquire should consider additional analysis techniques, such multicriteria tools that help researchers to capture qualitative criteria that influence decision making. Thus, financial results could be complemented with other factors that influence firm turnover. Techniques to associate financial values to qualitative assessment scales could also be employed to create a single, easy to understand and shared meaning for all decision makers.

5 References

Ballou RH (1999) Business Logistics Management. 4th ed. Prentice-Hall, Upper Saddle River, NJ.

Boaventura EM (2009) Metodologia da Pesquisa: Monografia; Dissertação; Tese. Atlas, São Paulo.

Bornia AC (2010) Análise gerencial de custos: aplicação em empresas modernas. 3. ed. Atlas, São Paulo

Engblom J, et al. (2012) Multiple-method analysis of logistics costs. International Journal of Production Economics, v. 137, n. 1, p. 29-35. doi:10.1016/j.ijpe.2012.01.007

Fernandes BC, Galamba FH, Tosta LI, Lima RS (2011) Impactos da utilização de centros de distribuição na logística de distribuição de produtos acabados. Journal of Transport Literature, vol. 5, n. 3, pp. 163-181.

Gudehus T, Kotzab H (2009) Comprehensive logistics. Springer, Berlin.

Hill A (2003) - Centros de Distribuição: estratégia para redução de custos e garantia de entrega rápida e eficaz - 4ª Conferência sobre logística colaborativa.

Moraes C, Wernke R (2006) Análise custo/volume/lucro aplicada ao comércio de pescados. Revista Contemporânea de Contabilidade, v. 1, n. 6, p. 81-101.

Ravichandran R (1993) A decision support system for stochastic cost-volume-profit analysis. Decision Support Systems, v. 10, n. 4, p. 379-399. doi:10.1016/0167-9236(93)90069-F

Stock JR, Lambert DM (2001) Strategic Logistics Management. 4th ed. McGraw-Hill Co, New York.

Waller MA, Fawcett S (2012) The total cost concept of logistics: one of many fundamental logistics concepts begging for answers. Journal of Business Logistics. DOI: 10.1111/j.0000-0000.2011.01033.x

Womack JP, Jones DT, Roos D (1992) A máquina que mudou o mundo.Campus, Rio de Janeiro.

Yoshizaki H, Ho L (2009) Collaboration intensity in the Brazilian supermarket retail chain. Supply Chain Management: An International Journal, v.14, IIS.1, pp.11-21. http://dx.doi.org/10.1108/13598540910927269

Analysis and comparison of two bike-sharing systems: characteristics, similarities and sustainable potential of the solutions

Sousa-Zomer TT[1], Cantú VZ[2], Cauchick Miguel PA[3]

Abstract: Product-Service Systems (PSS) represent a business proposition with potential to reorient the current production and consumption patterns towards sustainability. Although PSS became a popular subject, PSS research is still dominated by theoretical work and more empirical investigations are required. This paper aims at analyzing two use-oriented bike-sharing systems with a large sustainable potential in order to contribute to PSS empirical knowledge. Since there are only few contributions in the literature that compare two or more systems like these in different countries, a PSS located in a developed country and other available in an emerging economy were selected to be investigated. A qualitative analysis was carried out considering the contextual conditions of each solution, the PSS elements and the sustainable aspects, based on secondary data. The results confirm that these PSS models can provide environmental, economic and social benefits and represent an innovative approach for sustainable mobility. Aspects related to customer behavior and acceptance in face of PSS solutions are directions for future work.

Keywords: product-service systems, PSS, innovation strategy, bike-sharing systems, sustainability.

1 Introduction

Product-Service Systems (PSS) have been widely discussed as a promising approach to drive the current production and consumption patterns towards sustainability (Ceschin, 2013). A PSS can be defined as an innovation strategy that shifts the business focus from designing and selling physical products to selling a mixed of tangible products and intangible services that can fulfill customers' needs (Tukker, 2004). In addition to the environmental benefits, PSS solutions also lead to social benefits and represent opportunities for emerging contexts with less economic possibilities (Ceschin, 2014).

PSS has become a popular subject and a wide range of research in the PSS and sustainability fields have been developed (Tukker, 2013). However, PSS research is still dominated by theoretical work and more empirical investigations are necessary to contribute to the theory building (Beuren et al., 2013). Empirical investigations are also required to help identify the multiplicity of PSS solutions and their associated strategies and practices (Cook, 2014).

In this sense, this work aims to analyze two PSS solutions that represent an effective alternative for sustainable mobility, since in the move towards sustainable consumption and production patterns mobility is one of the priority areas (Zhang et al., 2014). The solutions consist of two bike-sharing systems within different contextual situations. Specifically, the purpose is to identify convergent aspects, main differences in PSS implementation, and to evaluate sustainable performance of both PSS situations in order to contribute to PSS empirical knowledge. The remainder of this paper is structured as follows. After this introduction, the following section presents a literature review by briefly covering PSS and

1 **Thayla Tavares de Sousa-Zomer** (thayla.ts@gmail.com)
Post-graduate Programme in Production Engineering. UFSC.
2 **Vinícius Zago Cantú** (viniciuszac@gmail.com)
Undergraduate course in Production Engineering.
UFSC Federal University of Santa Catarina. Florianópolis, Santa Catarina, Brazil.
3 **Paulo Augusto Cauchick Miguel** (paulo.cauchick@ufsc.br)
Production and System Engineering Department. UFSC.
Campus Universitário Trindade, Caixa Postal 476, 88040-970 Florianópolis, Santa Catarina, Brazil.

sustainability issues. The third section presents the research design and procedures. The fourth section discusses the main results and, finally, concluding remarks are drawn in addition to some insights for future work.

2 Sustainable product-service systems

PSS strategies have been seen as an excellent vehicle to enhance competitiveness and to foster sustainability simultaneously (Tukker, 2004). However, PSS implementation remains a research gap in the literature (Reim et al., 2014). Although PSS literature is expanding, there is concern that sustainable PSS has still not been widely implemented and diffused, because in many situations they challenge existing consumption and production patterns (Ceschin, 2013).

PSS empirical investigations may contribute to the theory development and to improve new methodologies and operational solutions (Beuren et al., 2013). It is useful, therefore, to investigate more existing cases to help better understand how PSS can be designed in order to facilitate customer acceptance and satisfaction. In fact, PSS empirical studies has been revealing diverse PSS designs and practices, each embedded in their own trajectories and institutional arenas (Cook, 2014) which is very important to theory development. Furthermore, the identification and discussion of empirical examples and tactics in the operational level may provide more information for companies in the transition and implementation processes toward PSS (Reim et al., 2014). Although PSS concept has been discussed over a decade, not much attention has been given to understand how the process of introduction and scaling-up takes place (Ceschin, 2014). To shift towards eco-innovations like PSS, companies should generate sufficient value for customers and fulfill the sustainable requirements at the same time (Chou et al., 2015).

Concerning mobility, a move towards sustainable mobility represents an increase in access to environmentally sustainable transport, especially for communities with a high percentage of low-income households (Zhang et al., 2014). Bike-sharing programs have emerged as an innovative approach in a growing number of cities around the world (Fishman et al., 2014). They can provide many benefits such as flexible mobility, pollution emission reductions, physical activity benefits, reduced congestion and fuel use, individual financial savings and support for multimodal transport connections (Fishman et al., 2015).

These systems can be classified as use-oriented PSS solutions (according to Tukker, 2004). Use-oriented PSS systems can be defined as value propositions where a company offers the access to products that enable customers to get the results they need, without owning the product (Ceschin, 2014). These systems may allow environmental impacts minimization, due to considerably more intensive use or prolonged life of capital goods used in the system (Tukker, 2004).

However, although bike share programs have existed for almost half a century, just in the recent decade the prevalence and popularity of these systems has increased (Fishman et al., 2014). In this sense, due to the popularity and the sustainable potential of these PSS, empirical studies should be performed to investigate the operational practices associated with each business and context, in order to provide insights through PSS implementation and diffusion. Next section presents the research methods adopted to analyze the PSS solutions under study.

3 Research methods

This paper reports on the results of an explorative and qualitative study involving two business to consumer (B2C) PSS solutions, since knowledge and experience regarding PSS business models are still limited (Beuren et al., 2013). Starting from a literature review, two PSS solutions were selected due to its sustainable potential and relevance as an initiative to expand sustainable transport opportunities and for being a business model in expansion in many countries and implemented in many cities throughout the world (Keskin, 2006). In addition, similar to the work performed by Keskin (2006) both situations have been chosen according to their innovativeness in terms of products and services and organizational schemes, from simple to complex, to demonstrate the development and the sustainable potential of bike-sharing systems within contexts rather different. Furthermore, since PSS diffusion is highly dependent of the culture in which it will operate (Ceschin, 2014), it is important to perform more investigations comparing similar solutions available in different contexts.

One of the bike-sharing systems under study is available in Brazil (Mobilicidade, 2014) and the other one is located in France (Vélib', 2014), one of the largest in the world. This kind of business models is promising for both industrialized and emerging contexts (Ceschin, 2014), and therefore both were selected in order to compare the main differences according to each economy reality. Starting from gathered information about both business models, an analysis based on the literature was performed. Data were collected by a combination of techniques such as observations, technical information, and secondary data. Firstly, an overview of both systems and contextual conditions are presented (based on Keskin, 2006) and PSS conceptual elements (product, service, actors' network and infrastructure) are analyzed. Afterward, an analysis of products and services is carried out in order to identify relevant aspects of each situation. Finally, an analysis concerning aspects in the three sustainability dimensions - i.e. environmental, economic, and social - was carried out to compare both PSS sustainable performance. Next section presents the main results.

4 Analysis of the bike-sharing systems: Bike Rio and Vélib'

The first PSS in study is the Bike Rio system available in Rio de Janeiro, Brazil, that has been in operation since 2011. The main objectives of the Bike Rio are to introduce the bicycle as a non-polluting and healthy public transport in order to combat sedentary lifestyles, reduces traffic congestion, environmental pollution, and to promote social responsibility (Mobilicidade, 2014). The system is an initiative of the city hall, and is managed by a private company, selected in a bidding process. It comprises 60 stations and 600 bikes distributed in 10 districts operating daily from 6 am to 12 am. The PSS also has a private bank as a partner.

The system allows the customers to use a bicycle (available at the stations) for a period of 60 minutes and to return it at any other station. The user can rent another bicycle after 15 minutes. To make the registration and the bicycles rental, the customer must have a mobile phone to be used as an interface with the system. Payment is made by credit card. There are two registration options: a daily payment or a monthly plan. The rent for periods up to one hour is included in the registration fee. Other fees are applied when the customer overextend the usage time.

The Vélib' bike-sharing system is available in Paris, France, and has been in operation since 2007. The system has 1,800 stations and around 20,600 bicycles. It represents an alternative and an addition to the urban public transport, both for transportation and for population leisure. The Paris Vélib' is operated and managed by a private company, but it is an initiative of the city hall. The city hall is responsible for infrastructure maintenance and expansion, necessary for the proper system operation. The services provided by the private company include the bicycles and stations availability, equipment maintenance, daily bike redistribution between the stations, and customer service. The system operates 24 hours a day, seven days a week and allows customers to withdraw a bicycle at a station, use it for a period of 30 minutes and return it to any of the 1,800 stations across the city. When the customer uses the bike for an extra time, additional fees are charged. However, the customers can return the bike at any station and rent another in the sequence. The rental plans vary to adapt to different customer profiles and needs. The purchase of short-term tickets can be made at stations, through credit cards. For Paris metropolitan transport users that have a specific card, it is possible to use it in the Vélib' system.

In both systems it is possible to identify products and services developed as part of an integrated system. Different actors such as the city hall, the companies (service providers), the population, and the financing agents represent the actors' network. It worth pointing out that the both systems are dependent on a supporting infrastructure such as stations, public spaces, and bike paths. The main service on both PSS is the provision of bicycles for transportation purposes. Equipment maintenance and customer service also support the system.

Three main products were identified in both systems for comparison: bicycles, stations and support vehicles. Concerning the bicycles, in both systems they are distinct from common bicycles, by the color (Bike Rio) and by the design (Vélib'). Both also carry RFID identification tags. The bikes from Bike Rio are manufactured in aluminum, while in the Vélib' they are manufactured in steel. Regarding the stations, there is a panel for customers and system interaction in the Vélib' system. In the Bike Rio, the customer interface with the system is made by a website and the stations are powered by solar energy. With respect to the support vehicles, they are used for transporting and supplying bicycles among stations.

Concerning the services, the main service (the bicycle provision) is offered all day in the Vélib' system while in the Bike Rio it is available 18 hours a day. Furthermore, the integration with other urban transportation is only possible in the Vélib' system. In both systems the customer pays only for the time the product is actually used, but only credit cards are accepted. Through the analysis of PSS characteristics, some issues related to the PSS sustainable potential have been identified and are presented in next.

4.1 Bike-sharing systems sustainable potential

Both bike-sharing systems are less polluting options than conventional transportation modes, and can provide many sustainable benefits (Table 1). The Bike Rio system is part of a low-carbon development program. This unprecedented program, launched at the Rio + 20 is a partnership between the city of Rio de Janeiro and the World Bank, and is certified by ISO 9001 quality standard. The program aims to accumulate the carbon credits generated in the main city sustainable programs (World Bank, 2012). For the future, the idea is to sell these credits on the international market. Thus, in addition to environmental benefits, the project will provide economic benefits that will be converted into social investments in the city (World Bank, 2012). So far, the system has accumulated 1,760.60 tons of carbon credits (Mobilicidade, 2014).

Table 01
Bike-sharing systems sustainable benefits.

Sustainable aspects	Vélib'	Bike Rio
Pollutants emission reduction	y	y
Fossil fuels consumption reduction	y	y
Maintenance to extend the product life	y	y
Bikes designed to be more durable	y	y
Renewable energy use	n	y
Competition	n	n
Affordable costs to the customer	y	y
Inclusion in the public transport system	y	n
Alignment with the city planning	y	y
Customer use and acceptance	y	y
Health promotion	y	y
Business competitiveness	y	y
Stakeholders gains	y	y

Source: developed by the authors, based on the collected data (y – 'yes'; n – 'no').

In addition, the Bike Rio system uses solar energy to meet the demand required for the system operation, contributing to energy consumption reduction, since solar energy is a clean and a renewable source. Regarding resources use, periodic maintenance allows increasing the bicycle useful life, generating less waste and therefore reducing resources use to manufacture new bicycles. In the Vélib' system, the vehicles for bicycles transport between stations are electric (Hemne et al., 2010), which also contributes to minimizing greenhouse emissions.

In the social dimension, the bike-sharing systems allow customers access from all economic levels and represent a transportation alternative for emerging contexts. In the Vélib' system, there is a reduction fee program to the beneficiaries of free public transport in Paris. It also offers convenience, flexibility and mobility to the population and promotes physical activity and health. The reduction of transport time in major cities is another benefit. Both systems have accessible costs, and in the Vélib' system, which hasmore stations and bicycles the cost to the user is practically the cost of registration, since almost every 300 meters there is a station to pick up and drop off the bike, enabling the user to make a return before 30 minutes. Another benefit that Vélib' system offers is the system's integration with other public transport modes. The Bike Rio allows connection to other transport modes, but is not integrated from the point of view of pass payment and is still restricted to a certain city region. The acceptance of the PSS by customers is positive. In Rio de Janeiro, it has been held 4,890,794 trips so far (Mobilicidade, 2014) and this number grows daily. In the Vélib' system, in a survey performed with 853 customers in 2009, 94% of the system' users were 'satisfied' with the service, and more than 50 million locations had been held since PSS launching (Hemne et al., 2010). As both systems have partnerships with the municipal governments, the two PSS are aligned with the city's planning and have the potential to improve the community environment.

In the economic dimension, PSS allows gains to all stakeholders. The customer has benefits because the price is affordable, smaller than the use of other public transport modes (in Rio Bike the cost to the user is US$ 3.50 monthly, limited to 60 minutes use between pick up a bicycle and drop off it in a station, but with unlimited use). In the Vélib' the cost is around US$ 2.7 per month (29 € per year) for unlimited use, but limited to 30 minutes between bicycle pick up and return it to a station. In the Bike Rio, the sponsor bank and the company have profits from the bicycles renting as well as the publicity. Society in general wins with a complementary system for urban transport and with the benefits of carbon credits. In the Vélib' system the actors earnings are similar. In both systems there is no other companies offering the same type of service, i.e. there is no competition. These PSS models bring sustainable benefits, being seen as sustainable solutions. Finally, next section presents the main conclusive points of this work.

5 Conclusions

Due to the environmental impacts associated with vehicles usage, it is necessary to develop new environmentally-friendly mobility strategies. The bike-sharing systems under study represent a promising initiative to increase sustainable transport supply in urban contexts. They allow achieving many environmental, economic and social benefits and their implementation on a global level is expanding in recent years.

The analysis and comparison between the solutions demonstrated differences in both systems like integration with other transport modes and renewable energy usage that may affect customer acceptance and PSS sustainable performance. Customer behaviour, acceptance and satisfaction need further study. Understanding the real factors that motivate customers to use a bike-sharing system can be useful in efforts to spread its future use and can help in the understanding of the motivating factors and barriers to PSS acceptance. These factors can be translated into design strategies to facilitate the PSS introduction, and they are important research gaps that must be explored in future work.

6 References

Beuren FH, Gomes Ferreira, MG and Cauchick Miguel PA (2013) Product-service systems: A literature review on integrated products and services. J Clean Prod 47:222-31.

Boehm M and Thomas O (2013) Looking beyond the rim of one's teacup: a multidisciplinary literature review of Product-Service Systems in Information Systems, Business Management, and Engineering & Design. J Clean Prod 51:245-60.

Ceschin F (2013) Critical factors for implementing and diffusing sustainable product-Service systems: insights from innovation studies and companies' experiences. J Clean Prod 45:74-88.

Ceschin F (2014) Sustainable Product-Service Systems. Springer, London.

Chou CJ, Chen CW and Conley C (2015) An approach to assessing sustainable product-service systems. J Clean Prod 86:277-84.

Cook M (2014) Fluid transitions to more sustainable product service systems. Environ Innov Soc Transitions12:1-13.

Fishman E, Washington S and Haworth N (2014). Bike share's impact on car use: Evidence from the United States, Great Britain, and Australia. Transport Res Part D 31:13-20.

Fishman E, Washington S, Haworth, N and Watson A (2015) Factors influencing bike share membership: An analysis of Melbourne and Brisbane. Transport Res Part A 71:17-30.

Hemne S, Orsato RJ and Van Wassenhove L (2010) Vélib': sustainable market space, INSEAD, Fontainebleu.

Keskin D (2006) Analysis of public use bicycle systems from a Product-Service System perspective, Dissertation (Master of Science in Industrial Design). Middle East Technical University, Ancara.

Mobilicidade (2014) About Bike Rio System. Available from: < http://www.mobilicidade.com.br/siteoficial >. [15 December 2014].

Reim W, Parida V and Örtqvist D (2014) Product-Service Systems (PSS) Business Models and Tactics - A Systematic Literature Review. J Clean Prod, In press, doi: 10.1016/j.jclepro.2014.07.003.

Tukker A (2004) Eight types of product-service system: Eight ways to sustainability? Experiences from suspronet. Bus Strateg Environ 13(4):246-60.

Tukker A (2013) Product services for a resource-efficient and circular economy - a review. J Clean Prod, In press, doi: 10.1016/j.jclepro.2013.11.049.

Vélib' (2014) Official Website. Available from :< https://abo-paris.cyclocity.fr/>. [16 December 2014].

World Bank (2012) Rio de Janeiro lança programa para reduzir gases do efeito estufa. Available from:<http://www.worldbank.org/pt/news/feature/2012/06/18/rio-de-janeiro-to-fight-greenhouse-gas-emissions>. [19 December 2014].

Zhang L, Zhang J, Duan Z and Bryde D (2014) Sustainable bike-sharing systems: characteristics and commonalities across cases in urban China. J Clean Prod, In press, doi: 10.1016/j.jclepro.2014.04.006.

Alliance Taxonomies: A Literature Review

Barbic F[1], Cagliano R[2], Hidalgo A[3]

Abstract: The literature on inter-firm forms of governance have been studied from different theoretical perspectives and has grown extensively in last few decades. Inter-firm forms of governance present a broad array of collaborative relationships, such as joint ventures, strategic alliances, buyer-supplier agreements, networks, trade associations and consortia. The aim of this paper is to describe existing alliance taxonomies, to identify main variables that influence formulation and functioning of particular form, and to provide practical implications for practitioners when choosing governance form for collaborations. Purpose of this paper has been accomplished through review of relevant literature on governance forms from different theoretical perspectives.

Keywords: alliance taxonomy; governance forms; governance structures; strategic alliances; literature review.

1 Introduction

Information revolution reduced costs of coordination, communication and control. As a result, we witnessed an increased externalization of transactions and greater specialization in organizations. Large, multipurpose companies were replace by networks of smaller, specialized organizations. Different types of inter-firm organizations emerged, such as strategic alliances, joint ventures, networks, consortia, buyer–supplier partnerships, trade associations and others (Gulati, 1998). The aim of this paper is to review existing alliance taxonomies and the main variables that influence formation and functioning of particular form, and to provide implications for practitioners when choosing governance form for their collaborations. Inter-firm forms have been studied from several theoretical perspectives (Contractor and Lorange, 1988); such as transactional cost theory (Williamson, 1991), the resource-based view (Gulati, 1998), the resource dependence theory (Pfeffer and Salancik, 1978), the relational view (Dyer and Singh, 1998), property right theory (Hart and Moore, 1990), trust (Zaheer, et al., 1998) and organizational sociology (Granovetter, 1985). Various branches of social science that contributed to literature on inter-firm relationships often used different terminology what make systematic examination of the field difficult. Mostly used terms in literature are: “hybrids”, mostly in economics (Makadok and Coff, 2009; Ménard, 2004; Williamson, 1991); “alliances”, mostly in management (Doz and Hamel, 1998; Gulati, 1998; Lavie, 2007); and “networks”, mostly in sociology (Granovetter, 1985; Phelps et al., 2012). Other terms, such as plural (Cannon et al., 2000), intermediate (Kasch and Dowling, 2008), or non-standard forms (Helper et al., 2000) can also be found. Additional problem in effective dissemination of literature presents usage of same term for many different things (Grandori and Soda, 1995). Even at the early stage on inter-firm research, Nohria and Eccles (1992) state that term “network” lost its precision. Term network is widely used in many other fields of science, ranging from neural science to electrical engineering and programming.

1 **Frano Barbic** (frano.barbic@polimi.it)
ETSII, Universidad Politécnica de Madrid.
Calle José Gutiérrez Abascal 2, 28006 Madrid, Spain.
DIG, Politecnico di Milano. Via Lambruschini 4/b, 20156 Milano, Italy.

2 **Raffaella Cagliano** (raffaella.cagliano@polimi.it)
DIG, Politecnico di Milano. Via Lambruschini 4/b, 20156 Milano, Italy.

3 **Antonio Hidalgo** (antonio.hidalgo@upm.es)
ETSII, Universidad Politécnica de Madrid.
Calle José Gutiérrez Abascal 2, 28006 Madrid, Spain.

2 Method of Enquiry

Our study provides a transparent overview of existing alliance taxonomies. We had to be very selective with inclusion criteria due to extensive literature related to the topic in question. As an example, the inclusion of the search term "alliance" return more than 10,000 articles. We restricted our research on publication in most cited peer-reviewed journals related to alliance literature: Strategic Management Journal, Long Range Planning, Organization Science, Organization Studies, Academy of Management Review, Academy of Management Journal, Administrative Science Quarterly, Journal of Management, Journal of Management Studies, Management Studies, Journal of Law, Economics, and Organization, Research Policy, California Management Review, Harvard Business Review, MIT Sloan Management Review. We searched the Web of Science database without time limit restriction. The selected subject areas were Sociology, Business and Management. To be include in review papers had to propose new alliance taxonomy or made strong contribution to alliance taxonomy to be included in review. We searched terms consist of different combinations, wordings and spellings (UK/US) related to alliance taxonomies in paper's title, abstract and keywords: (alliance; network; hybrid; inter-firm; governance; form*; structure; mode; typ*; taxonomy*). This search provides 102 papers. After a reading of abstracts, 61 papers were discarded because they do not propose new alliance taxonomy or make strong contribution to alliance taxonomy. After further reading of full papers, we additionally discarded 26 papers, which left us with final sample of 15 papers.

3 Alliance Taxonomies

There are few existing taxonomies of alliance governance forms. One of the first taxonomies is one found in Pfeffer and Salancik (1978), routed in resource dependence theory. Authors use critical uncertainty and interdependence, asymmetry in resources and information controlled as variables predicting choice of governance structure. Pfeffer and Salancik's (1978) typology consist of joint ventures, interlocking directorates, associations and cartels, and social and personal networks.

Probably most fruitful theory in explaining alliance forms is transaction cost theory. After initial refusal to accept alliance forms as something better than second best choice between market and hierarchy, research routed in the transaction cost theory produced important contributions to literature on governance structure choice. Transaction cost economics contribution to literature on choice of governance structures is mostly related to characteristics of alliance activities and transactions (Pisano, 1989; Williamson, 1991; Oxley and Sampson, 2004). Earlier studies in transaction cost economics mostly focused on ownership as main dimension that distinguish markets from hierarchy (Pisano, 1989), with later studies adding authority and incentives (Holmstrom and Milgrom, 1994; Williamson, 1991) as key dimensions distinguishing markets from hierarchy. Researchers (Pisano, 1989; Oxley, 1997; Sampson, 2004) also found evidence that increase in scope of activities within an alliance lead to adoption of more hierarchical governance structures. Furthermore, research based in transaction cost theory suggests that transaction attributes such as asset specificity, uncertainty, and transaction frequency represent important variables for choice of governance structures. Wider organizational literature has identified a number of other transaction and task-related attributes that influence governance structures, such as transaction volume, transaction duration, and task complexity (Ebers and Oerlemans, 2013). Exploring the alignment of transactions and governance in R&D alliances, Sampson (2004), found that firms entering into alliances face considerable moral hazard problems. Using transaction cost, Contractor and Lorange (1988) found that degree of organizational interdependence is important variable to split alliance forms on equity joint venture, development or coproduction, non-equity corporative agreements in R&D, management or marketing service agreement, know-how licensing, production assembly and buy-back agreements, technical training and start-up assistance. Pisano (1989) use equity ownerships to distinguish between equity and non-equity alliances. Under equity alliances he included equity joint ventures and minority equity, and under non-equity alliances unidirectional agreements and bidirectional agreements. Oxley (1997) argue that a long list of features, such as formal and informal monitoring, provision for third-party arbitration, details about control rights and extend of effective hostage exchanges built into the agreement, are necessary to make fine-grained taxonomies. He identified three broad categories of governance forms according to how they deal with contractual hazards and appropriability. These are unilateral contractual agreements (e.g. unilateral licensing agreements, long-term supply contracts, R&D

contracts); bilateral contractual agreements (e.g. technology sharing or cross-licensing agreements and joint research agreements); equity-based alliances (e.g. joint ventures and research corporation). Oxley (1997) hypothesise that firms will apply more hierarchical governance form if they are involved in product or process design, than if they are involved in only production or marketing; if they have broader common product range or cover wider geographical scope; if number of partners involved in alliance is higher; and less hierarchical if partners are involved in multiple alliances. Basing their study in transaction cost economics Gulati and Singh (1998) disputed appropriability hazard as predictor of alliance form. They argued that anticipated coordination costs are better predictor since they include role of trust. Their typology goes from joint ventures, which is separate entity in which each partner owns a part of equity; to contractual alliances, with no shared ownership but joint activities coordinated through negotiations; and minority alliances in the middle, in which one or several partners take minority equity in the other(s). Ménard (2004) argues that various governance structures are contingent to forces that favor alliance structure (uncertainty and complexity) and degree of centralization/control needed to provide autonomy of partners. He use two-dimensional chart with pooled rights and strategic resources on one axis and decentralization of coordination/control on other axis to distinguish between alliances. On one side of the spectrum, close to spot markets are information-based networks and on other are strategic centers, close to hierarchies. Limitation of presented theories is that they treat alliance forms of governance as intermediate forms between pure market and pure hierarchy (Hennart, 1993; Holmstrom and Milgrom, 1994). Makadok and Coff (2009) distinguish between intermediate and hybrid forms, defining first as having same intensity in all dimensions that distinguish markets from hierarchy, and second as market-like in some dimensions while simultaneously hierarchy-like in others. Using authority, ownership and incentives as key dimensions, they developed a theoretical model that predicts appearance of particular governance form. Makadok and Coff (2009) leave possibility that other mechanism, like rent seeking, property rights, incentive systems, and adaptation, (see Gibbons, 2005), may also explain alliance forms.

Apart from transaction cost economics, resource based view (Gulati, 1998) made huge contribution to literature on drivers influencing the choice of alliance governance structures. Das and Teng (2000) argue that resources profiles of partner firms are main determinant of preferred governance structure. Choice of the particular governance structure depends on how resources of the two parties are mixed-up in the relationship. They identify four categories of alliance governance forms: unilateral contract-based alliances, bilateral contract-based alliances, minority equity alliances and equity joint ventures. Das and Teng (2000) hypothesize that partner firm will prefer an equity joint venture if its primary resources are property-based and its partner's primary resources are knowledge-based, but minority equity alliance when its primary resources are knowledge-based and its partner's primary resources are property-based. In case when both partners' primary resources are knowledge-based firm will prefer a bilateral contract-based alliance, and when both partner firms' primary resources are property-based firm will prefer a unilateral contract-based alliance. In same vein, Chen and Chen (2003) combined resources based theory with transaction cost model. They classify strategic alliances into two kinds of resource-sharing schemes: exchange and integration. An exchange alliance that is similar to out-sourcing and where partners exchange resources and then utilize them independently. On the other hand, in integration alliances partners pool resources into an organization for a common purpose. They found that whilst transactional cost model is powerful in explaining the choice between joint ventures and contractual alliances, the resource based view explain choice between exchange and integration alliances. How alliance purpose influence choice of the governance form in inter-firm relationships have been well researched. Pangarkar and Klein (2001) find that alliances with R&D purposes are more hierarchically oriented than those with marketing alliances. Examining manufacturing collaborations, Casciaro (2003) found that industries characterized by high scale/scope and learning economies, might have high opportunism hazards leading toward a more equity form of governance. Using large data set, Villalonga and McGahan (2005) investigate how firms choose among acquisition, alliances and divestiture when expanding firm boundaries. Under acquisitions authors include mergers, full or majority acquisitions and minority acquisitions; alliances include joint ventures, both equity and non-equity alliances in technology, R&D, manufacturing or marketing, and licensing; divestitures include spin-offs and sell-offs. Authors hypothesize that focal firm attributes, attributes of relationship between partners, partner firm attributes, transaction attributes and attributes of relationship between transaction and focal firm determines the choice among alliances, acquisitions and divestiture, and found support for explanations based on resource, transaction cost, internalization, organizational learning, social embeddednes, asymmetric information and real options. Using same theoretical perspective, Teng and Das (2008), hypothesize role of alliances objectives, alliance management experience and internalization of partners as predictor for choice of governance structure. Authors make a distinction between joint ventures, minority equity alliances and contractual alliances, and found that more hierarchical governance structures may be expected in both R&D and marketing alliances, when the partners have limited alliance management experience and when partners are not from same country.

Studies based in organization theory, have highlighted importance of the coordination mechanisms; the degree of centralization; and the formalization of decision making for choice of governance structures (Ménard, 2004). Grandori and Soda (1995) use formalization, centralization of coordination between partners and mix of coordination mechanism as dimensions to distinguish alliances. Authors classify alliances as: social networks, relying on personalized relationships; bureaucratic networks, which use formal agreements to specify the organizational relationships between allied parties; and proprietary networks, based on cross-holding property rights. In its later work, Grandori (1997) use contributions from transaction cost economics and agency theory to provide more fine-grained typology of alliances. She splits alliance forms based on type of interdependence and mixes of coordination mechanisms used in alliances. Under each category established in previous paper, she divide alliances as pooled, intensive, sequential and reciprocal. Under social networks can be found “Marshallian” industrial districts, differentiated and integrated ID, constellations, and informal ID sub-contracting; Bureaucratic networks consist of trade associations, horizontal and research consortia, complex industrial project consortia, licensing and concessions, one-way hierarchical sub-contracting, service franchising and two-way co-makership sub-contracting; and proprietary networks consist of production joint venture in mature sectors, R&D joint ventures, profit-sharing ventures and capital ventures. Although model can be used as predictor when particular governance structure may be used, it is based on antecedent variables and does not take in account dynamics i.e. that interdependence can vary during time. In same vein, Sauvée (2002) classified alliances according to whether the allocation of decision rights requires horizontal or vertical coordination. Using degree of centralization as predicting variable, Park (1996) classified alliances as vertical-bilateral (long-term contracts, licensing, franchising, joint ventures); vertical-trilateral (certain long-term contracts, network for plant construction, certain university-industry networks); horizontal-bilateral (cartels, collusions, R&D consortia, research joint venture, some licensing, joint ventures); and horizontal-trilateral (trade associations, some hospital consortia, independent federations). Baker et al. (2008) highlight allocation of asset ownership, decision rights, and payoffs as main variables when deciding governance structures. They start from issues emphasized by practitioners, namely, spillover effects and contracting problems ex post. Their classification goes from mergers and acquisitions to total divestitures, with licensing agreements, unstructured collaborations and royalty agreements as intermediate forms.

4 Conclusion

The literature review reviles that some governance forms have been extensively researched, while other are understudied. This does not necessary reflect prevalence of particular alliance form, or its importance for business practice. It is possible that prevalence of particular alliance form in literature lie in accessibility of data on that particular form. Mayer and Teece (2008) argue that we do not know enough about how various forms differ. The cause of that can be found in fact that most of empirical studies focus on particular alliance form, with only few attempts comparisons across different alliance forms. Moreover, when describing and analyzing governance structures, research has utilized a wide range of different dimensions and concepts (Ebers and Oerlemans, 2013). All this lead us to conclude that building a coherent analytical framework will be impossible until we discover similarities and differences between alliance forms. On the other hand, holistic theory of alliances does not exist. Narrow point of view of every single theoretical perspective made important contributions to our knowledge about alliance forms, but further progress of the field is possible only by combining different theoretical perspectives of alliance forms. Especially promising seams combinations of economic and sociological perspectives. From managers’ point of view, it is important that they understand both the advantages and disadvantages of every alliance governance structure. They need to take in account contributions from all theoretical perspectives when choosing governance form. Inconsistency between drivers and characteristics of desirable governance form and the selected governance form can lead to ineffectiveness, and even to dissolution or change in governance form.

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6 References

Baker et al. (2008). Strategic alliances: Bridges between "islands of conscious power". Journal of the Japanese and International Economies, 22(2), 146-163.

Cannon et al. (2000). Contracts, norms, and plural form governance. Journal of the Academy of Marketing Science, 28(2), 180-194.

Casciaro, T. (2003). Determinants of governance structure in alliances: the role of strategic, task and partner uncertainties. Industrial and Corporate Change, 12(6), 1223-1251.

Chen, H., and Chen, T. J. (2003). Governance structures in strategic alliances: Transaction cost versus resource-based perspective. Journal of World Business, 38(1), 1-14.

Contractor, F. J., and Lorange, P. (1988). Why should firms cooperate? The strategy and economics basis for cooperative ventures. Cooperative Strategies in International Business, 3-30.

Das, T. K., and Teng, B. S. (2000). A resource-based theory of strategic alliances. Journal of Management, 26(1), 31-61.

Doz, Y. L., and Hamel, G. (1998). Alliance advantage: The art of creating value through partnering. Harvard Business Press.

Dyer, J. H., and Singh, H. (1998). The relational view: cooperative strategy and sources of interorganizational competitive advantage. Academy of Management Review, 23(4), 660-679.

Ebers, M., and Oerlemans, L. (2013). The Variety of Governance Structures Beyond Market and Hierarchy. Journal of Management, 0149206313506938.

Gibbons, R. (2005). Four formal (izable) theories of the firm?. Journal of Economic Behavior & Organization, 58(2), 200-245.

Grandori, A., and Soda, G. (1995). Inter-firm networks: antecedents, mechanisms and forms. Organization Studies, 16(2), 183-214.

Grandori, A. (1997). An organizational assessment of interfirm coordination modes. Organization Studies, 18(6), 897-925.

Granovetter, M. (1985). Economic action and social structure: the problem of embeddedness. American Journal of Sociology, 481-510.

Gulati, R., and Singh, H. (1998). The architecture of cooperation: Managing coordination costs and appropriation concerns in strategic alliances. Administrative Science Quarterly, 781-814.

Gulati, R. (1998). Alliances and networks. Strategic Management Journal, 19(4), 293-317.

Hart, O., and Moore, J. (1990). Property Rights and the Nature of the Firm.

Helper, S., et al. (2000). Pragmatic collaborations: advancing knowledge while controlling opportunism. Industrial and Corporate Change, 9(3), 443-488.

Hennart, J. F. (1993). Explaining the swollen middle: Why most transactions are a mix of "market" and "hierarchy". Organization Science, 4(4), 529-547.

Holmstrom, B., and Milgrom, P. (1994). The firm as an incentive system. The American Economic Review, 972-991.

Kasch, S., and Dowling, M. (2008). Commercialization strategies of young biotechnology firms: An empirical analysis of the US industry. Research Policy, 37(10), 1765-1777.

Lavie, D. (2007). Alliance portfolios and firm performance: A study of value creation and appropriation in the US software industry. Strategic Management Journal, 28(12), 1187-1212.

Makadok, R., and Coff, R. (2009). Both market and hierarchy: An incentive-system theory of hybrid governance forms. Academy of Management Review, 34(2), 297-319.

Mayer, K. J., and Teece, D. J. (2008). Unpacking strategic alliances: The structure and purpose of alliance versus supplier relationships. Journal of Economic Behavior & Organization, 66(1), 106-127.

Ménard, C. (2004). The economics of hybrid organizations. Journal of Institutional and Theoretical Economics, 160(3), 345-376.

Milgrom, P. R., and Roberts, J. (1992). Economics, organization and management (Vol. 7). Englewood Cliffs, NJ: Prentice-hall.

Nohria, N. and Eccles, R.G. (1992). Networks and Organizations: Structure, Form, and Action. Boston: Harvard Business School Press.

Oxley, J. E. (1997). Appropriability hazards and governance in strategic alliances: A transaction cost approach. Journal of Law, Economics, and Organization, 13(2), 387-409.

Oxley, J. E., and Sampson, R. C. (2004). The scope and governance of international R&D alliances. Strategic Management Journal, 25(8-9), 723-749.

Pangarkar, N., and Klein, S. (2001). The impacts of alliance purpose and partner similarity on alliance governance. British Journal of Management, 12(4), 341-353.

Park, S. H. (1996). Managing an interorganizational network: a framework of the institutional mechanism for network control. Organization Studies, 17(5), 795-824.

Pfeffer, J. S., and Salancik, G. (1978). GR (1978). The external control of organizations: a resource dependence perspective. New York.

Phelps, C., Heidl, R. and Wadhwa, A. (2012). Knowledge, networks, and knowledge networks: a review and research agenda. Journal of Management, 38(4), 1115-1166.

Pisano, G. P. (1989). Using equity participation to support exchange: Evidence from the biotechnology industry. Journal of Law, Economics, and Organization, 5, 109.

Sampson, R. C. (2004). Organizational choice in R&D alliances: Knowledge-based and transaction cost perspectives. Managerial and Decision Economics,25(6-7), 421-436.

Sauvée, L. (2002). "Effectiveness, Efficiency, and the Design of Network Governance. In Chain and Network Management in Agribusiness and the Food Industry, Noordwijk aan Zee (NL): 673-684.

Teng, B. S., and Das, T. K. (2008). Governance structure choice in strategic alliances: The roles of alliance objectives, alliance management experience, and international partners. Management Decision, 46(5), 725-742.

Villalonga, B., and McGahan, A. M. (2005). The choice among acquisitions, alliances, and divestitures. Strategic Management Journal, 26(13), 1183-1208.

Williamson, O. E. (1991). Comparative economic organization: The analysis of discrete structural alternatives. Administrative Science Quarterly, 269-296.

Zaheer, A., et al. (1998). Does trust matter? Exploring the effects of interorganizational and interpersonal trust on performance. Organization Science, 9(2), 141-159.

Preliminary definition of an enterprise cooperation maturity model (ECOMM)

Juan Antonio López-Del-Castillo, Llanos Cuenca[1]

Abstract: The aim of this work is the preliminary design of a maturity model for business cooperation, by identifying the key areas that must be measured in the field of business cooperation and preliminary definition of maturity levels. Key areas for evaluation are: number of actors involved in decision making, level of cooperation, interdependence of the nature of relationships, number of cooperation mechanisms, information processing, form of decision, complicity level, objectives / common characteristics, degree of benefit among participants, stable relationship of cooperation and interaction force. The key areas are evaluated using a five-level scheme: initial, repetitive, defined, managed and optimized. This approach is applicable to any type of company involve in a collaborative process.

Keywords: Maturity Model, enterprise cooperation, key areas, collaboration, interoperability.

1 Introduction

Business cooperation is defined as an agreement between two or more independent companies, joining or sharing some of their skills and / or resources, without actually merging, establish a degree of interrelation, in order to increase their competitive sales. It can be considered that the cooperation agreements have three distinctive features: companies that agree to achieve common goals remain independent after finishing the agreement; performance control of assigned tasks and benefits are shared between partners; and these partners contribute continuously in one or more areas.

Cooperation between companies seeks to achieve a goal that can not be attained individually, or at least not with the same efficiency level. Companies establish cooperative relations with the assumption that it is directly linked to generate benefits for participating organizations.

2 Cooperation, collaboration and interoperability

This paper will focus mainly on cooperation processes taking place in enterprise networks. Another important concept in the relationships established among companies is interoperability. The enterprise interoperability is defined as the ability for interaction between companies; such interaction can take place at three levels: data, application and business process (IDEAS, 2003). Interoperability could be a concept that goes hand in hand with the processes of cooperation and collaboration. In a collaborative network environment, integration and interoperability improve the competitive advantages of Collaborative Network and the members who compose it. In this context, these concepts become central to the achievement of business objectives, objectives in terms of time, quality and costs (Chituc et al., 2008). Some authors believe that collaboration is a process that involves the sub-process of communication, coordination and cooperation. According Schuh et al. (2014), it is characteristic of collaboration partner companies which communicate with each other, coordinate their activities and cooperate to achieve a common goal.

1 **Llanos Cuenca** (llcuenca@cigip.upv.es)
Research Center on Production Management and Engineering (CIGIP).
Universitat Politècnica de València. Valencia (Spain).

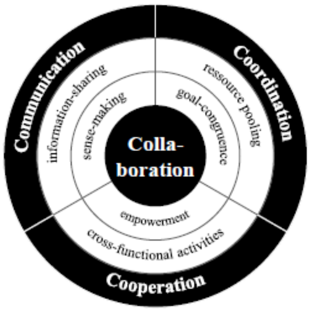

Fig.1
Collaborative practices scheme.
(Schuh et al. (2014).

However, other authors define these concepts in a different way, especially when they are compared between them. Camarinha-Matos et al. (2005) carry on a comparative between collaboration and cooperation with the objective of clarifying the definition and establishing main differential characteristics. Cooperation not only refers to the information exchange but also resources shared to achieve common objectives.

Cooperation is achieved through the wok division among participants. In this case, the added value is the result of the addition of individual value generated by different participants in an almost independently way. A traditional supply chain based on customer-supplier with defined roles in the value chain relationships are an example of the cooperative process among its constituents. Each participant performs his part of the work, almost independently (although coordinated with others). However, a common plan exists, which is not defined together in most cases, but basically defined by a single entity. Collaboration is a process in which entities share information, resources and responsibilities to jointly plan, implement and evaluate a program of activities to achieve a common goal. This concept can be seen as a process of shared creation, ie, as a process in which a group of entities can enhance the capabilities of the other. Collaboration includes mutual commitment of participants to solve a joint problem, which implies mutual trust and hence involves time, effort and dedication. Individual contributions to value creation are much more difficult to determine in this case. The collaborative network of companies is the kind of coalition that requires higher levels of integration. In addition to all the features that have cooperative networks should be added that companies have common goals, form joint identities and the work is done jointly (joint creation).

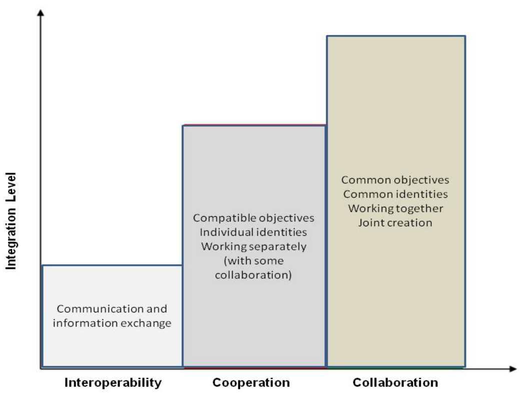

Fig.2
Key features and integration level in interoperability,
cooperation and collaboration (Own Source).

Interoperability refers only to information sharing and communication among participants. This concept involves the lowest level of integration between companies compared to cooperation and collaboration concepts. Finally, collaboration would be at the highest level of integration between companies. Therefore, collaboration is not as easily achieved as cooperation and individual value creation contributions are much more difficult to determine compared to cooperation. According Arshinder et al. (2006), collaboration could be defined as 'working Jointly' (working together), while cooperation is defined as 'operation Jointly' (joint task). The following table shows a summary of the main defined characteristics of interoperability, cooperation and collaboration.

Table 1
Main characteristics associated to interoperability, cooperation and collaboration.

Concept	Characteristics	References
Interoperability	Communication among participants and information exchange Interaction capacity between companies , at three levels: data, application and business processes It represents the ability of two or more systems or components to exchange information and to use it	IEEE Standard Computer Dictionary (1990); IDEAS (2003); Ducq, Y.; Chen, D.; Vallespir, B. (2005)
Cooperation	Compatible objectives between participants Individual identities working separately (with some kind of coordination) Maintaining the legal and economic independence among cooperating companies Achieving not attainable goal individually Compatible objectives in the sense that the results can be added or compose in a value chain leading to the final product or service Work division among participants. Each participant performs his part of the work almost independently (although coordinated with others) Resources, knowledge and skills that each company has separately in order to obtain a higher profit share Work together (operation Jointly) are performed	Camarinha Matos, L.M., (2005); Pinto et al. (1993); Camisón Zornoza, C. (1993); Oviedo García, M.A. (1993); Stuart (2000); (Dussauge y Garrette, 1991); (Hord, 1981; Roschelle y Teasley, 1995); Arshinder et al. (2006)
Collaboration	Joint identities. Working together (co-creation) The objectives are not only aligned, but there are common goals among participating companies It is a process that evolves and involves two or more entities Includes mutual commitment of participants to solve a joint problem The individual contributions to value creation are difficult to determine It works together (working Jointly)	Arshinder et al. (2006); Camarinha Matos, L.M., (2005); Bedwell, W.L. (2011); Child and Faulkner (1998); Tidd et al. (2001); Gomes-Casseres (2003); Tether and Tajar (2008); Hipp (2010); (Menguzzato, M., 1992); Marks et al., (2001)

3 Enterprise Cooperation Maturity Model (ECOMM)

3.1 Key areas

After reading and analyzing eighteen research articles related to business cooperation and interoperability between companies, were initially selected 21 key areas. After this initial identification, it has been observed that there might be redundancies or overlaps between different key areas. Furthermore, it was considered that the Maturity Model should be more useful on a practical level. Therefore, it was decided that key areas are the following twelve:

Table 2
Key Areas to be assessed.

Key Areas Maturity Model		Key areas initially considered	Author
1	Cooperation Form	Cooperation type	Gang and. Zhi-tao (2009)
2	Number of actors involved in decision	Number of actors involved in decision	Cuenca et al. (2013)
3	Cooperation Level	Cooperation Level	Cuenca et al. (2013)
4	Interdependent nature of relationships	Interdependent nature of relationships	Cuenca et al. (2013)
5	Nº of cooperation mechanisms	Nº of cooperation mechanisms	Cuenca et al. (2013)
		Techniques competences	Cheikhrounou, Piot and Pouly (2008)
6	Information processing	Information in the process	Cuenca et al. (2013)
		Information exchanged	Cuenca et al. (2013)
7	Decision form	Decision form	Trigo and Vence (2011)
		Resource property	Cheikhrounou,. Piot and Pouly (2008)
8	Level of complicity	Complicity level	Gang and Zhi-tao (2009)
		Partner trust	Cheikhrounou,. Piot and Pouly (2008)
		Emotional intensity	Gang and. Zhi-tao (2009)
9	Objective/common characteristics	Common objectives	Cheikhrounou,. Piot and Pouly (2008)
10	Degree of benefit among participants	Benefits level	Gang and. Zhi-tao (2009)
11	Stability of the cooperative relationship	Stability of the cooperative relationship	Chen et al. (2008)
		Commitment validity	Gang and. Zhi-tao
		Level of competition between actors	Liu and Li (2013)
12	Interaction force	Fuerza de la dependencia de recursos (competencia)	Liu and Li (2013)
		Fuerza de dependencia de los recursos	Du and Fu (2011)

Next, each key area will be described and it will be explained what is intended to evaluate. An important aspect is to determine the **cooperation form** that exists among the participating companies, as each form of cooperation has its own characteristics and usually indicates a lesser or greater degree of cooperation among participants. Another important aspect is to identify the actors who take part in decisions and their decision-making power. The **level of cooperation** among companies is a very important area to be evaluated. According Gang and Gang Zhi-Tao (2009), the degree of competition-cooperation relationship among companies can be classified into: super-strong cooperation, strong cooperation, weak cooperation, weak competition, strong competition and super strong competition.

The **interdependent nature of relationships** refers to the degree of dependence between the different actors of cooperation, knowledge of such interdependence and in what respects takes place for each of the actors; and if such interdependence is satisfactory to all stakeholders or participants in cooperation. The **number of cooperation mechanisms** refers to the different protocols and procedures laid down in the relationship among different participants in a cooperative relationship. The **information processing** is an aspect of increasing importance. According to Chang et al. (2010), the main variables in which firms exchange information include: technological capacity of information systems more reliable information, information processing, performance on the delivery; and flexibility in billing and payment. The **decision-making form** is an important aspect in the relationship of cooperation among members of the same supply chain or among companies which are interrelated. With the Maturity Model, it will be intended to assess whether decisions affecting several cooperation partners, if the sequence of decisions and their onset is defined, the use and definition of procedures for decision-making; and satisfaction with the procedure for decision-making. The **level of complicity** among the different participants is set based resource sharing. They can be human resources, know-how, technology, financial resources and intangible resources (reputation).

A very important part for a cooperative relationship among companies is established is the existence of **objective and common characteristics** between them. The higher the amount of common objectives, greater chance of success will the cooperative relationship. According Yang and Ji (2009), firms cooperate vertically along the Supply Chain (suppliers, manufacturers, warehouses, distribution centers and retailers) and horizontally among partners / competitors. According to Chen et al., (2008), the cooperative relationship among companies is often unstable. The uncertainty caused by market opportunities and competition makes companies feel insecure and have to cooperate with each other to resist the risk and pressure from the environment. Finally, it has taken into account the **Strength of the interaction** among different firms producing Maturity Model. According Zhi-Tao and Hong (2011), the strength of cooperation relationships among enterprises (SCRS) is an indicator that measures the extent of the cooperation relations among companies.

3.2. Levels

After defining the key areas, it is necessary to define the levels that serve to evaluate each key area of business cooperation in this Maturity Model. The maturity levels identified are based on the levels proposed in the SECM-Maturity Model (Cuenca, et al., 2013).

Level 1: Initial. Businesses interact occasionally establishing a cooperative relationship. **Level 2: Repeatable.** Businesses interact with some regularity establishing a cooperative relationship, but the intensity of the relationship is not very strong. **Level 3: Defined.** Businesses interact regularly establishing a cooperative relationship and the areas where such cooperation occurs are defined. **Level 4: Managed.** Businesses interact regularly establishing a cooperative relationship; the areas where such cooperation in the medium to long term occurs are defined. There are complementarities between the resources managed by each company. **Level 5: Optimized.** Businesses interact regularly establishing a cooperative relationship; the areas where such cooperation in the medium to long term occurs are defined. There are complementarities between the resources managed by each company; and there is interdependence between the resources of each company, since each of the participants in the cooperative companies is specialized in a particular resource.

4 Conclusion

Maturity Models are an important tool that can help the companies to achieve a better positioning of the organization and to find better solutions for change. This Maturity Model is a tool that can be used to evaluate any cooperation between companies. It will be particularly useful in the case of networks of companies or firms operating in the same supply chain, which could mean a breakthrough because the trend is to operate at the level of supply chain rather than at the enterprise level individually. By using this tool, companies will know what aspects of each key area should be improved to reach a higher level of cooperation to enable them to obtain competitive advantages and more profits. We are currently working on defining the full model; and validation of the model is done through questionnaires to be made by companies in a given sector.

5 References

Arshinder K, Kanda, A., Deshmukh SG (2006). A coordination based perspective on the procurement process in supply chain. Int J Value Chain Manage 1(2):117-138

Bedwell, W. L., Wildman, J. L., Díaz Granados, D., Salazar, M., Kramer, W. S., & Salas, E. (2012). Collaboration at work: An integrative multilevel conceptualization. Human Resource Management Review, 22(2), 128-145.

Camarinha-Matos, L.M. & Afsarmanesh, H. (2005). Collaborative networks. A new scientific discipline. J. Intelligent Manufacturing, 16(4-5), pp439-452

Camisón Zornoza, C. (1993). Revista Europea de Dirección y Economía de la Empresa, Volumen 2, Número 3. Dirección de empresas con entornos globales y abiertos: hacia la estrategia de alianzas.

Chang C.V., C. R. Wu, and C. C. Liao (2010), 'The Virtual Cooperation Platform in Enterprise and Supplier Cooperation Models', Cyberpsychology, Behavior, and Social Networking, vol. 13, no. 4, pp. 473–475, Aug.

Chen, Y. Li, H. Wu y X. Yang (2008). An Evolutionary Game Analysis on Stability of the Cooperation Relationship in Virtual Enterprise

Child, J., Faulkner, D., 1998. Strategies of Cooperation: Managing Alliances Networks and Joint Ventures. Oxford University Press, Oxford, UK.

Chituc, C.; Toscano, C.; Azevedo, A (2008). Interoperability in Collaborative Networks: Independent and industry-specific initiatives. The case of the footwear industry.

Cheikhrouhou N., Piot G., Pouly M. 2010. A multi-criteria model for the evaluation of business benefits in horizontal collaborative networks, Journal of Intelligent Manufacturing, 21 (3), 301-309.

Cuenca, L. et al. (2013). Structural elements of coordination mechanisms in collaborative planning processes and their assessment through maturity models: Application to a ceramic tile company.

Cuenca, L. et al. (2013). Structural elements of coordination mechanisms in collaborative planning processes and their assessment through maturity models: Application to a ceramic tile company.

Du Z., and Hong Fu (2011). Research on the Active Mechanism of the Inter-firm Cooperative Relationship Strength Based on the Game Theory. CSEE (5), volume 218 of Communications in Computer and Information Science, page 604-611.

Ducq, Y.; Chen, D.; Vallespir, B(2005). Interoperability in enterprise modelling: requirements and roadmap

Dussauge, P. y Garrette, B. (1991). “Alliances stratègiques, mode d’emploi”, Revue Française de Gestion, septiembre-octobre, pp. 4-18

Gomes-Casseres, B., A.B. Jaffe and J. Hagedoorn (2003). “Do Alliances Promote Knowledge Flows?” Mimeo

Hipp, C., 2010. Collaborative innovation in services. In: Gallouj, F., Djellal, F. (Eds.), The Handbook of Innovation and Services: A Multi-Disciplinary Perspective. Edward Elgar, United Kingdom, pp. 318–341.

Hord, Shirley M. Working Together: Cooperation Or Collaboration? Austin, Texas: Development Center for Teacher Education, The University of Texas, 1981.

IDEAS. (2003). IDEAS project deliverables (WP1-WP7)

IEEE (1990). IEEE Standard Computer Dictionary: A Compilation of IEEE Standard Computer Glossaries. New York: IEEE.

Liu P. and Y. Li, “Permanence for a competition and cooperation model of enterprise cluster with delays and feedback controls,” Electronic Journal of Differential Equations, vol. 2013, no. 22, pp. 1–9, 2013.

Gang Li , DU Zhi-tao, 2009. The Identified Model of the Strength of Competition-Cooperation Relationship between Enterprises.

Menguzzato, M. (1992). La cooperación empresarial. Análisis de su proceso. Valencia. IMPIVA.

Marks, B., Stowell, M.H., Vallis, Y., Mills, I.G., Gibson, A., Hopkins, C.R., and McMahon, H.T. (2001). GTPase activity of dynamin and resulting conformation change are essential for endocytosis. Nature 410, 231–235.

Oviedo García, M.A.; Casillas Bueno, J.C.; Moreno Menéndez, A. (1993). La PYME española ante la cooperación transnacional

Pinto, M.B., Pinto, J.K. and Prescott, J.E. (1993) ‘Antecedents and consequences of project team cross-functional cooperation’, Management Science, Vol. 39, No. 10, pp.1281–1297.

Roschelle, J. y Teasley, S. D. (1995). Construction of shared knowledge in collaborative problem solving. En C. O'Malley (Ed.), Computer-supported collaborative learning (pp. 69-97). New York: Springer-Verlag.

Stuart, T. E. (2000). Interorganizational alliances and the performance of firms: A study of growth and innovation rates in a high-technology industry. Strategic Management Journal, 21, 791–811.

Schuh, G., Potente, T., Varandani, R., Hausberg, C. Fränken, B. (2014).Collaboration Moves Productivity to The Next Level

Tether, B.S., and A. Tajar, 2008. Beyond industry-university links: Sourcing knowledge for innovation from consultants, private research organizations, and public science base. Research Policy 37 (6-7): 1079-95

Tidd, J., Bessant, J. and Pavitt, K.(2001) Managing Innovation: Integrating technological, market & organisational change. John Wiley & sons, Chichester. Second edition.

Trigo, A. and Vence, X. (2012) ‘Scope and patterns of innovation cooperation in Spanish service enterprises’, Research Policy, Vol. 41, pp.602-613.

Y. Yang y T. Ji (2009). Study on Cooperation Model in Virtual Enterprise

Zhi Tao, Du ;Hong, Fu (2011). Research on the Active Mechanism of the Inter-firm Cooperative Relationship Strength Based on the Game Theory

Rubric to assess the competence of innovation, creativity and entrepreneurship in bachelor degree

Llanos Cuenca[1], Faustino Alarcón, Andrés Boza Marta Fernández-Diego, Leonor Ruiz, Mari Luz Gordo, Raul Poler, Mareva Alemany

Abstract: Innovation has a special value for the survival and development of organizations, especially in a changing context. To develop the innovation, creativity and entrepreneurship capacities in students enhances their skills. A competency describes what training participants should be able to do at the end of the training. The competence is acquired through various learning outcomes to be achieved. Competition in innovation is closely related to the ability to propose and implement creative ideas to solve problems, ability to create and maintain connections work, etc. In this article is presented a method for measuring the competence of innovation, creativity and entrepreneurship in bachelor degree by introducing different levels of scope.

Keywords: Rubric, competence, innovation, evaluation.

1 Introduction

This article is part of an innovation and educational improvement project (RECICRE), focusing on the definition and implementation of evaluation mechanisms for the acquisition of competence innovation, creativity and entrepreneurship and the learning objects project (OAICE), oriented to facilitate the acquisition of such competence. The defined rubric can be transferable to different subjects in different bachelor degrees.
The project has been developed in collaboration with the European IDEA Tempus project which aims to improve the integration of knowledge in the interdisciplinary area of Engineering, Design and Business in higher education from an industrial perspective, improving innovation and as improving education-industry relations. The motivation for this proposal is to contribute to systematic evaluation mechanisms to ensure the acquisition of competence dimension, innovation, creativity and entrepreneurship.

2 Innovation development

The overall objective was extended in several detailed objectives. Each of the detailed objectives was carried out by one or more activities developed by the research team. Activities sequencing has allowed interactions between them to complete the desired objective. One and two activities followed the literature review process for learning outcomes related to innovation competence for bachelor degree and master. It was conducted via Google Scholar (scholar.google.es) and Scopus; also including the preliminary list of learning outcomes of the sciences institute of innovation (Ice, 2013) and results of the Tempus project (Tempus, 2014). For the development of the rubric (activity three) and following the similarity that they have with maturity models, the methodology defined in (Cuenca et al., 2013) was applied. Key areas (in this case learning outcomes) and the description of each one of the scope levels were identified. The development of the activity three (definition section) can lead to rethink the

1 **Llanos Cuenca** (llcuenca@omp.upv.es)
Dpto. de Organización de Empresas.
Escuela Técnica Superior de Ingeniería Informática.
Universitat Politècnica de València.
Camino de Vera s/n 46022 Valencia (Spain).

definition and/or writing learning outcomes, and the results of the activity four (validation) may imply a better definition. Finally the review and closing allows evaluating the results and proposing actions to improve the validation and/or definition of the rubric.

3 Findings

The results obtained in the project are directly related to the activities and have allowed assessing their compliance. The rubric was designed to assess the learning outcomes in bachelor degree associated with innovation, creativity and entrepreneurship competence. We have established the relationship between competencies, learning outcomes and learning objects (Fig. 1).

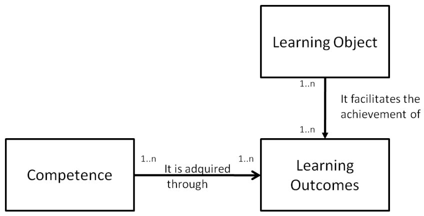

Fig.1
Structural model of competences
(adapted from Cuenca et al., 2014).

Learning outcomes have been classified into different outlooks. The learning outlooks are: creativity, enterprising, integrating and forecasting. Important elements associated to innovation (Bapat et al., 2014).

Creativity

Generating Ideas (GI): Coming up with a variety of approaches to problem solving.

Critical Thinking (GT): Logically identifying how different possible approaches are strong and weak, and analyzing these judgments.

Synthesis/Reorganization (SR): Finding a better way to approach problems through synthesizing and reorganizing the information.

Creative Problem Solving (CPR): Using novel ideas to solve problems as a leader.

Enterprising

Identifying Problem (IP): Pinpointing the actual nature and cause of problems and the dynamics that underlie them.

Seeking Improvement (SI): Constantly looking for ways that one can improve one's organization.

Gathering Information (GI): Identifying useful sources of information and gathering and utilizing only that information which is essential.

Independent Thinking (IT): Thinking 'outside the box' even if this sometimes may go against popular opinion.

Technological Savvy (TS): Understanding and utilizing technology to improve work processes.

Integrating Perspectives

Openness to Ideas (OI): A willingness to listen to suggestions from others and to try new ideas.

Research Orientation (RO): Observing the behavior of others, reading extensively, and keeping your mind open to ideas and solutions from others. Reading and talking to people in related fields to discover innovations or current trends in the field.

Collaborating (C): Working with others and seeking the opinions of others to reach a creative solution.

Engaging in Non-Work Related Interests (ENWI): Being well-rounded and seeking information from other fields and areas of life to find novel approaches to situations.

Forecasting

Perceiving Systems (PS): Acknowledging important changes that occur in a system or predicting accurately when they might occur.

Evaluating Long-Term Consequences (EC): Concluding what a change in systems will result in long-term

Visioning (V): Developing an image of an ideal working state of an organization.

Managing the Future (MF): Evaluating future directions and risks based on current and future strengths, weaknesses, opportunities and threats.

Managing Change perspective is also included in Bapat's model, but in this case there no exist any outcome learning associated.

The following table shows the rubric defined.

Table 02
Rubric to assess the competence of innovation, creativity and entrepreneurship in bachelor degree.

	Learning outlook/Results		Level 1	Level 2	Level 3	Level 4
CREATIVITY	GI	Providing suggestions about ideas, situations, cases or existing problems.	Suggestions haven't been forthcoming.	A few suggestions have been provided but they are only relevant in specific cases.	Some suggestions have been made. They are quality appropriate and relevant in several cases.	Suggestions have been made which show good quality and can be widely applied.
	CT	Evaluating the real-life scenario where the new method crops up	It hasn't been evaluated.	A brief assessment has been carried out at a low level of detail.	A number of evaluations have been carried out to an appropriate detail level.	A broad evaluation has been carried out to a high detail level.
	GI	Finding new methods and processes to do things	New methods and processes haven't been found as yet.	The newly discovered methods and processes are restricted.	The newly discovered methods and processes are quality-appropriate.	The newly discovered methods and processes are of good quality.
	CRS	Experimenting with new processes.	Trying new ways of doing things hasn't even been considered.	A process that could be executed in different ways has been identified but the potential alternatives are only described categorically.	The activities that could be changed have been identified defining a new process and the potential alternatives.	New processes have been outlined and also a way to measure their efficiency.
	GI	Familiarising yourself with the tools and techniques of ideas generation	Idea generation tools and techniques are unknown.	There is a vague understanding about idea generation tools and techniques.	There is a deep understanding about the most relevant idea generation tools and techniques but they haven't been used.	There is a deep understanding about the most relevant idea generation tools and techniques and most of them have been used.
	S/R	Embodying the generated ideas formally	The generated ideas are not comprehensible because they haven't been expressed clearly.	The generated ideas are comprehensible but the way in which they have been described is unsuitable.	The generated ideas are comprehensible. The way they have been described is suitable but lacking precision.	The generated ideas are comprehensible and they have been described in a suitable and formal way.
	GI	Proposing ideas and innovative solutions in terms of both content and procedures for applying them.	No ideas or innovative solutions have been proposed.	The content of some idea or innovative solution has been proposed but the process of applying them hasn't been specified.	The content of various ideas and innovative solutions has been proposed as well as the outline of the process to apply them.	The content of various ideas and innovative solutions has been proposed and the application process has been clearly outlined.

	CPS	Utilising creativity techniques to provide and reason good quality ideas which are original or unconventional.	Creativity techniques are not utilised to analyse and solve problems.	Creativity techniques are utilised at times. On less than 50% of occasions.	Creativity techniques are frequently utilised. On more than 50% of occasions.	Whenever necessary, creativity techniques are utilised to analyse and solve problems.
	GI	Putting forward good quality and suitable contributions to tackle situations and problem solving.	Suitable contributions have not been provided.	Suitable contributions have been provided and some are good enough to tackle potential problems.	Suitable contributions have been provided and they are good enough to tackle existing situations.	Suitable contributions are provided to high quality level and correlated to existing situations and problems.
	CT	Finding the constraints and weak points in their processes and working methods.	Only a description of the working processes and methods is provided.	A critical analysis is undertaken.	Constraints and weak points are identified.	Constraints and weak points are understood.
ENTREPRENEURSHIP	**Learning outlook/Results**		**Level 1**	**Level 2**	**Level 3**	**Level 4**
	SI	Analysing an existing situation and identifying areas for improvement.	The analysis of the situation was limited and areas for improvement were not identified.	The analysis of the situation was appropriate but the identification of areas for improvement was limited.	The situation was appropriately analysed and the identification of areas for improvement was completed.	The analysis of the situation and the identification of areas for improvement was completed and increased over time.
	SI	Searching new procedures and methods in order to do things.	Current procedures and methods have been identified but new procedures weren't sought.	The search for new procedures and methods is limited, unfinished and lacks in detail.	The search for new procedures and quality methods shows an adequate quality.	New procedures and methods were searched that were constant in time and duplicable.
	SI	Thinking up new ways of doing things.	New ways to make things haven't been identified.	A new way of doing things has been described, although the pros and cons are not yet understood.	Two or more new ways of doing things have been described, but not all the pros and cons are understood as yet.	Two or more new ways of doing things are described and all the pros and cons are understood.
INTEGRATION	**Learning outlook/Results**		**Level 1**	**Level 2**	**Level 3**	**Level 4**
	C	Expressing to someone else the generated ideas.	There isn't a predisposition for expressing new ideas.	The generated ideas are expressed at certain times and in reduced group sizes.	The generated ideas are expressed in most cases in more extended groups.	The ideas generated are always expressed to and amongst all groups.
	RO	Incorporating knowledge from a variety of disciplines, sources or fields in order to develop innovative ideas to apply in current or future situations.	Acquired knowledge from other fields is not integrated, preventing the development of innovative ideas.	A few innovative ideas have developed as a result of integrating a variety of disciplines and fields.	Most of the innovative ideas have developed as a result of integrating a variety of disciplines and fields.	Knowledge from a variety of disciplines, sources and fields is always integrated resulting in the development of innovative ideas.
PREDICTIONS	**Learning outlook/Results**		**Level 1**	**Level 2**	**Level 3**	**Level 4**
	EC	Identifying the innovation results.	The innovation results are not identified.	Some innovation results are identified but they are limited and lacking in detail.	The identified innovation results are complete and show good quality.	The identified innovations results are complete, show good quality and show an increase over time.
	EC	Considering who is going to be affected by the innovation, and in what way(s).	Is rarely considered who and how is going to be affected by the innovation.	At times is described who and how is going to be affected by the innovation.	In most cases is described who and how is going to be affected by the innovation.	In all cases it is described who is going to be affected by the innovation, and in what ways.
	MF	Assessing innovation risks and benefits.	Some risks and benefits are identified in a limited way.	An assessment is carried out to analyse the probability and potential repercussions of each risk or benefit.	An integral assessment of risks and benefits is carried out.	Risks and benefits are prioritised.

4 Conclusions

Rubrics facilitate the measurement of student performance in those areas that are complex to evaluate, through a set of graduated criteria for assessing learning, knowledge and/or skills gained by the student. The main advantage of this technique for students is to show them the different levels of achievement that can be achieved in a job, providing the aspects that must be met to achieve higher skill levels. Moreover, rubrics allow teachers an objective, fair and impartial evaluation by a scale that measures the skills and student performance. The innovation strategy followed in the project is highly transferable because address one of the generic competences and is not centered in the particular case of a subject. Finally it should be noted the importance of developing appropriate learning objects to facilitate the student's acquisition of skills, activity that is being developed under the educational innovation project OAICE.

5 Acknowledge.

The research has been conducted within the framework of the project for educational improvement (PIME/2013/A/016/B) 'RECICRE - Rubric for evaluating competence of innovation and the (A21/14) OAICE project (learning objects for Innovation, Creativity and Entrepreneurship Competence).

6 References

Bapat et al., (2014) Technical Report. http://www.chsbs.cmich.edu/leader_model/assess.htm

Cuenca L., Boza A., Alemany MME, Trienekens J.. (2013) Structural elements of coordination mechanisms in collaborative planning processes and their assessment through maturity models: Application to a ceramic tile company. Computers in Industry 64, 898–911

Cuenca L., Fernández-Diego M., Gordo M., Ruiz L., Alemany MME, Ortiz A. (2015). "Measuring competencies in higher education". Sustainable Learning in Higher Education. Innovation, Technology and Knowledge Management, pp 131-142

Ice 2014; Dimensiones Competenciales UPV Report Interno. ICE-Universitat Politècnica de València.

Idea Tempus, 2014 Inter Disciplinary Education Agenda http://tempus-idea.org.il/idea_wp/

Other references included in the project

Adams K., 2005 The source of Innovation and Creativity. A paper commissioned by the national center on education and the economy for the new commission on the skills of the American workforce.

American Federation of Teachers (AFT), National Council on Measurement in Education (NCME), & National Education Association (NEA). (1990). Standards for teacher competence in educational assessment of students. Washington, DC: American Federation of Teachers.

Black, P., & Wiliam, D. (1998). Assessment and classroom learning. Assessment in Education: Principles, Policy and Practice, 5(1), 7–74. CrossRef

Braun H., Kanjee A., Bettinger E., and Michael Kremer Improving Education Through Assessment, Innovation, and Evaluation. ISBN: 0-87724-058-2 by the American Academy of Arts and Sciences

Bruin, T. De., M. Rosemann, R. Freeze, U. Kulkarni, Understanding the main phases of developing a maturity assessment model, in: Proceedings of the 16th Australasian Conference on Information Systems, Sydney, Australia, 2005, pp. 1–10.

De Bruin, T., Rosemann, M., Freeze, R., & Kulkarni, U. (2005). Understanding the main phases of developing a maturity assessment model. In Proceedings of the 16th Australasian Conference on Information Systems, Sydney, Australia, 2005, pp. 1–10.

Gomez P.; Aguirre M.P.; Posso, F. y García G. (2002). Matriz de Valoración. EDUTEKA. http://www.eduteka.org/MatrizValoracion.php3

Goodrich H. (1997). Understanding Rubrics. Educational Leadership, 54(4), 14-17

Incode, 2012 Innovation competencies development as integral part of higher education. http://www.incode-eu.eu/en/

Kairisto-Mertanen, L., Penttilä, T., & Nuotio, J. (2011). On the definition of innovation competencies. In I. Torniainen, S. Mahlamäki-Kultanen, P. Nokelainen, & I. Paul (Eds.), Innovations for competence management conference proceedings. Series C, reports and other current publications. Part 83. Lahti: Lahti University of Applied Sciences, Esa Print.

Keeves, J. P. (Ed.). (1997). Educational research, methodology and measurement: An international handbook (2nd ed.). New York, NY: Pergamon.

Looney, J. W. (2009). Assessment and innovation in education. OECD Education Working Papers, No. 24, OECD Publishing. Retrieved from http://dx.doi.org/10.1787/222814543073

Lopez J.L. (2002). Uso de rúbricas generalizadas para evaluar conocimientos en la técnica didáctica Aprendizaje Basado en Problemas. Documento en internet www.mty.itesm.mx/rectoria/dda/rieee/html/2002.htm [

Marin-Garcia J.A., Pérez-Peñalver M.J., Watts F.(2013) How to assess innovation competence in services: The case of university students. Dirección y Organización 50 (2013) 48-62

Markwell et al, 2003 Improving teaching and learning in universities. Business/Higher education round table, issue 18, 2003

Navarro J.P; Ortells M.J,; Martí M. Las rúbricas de evaluación como instrumento de aprendizaje entre pares. giac.upc.es/JAC10/09/Doc_69.pdf

NCME, 1990 American Federation of Teachers (AFT), National Council on Measurement in Education (NCME), and National Education Association (NEA). 1990. Standards for Teacher Competence in Educational Assessment of Students.Washington, DC: American Federation of Teachers.

UNESCO, 2000 UNESCO 2000b. Status and Trends 2000: Assessing learning achievement. Paris:

Watts F., Marin-Garcia J.A., García Carbonell A., Aznar-Mas L. Validaton of a rubric to assess innovation competence. Working Papers on Operations Management. Vol 3, Nº 1 (61-70) ISSN: 1989-9068

Why Brazilian Women are not on Top: The Work-Life Reconciliation Hypothesis

Agostinho M[1]

Abstract: The female presence in middle management is already significant in Brazil. Yet, women hold only 7% of the board seats. Why are there so few women in corporative top ranks? Is it possible that prejudice and sexism work selectively, allowing women to ascend not beyond a certain point in corporate hierarchy? This paper rejects such perspective and aims at understanding the dynamics that drive women against the executive suite. The premise beneath this research is that women are not victims, but autonomous individuals. In order to test the hypothesis of Brazilian women choosing not to ascend, the first step was to analyse IBGE[2] data on work force and employment. Thereafter, the research explores the possibility that organisational dynamics is a major factor for women to deal with work-life issues. Studies of scientific organisations shows that flexibility helps conciliate work and life. The conclusion is: if corporations could emulate the scientific organisational environment, probably they would not only attract more women to the executive suite, but also adapt to a transforming society.

Keywords: Women; top-management; work-life balance; work organisation.

1 Introduction

The board of directors has been, in most cases, a male-exclusive space. In Brazil, it is not different. Women hold only 7% of the board seats of Brazilian companies (IBGC, 2011). This number, however, is not so low if compared with other countries. Although in Norway and Sweden women occupy more than one third of the positions on the highest levels, in many developed countries, the number of women at the top of the corporations ranges between 1% (Japan) and 15% (US).

The fact that it is rare to find women in top management positions has often been treated with sexist bias. Some authors argue that the lack of opportunities results from the old prejudice that pushes women towards so-called female occupations (Thiry-Cherques, 2003). According to this point of view, those occupations are not so well regarded as male ones and, therefore, their salaries – for women and men alike – are lower than salaries of typical male occupations. Others defend regulations that oblige organisations to promote a certain amount of women to high positions as a way to compensate them for a social injustice. In any case, those arguments imply that women are victims or, at least, passive individuals.

Since the 80's, literature has presented several arguments in favour of genre diversity among board members (Smith et al, 2006). Moreover, women have been proving their competence in many fields and the job market already recognizes their superior educational background. The female presence in middle management is already significant. Hence, why are there so few women (Brazilian, in particular) in corporate top ranks? Is it possible that prejudice and sexism work selectively, allowing women to ascend not beyond a certain point in the corporate hierarchy where their leadership is useful, but not too powerful to threat men on board?

This paper rejects such perspective and aims at understanding the dynamics that drive women against the executive suite. The premise beneath this research is that women are not victims, but autonomous individuals capable of acting in accordance to their judgement. Therefore, the focus is on aspects that

1 **Marcia Cristina Esteves Agostinho** (marciadecastro1994@gmail.com)
Centro de Conhecimento em Engenharia.
Universidade Estácio de Sá – UNESA. Campus Akxe.
Av. Prefeito Dulcídio Cardoso, 2900 - Barra da Tijuca,
Rio de Janeiro, RJ - 22631-052, Brasil.

2 Brazilian Institute of Geography and Statistics.

distinguish middle management from the highest positions and could make an eventual uprising less attractive for them.

2 Methodology

In order to test the hypothesis of Brazilian women choosing not to ascend, the first step was to analyse IBGE[3] data on work force and employment. Then, it was possible to identify women's behaviour regarding education, occupations, and turnover.

As turnover is a key-concept for the issue of career progress, the next step was to research the international literature, focusing on female turnover – mainly in top management. The results pointed to a relation between female turnover and work-life balance, suggesting that it tends to be higher than male turnover. Considering that such results may imply some cultural bias, it was decided to prioritize research papers from countries culturally similar to Brazil.

Thereafter, a study conducted in Portugal (Brandão, 2013) became an important reference to the present research. Investigating work in a scientific institute in Lisbon, the author did not observed any difference concerning female or male turnover. Such atypical findings provided the insight – explored here – that organisational dynamics is a major element for women to deal with work-life issues.

Previous researches on how scientific laboratories (Latour & Woolgar, 1997) and science-based companies (Agostinho, 1994) are operated suggest a remarkable difference between knowledge-based institutions and business corporations. Such differences in organisational cultural result in different workplace rules, which tend to be more favorable to flexible work arrangements. This would explain why many talented female managers quit their jobs in big promising corporations, changing to nonprofits agencies and educational institutions, or even risk themselves as self-employed.

This insight guided the interpretation of statistic data and the discussion of results.

3 Women at Work

More educated and in charge of their fertility control, women started the twenty-first century with a strong participation in the labour market.

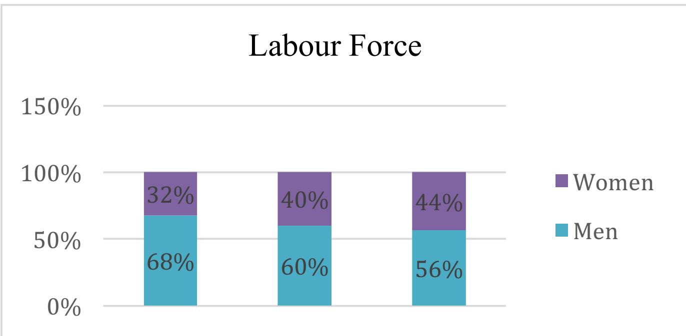

Fig.1
Economically active population in Brazil
years 1991, 2000 and 2010.

It is worth to note how intimate decisions – as having children – reflect upon aggregate numbers. In 1950, women had six children on average and they represented only 14.7% of the economically active population (Agostinho & Lopes, 2014). In 2009, however, the fertility rate in Brazil had already fallen to 1.94 children per woman, when women participation reached 44% of the economically active people. Yet, more than half of the economically active population is still male (56% in 2010). (IBGE - Census, SIDRA table 616)[4]

3 Brazilian Institute of Geography and Statistics.
4 http://www.sidra.ibge.gov.br/bda/tabela/protabl.asp?c=616&z=cd&o=2&i=P

Table 1
People available for work
Source: IBGE – PNAD Oct-Dec 2014.

Sex	Working-age population (million)	People in the labour force (million)	People in work (million)
Total	163.151	99.326	92.875
Men	77.670	56.091	52.977
Women	85.480	43.235	39.897

It is important to consider the absolute numbers. As shown on table 1, the quantity of women old enough to work is higher than the quantity of men with the same age. However, only half of them are willing to look for work. On the other hand, 72% of men are encouraged to find a job. It means that, in Brazil 2014, there are only 43 million women available for work, for any reason. It is worth to stress that, at the same time, 56 million men compete for a position in the job market.

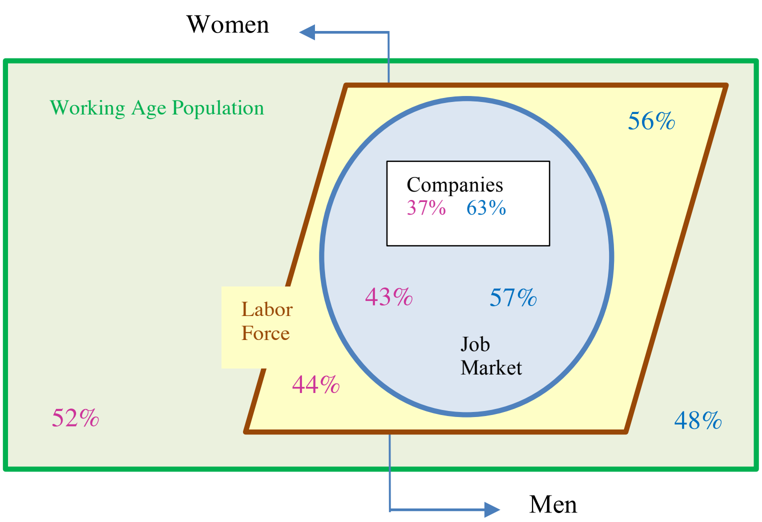

Fig.2
Proportion of men and women in the job market – Brazil Oct-Dec 2014.

Considering the numbers represented on figure 2, nowadays, the proportion of women and men who are in work is approximately the same as those in the labour force (43% / 44% for women and 57% / 56% for men). Therefore, it seems unlikely that job market expresses any prejudice or restrictions against female workers.

Furthermore, figure 2 also shows that the jobs held in companies are not a reality for most of working women. In that particular environment, 63% of employees are men. Although there are almost 40 million working women in Brazil, just 12 million[5] of them work in companies. In other words, 70% of such women have a different employment status.

Regarding the status of employment, table 2 reveals important differences between female and male decision-making.

5 http://www.sidra.ibge.gov.br/bda/tabela/protabl.asp?c=2718&z=p&o=5&i=P

Table 2
Employment status
Source: IBGE – SIDRA table 3461[6].

	Women %	Men %
Employed with contract	44%	46%
Employed without contract	**23%**	18%
Self-Employed	17%	25%
Civil service (including military)	**7%**	4%
Subsistence worker	4%	4%
Unpaid worker	**3%**	1%
Employers	2%	2%

Such statistics show that many women prefer civil service (7%) to a corporate career. The fact that only 4% of men go to civil service (including military) may suggest that women seek greater flexibility, but with less risk. However, women's aversion to risk is not so high, since 23% of women (against 18% of men) accept jobs without a contract. Thus, when they have to choose between flexibility and labour rights, women seem to stay with the first. The importance of flexible hours can also explain why so many women decide to work independently, as self-employed (17%) or employers (2%). But these numbers expose another important female trait: altruism. Unpaid work is three times more prevalent among women than among men, showing that female activity cannot be fully understood by the logic which governs corporate career success.

4 A Matter of Availability

Traditionally, women are in charge of family issues. Until some decades ago, maternity was seen as the reason why women could not dedicate her time to work as much as men do. However, the recent fall of fertility rate has not changed the protagonist role women play in the family. Even though many women have decided not to have any children, they have not given up on marriage. According to Brazilian official data (Agostinho, 2013), from 2003 to 2010, the number of marriages rose more than 30%. It means that, even if they are not mothers so frequently as before, they continue to be wives.

Table 3
Working hours per age and sex
Source: IBGE – Census 2010[7].

Sex	Hours per week	Less than 29 years old	30 to 39	40 to 49	50 to 59	More than 60 years old	All ages
Men	Less than 40	23%	16%	16%	19%	32%	20%
	40 to 44	47%	49%	48%	47%	41%	47%
	More than 44	30%	35%	36%	34%	27%	33%
Women	Less than 40	35%	31%	33%	38%	52%	35%
	40 to 44	44%	46%	44%	41%	31%	43%
	More than 44	21%	23%	23%	21%	17%	22%

The pattern of female working hours reflects women's duties and joys. It differs greatly from men's – although, like women, less than half men work the "typical" 40 or 44 hours per week. It should not be surprising that more than 1/3 of women work less than 40 hours per week. Probably, they would be more if those 52% of women over 60 years of age had also formal jobs in which 40 hours work is compulsory. In an environment of low flexibility as the Brazilian labour market, the oldest might be taking charge of

6 http://www.sidra.ibge.gov.br/bda/tabela/protabl.asp?c=3461&z=cd&o=13&i=P
7 http://www.sidra.ibge.gov.br/bda/tabela/protabl.asp?c=3582&z=cd&o=17&i=P

the care of the houses and the children of the 23% of younger women who dedicate more than 44 hours to work each week.

In 2010, nearly 8 million women worked more than 44 hours weekly (22% of women in the workforce). On the other hand, more than 16 million men were willing to dedicate much of their time to work (33% of power male). Therefore, there were twice as many men to take the top corporate positions.

In purely quantitative terms, this would be a reason for having more men than women in time-demanding jobs. After all, men are, at least, more available. Thus, what should be surprising is to see management positions equally distributed between men and women. Certainly, the level of education and the skills profile has favored women in this competition.

5 The Work-Life Reconciliation Hypothesis

If the focus of this research is on the kind of women that could be in the highest corporate ranks, it is useful to investigate work-life issues among women of the intellectual elite. After all, education has been considered as the main drive to professional ascension. Thus, scientists – in both universities and research institutes – become an excellent subject.

Two studies help to interpret our findings and to answer why Brazilian women are not on top: one, on academic scientists working with 9 universities in the US (Fox, Fonseca & Bao, 2011); another, on research scientists working in a technological institute in Portugal (Brandão, 2013). According to the American study, the fact of being married or having children under age 6 years increases the probability of work to family conflict only among men – *not* among women. The authors suggest that women scientists with children are highly selective in the way they devote time for work related activities.

It is worth to note that being ‘highly selective’ implies that those women have the power to decide when and where to perform their work. In other words, they have *autonomy* to manage their time, establishing priorities according to the changing demands of work and family.

Although scientists are also used to work extensive hours, it does not seem to cause a major impact on personal life. Brandão (2013) notes that “it is interesting to note that, despite the scientists/researchers of ITQB work 55 hours (...), they do not feel intensely the impact of work on his personal life”. She explains it with the fact that scientists have *flexibility*. They can leave the laboratory to solve urgent family problems and go on with their work afterwards.

Both these studies show the importance of autonomy and flexibility to manage work and family affairs. Contrary to university and scientific-based institutions, such things are not common in most companies. Even among top executives, a certain kind of “ethics of work” prevails, forcing people – men and women – to prioritize work over family.

The results presented here suggest that Brazilian women might be choosing not to ascend to the highest positions in order to better balance their professional and personal lives. Moreover, the interactions between man and women, both publically and privately, are becoming more symmetrical. In such context, it is reasonable to consider that male and female expectations will converge to the point of making corporations review their modes of organizing work towards alternatives that provide autonomy and flexibility.

Elsewhere (Agostinho, 2003; Agostinho & Castro, 2003), we developed an organisational framework whose fundamental aspect is autonomy. The ‘Autonomous Management System’ was designed to support teamwork and open communication, incorporating principles of network in the formal structure. Besides producing superior performance, this self-organizing management is able to help reconciliate the spheres of work and family which have being in conflict for so long.

6 Conclusion: In Search of Autonomy

Since the beginning of the last century, it has been evident the impact of social and psychological factors on work. The entry of women in the labour market enriched the discussion and provided new insights on motivation and work organisation. It also gave evidence to the conflict of work and family. The central argument in this paper is that such conflict is the main reason why so many women choose not to engage in top management jobs, mainly in the board of directors.

The scientific jobs have rules and dynamics that function as if it workers are presumed to be mature professionals adults, who are able to assume their responsibilities. The corporate jobs – which, in a certain sense, descend from industrial proletariat – are not used to rely on the capacity of judgement of the workers. If corporations could emulate the scientific organisational environment, probably they would attract more women to the executive suite and better adapt to a transforming society.

7 References

Agostinho, M. (1994). Da Bancada para o Balcão: como cientistas conduzem seus negócios. COPPE/UFRJ. Tese de Mestrado.

Agostinho, M. (2003). Complexidade e Organizações: em busca da Gestão Autônoma. São Paulo: Editora Atlas.

Agostinho, M. (2013). Vínculos: sexo e amor na evolução do casamento. Rio de Janeiro, Odisseia.Agostinho, M., Lopes, A. (2014). Reprodução e Produção Reflexiva: números de um Brasil menos fecundo. Revista Aquila, (10), 55-67.

Agostinho, M. E., & Teixeira de Castro, G. (2003). Co-creating a self-organizing management system: a Brazilian experience. In Complexity, Ethics and Creativity Conference. London School of Economics. Available in: http://www.researchgate.net/publication/237675945_CO-CREATING_A_SELF-ORGANIZING_MANAGEMENT_SYSTEM_A_BRAZILIAN_EXPERIENCE.

Brandão, D. P. (2013). Conflito trabalho-família e intenções de turnover na profissão de cientista em Portugal: o caso do ITQB.

Fox, M. F., Fonseca, C., & Bao, J. (2011). Work and family conflict in academic science: Patterns and predictors among women and men in research universities. Social Studies of Science, 0306312711417730.

IBGC (2011) Relatório de mulheres na Administração de Empresas Listadas.
Available in: http://www.ibgc.org.br/userfiles/files/Mulheres_no_Conselho.pdf

IBGE (2010). Censo Demográfico. Available in: http://www.ibge.gov.br/home

Latour, B., & Woolgar, S. (2013). Laboratory life: The construction of scientific facts. Princeton University Press.

Smith, N., Smith, V., & Verner, M. (2006). Do women in top management affect firm performance? A panel study of 2,500 Danish firms. International Journal of Productivity and Performance Management, 55(7), 569-593. Available in: http://www.emeraldinsight.com/doi/abs/10.1108/17410400610702160

Thiry-Cherques, H. R. (2003). Condição feminina e percepção dos valores morais no nível gerencial e técnico das organizações brasileiras. Revista de Administração Publica, 477-511.

Competitive strategies adopted by the Brazilian sugar and alcohol sector after the 1990s

Vargas J[1], Costa V[2]

Abstract: The evaluation of the evolution of the Brazilian sugarcane industry reveals deliberated intervention of the State, from the 1930s to the early 90s. The strong state presence set up a paradigm of subsidy, as a role performance model. Deregulation in the 1990s rouse the adoption by businesses of strategies aimed at increasing its competitiveness in a scenario marked by fierce competition. In this context the present study from bibliography about this sector identified the main competitive strategies used by sugarcane mills in the post-deregulation period and concluded that most mills experienced a technological upgrade and modernization of management models.

Keywords: sugarcane agroindustry, competitiveness, deregulation, competitive strategies.

1 Introduction

Sugar production marks the Brazilian Economy since the colonial period and has gone through several phases. From the second half of the nineteenth century the government implanted the incentive policy that increased the production of the ingenuities of sugar cane; because of this new grinding capacity they came to be designated sugar mills (Neves; Batalha, 1997).

According to Leite (2008), the process of state intervention in the sugar and alcohol sector before 1930 happened without any established institution specifically for this purpose. The creation of the Sugar and Alcohol Institute (IAA) in 1933, represented the introduction of regulatory mechanisms with designation of quotas of production, pricing and subsidies. (Shikida, Moraes & Alves, 2004).

In 1975, in the context of State protection it was instituted the National Alcohol Program (PROÁLCOOL) in order to encourage the production of alcohol, modernizing and expanding distilleries and increasing agricultural productivity. This program set up a paradigm of subsidy that has continued throughout the period of its validity.

Due to the strong guardianship and state regulation, the profitability of the sugar and alcohol sector remained ensured for decades, not causing competitiveness expansion actions.

The end of the IAA activities in March of 1990, was a milestone in the deregulation process. The deregulation process involved the release of production and commercialization, formerly under the guardianship of the State, the end of the state monopoly on exports, the extinction of quotas for commercialization and domestic production of sugar and the release of the commercialization of alcohol fuel. These changes led to sugar and alcohol agroindustry to a phase characterized by a new competitive environment, a valorization scheme of market policies and of competition among the companies in the sector (Ramos & Souza, 2005).

The extinction of the IAA opens the implantation of a new dynamic, marked by the adoption of strategies of several orders on the initiative of the sector and the companies which compose it. Among the strategies, we highlight: vertical integration, Mergers & Acquisitions (M&A), capital internationalization which modify forms of ownership and management, reaching a large number of companies (Abdo, Vian& Lima, 2006; Borges & Costa, 2009; Bacarin, Gebara & Factore, 2009; Ramos & Souza, 2005; Vian, 2003).

Understanding this process requires theoretical support that enables the domain of some concepts, among them: competitiveness, competitive strategy and types of strategies.

1 **Joacyr Vargas** (jvargas.adv@gmail.com)
2 **Vera Mariza Henriques de Miranda Costa** (verammcosta@uol.com.br)
Programa de Mestrado Profissional em Engenharia de Produção UNIARA,
Centro Universitário de Araraquara – Araraquara/SP – Brasil – CEP: 14.801-340.

The main aim of this study is to characterize and identify the main competitive strategies adopted by the Brazilian sugar and alcohol sector after deregulation process in the 1990s.

The article was developed from bibliography research, used for conceptual theoretical support; to characterize the evolutionary process of this sector; and for the identification and characterization of the competitive strategies adopted by this sector and by the companies that compose it. The research fits as longitudinal, since analyzes the evolution of a process. As to the objectives is classified as descriptive as it outlines this process and the strategies adopted from a certain point of its evolution. As for addressing the problem and the treatment of information collected is classified as qualitative research (Turrione & Mello, 2012; Yin, 2005).

2 Competitiveness and Competitive Strategies

According to Herrera, et al. (2005), the absence of a precise definition of competitiveness in the literature is due to the fact that the term is related to the types of proposals addressed and the methods used to get it.

In turn, competitiveness elapses from strategic actions that aim to adjust the company to competition to even gather ability to interfere in the characteristics of the competitive environment to making changes in its favor. (Herrera, et al. 2005).

According to Sobral & Peci (2008) the concept of strategy has a close correlation with competitive situations, involving themselves in the diversification of the organizations and the growing dynamism of markets and the organizational environment.

Ansoff (1991) defines strategy as "... one of the several sets of decision rules to guide an organization's behavior." Therefore, by adopting a specific approach aiming to obtain a good performance in many strategic areas of the business the company is implementing a competitive strategy.

For Ansoff (1991) the strategies that have acquired greater importance from the end of the twentieth century were: 1) the traditional, 2) of growth, 3) of the market differentiation and 4) of product differentiation and services. The first, aimed to maximize market share; the second, focused on ensuring the future growth of the organization; the third in the search for an image of differentiation for their products and services; the fourth in order to build a differential to its products and services in relation to those provided by competitors.

For effect of proposition of a competitive strategy, the competing industries and the own structure of the company constitute themselves in the main component of the organization's environment. The fact that the general environment and the external forces have impact all firms gives to them a relative influence. Thus, it is important for the organization to develop their own and differentiated skills and to interpret and deal with such forces, considering that an organization's relationship with its environment is the main objective of structuring a competitive strategy (Porter, 1991).

Hooley & Saunders (1996) consider that among the factors that directly affect the competitive position of a market, sector or even an organization are the factors related to a wider environment, composed from economical oscillation, political and legal factors, degrees of regulation, social acceptability and environmental impact. The authors estimate that the regulation factor affects the freedom of action of the organizations and when it is removed enhances the difficulties of the companies facing the competition.

2.1 Ratings Strategies

Porter (1991) proposes three categories of strategies: differentiation, leadership into the cost and focus. The differentiation relates to the development of a strong identity, which turns the product or service clearly distinct from the competitors. Leadership in the cost seeks to offer a product or service cheaper than the competitors. The focus strategy is aimed to the definition of a niche or market segment that can regard products or services, specific groups of customers or specific geographic markets.

Miles et al. (1978) from challenges to be faced by organizations define four types of strategies or adaptation patterns, involving: defensive behavior, prospective behavior, analytical behavior and reaction behavior. The defensive is identified in organizations with a high level of specialization, which prefer to remain working in situations in which they are accustomed to do it. The prospective behavior is typical of organizations devoted to investigation of new opportunities. The analytical is characteristic of companies that operate in two markets, a stable one and the other in the process of changing and finally the behavior of reaction is typical of companies operating in unstable environments and at the same time dealing with inefficient administration to operate adjustments in its structure or strategy.

Certo & Peter (1993) highlight, for analysis, four types of strategies: concentration; stability; growth; and reduction of expenses. They assert that in the concentration strategy the company uses its expertise and efficiency to build up a competitive advantage. The stability strategy elapses from defensive behavior that, according to the authors, may be necessary in fields where there is no growth and there are no new opportunities. The growth strategy is adopted at the possibility of using several mechanisms such as, M&A, partnerships, etc. The strategy of reduction of expenses is used in cases when the company needs to improve its efficiency to remove threats to its survival.

According to Maximiano (2005), the knowledge of the threats and opportunities presented in the environment, as well as the identification of strengths and weaknesses points of an organization are essential factors for the definition of strategies to be adopted.

It is important do special reference to the vertical integration a strategy, widely used in various segments of the Brazilian and international markets. It consists in concentration within the same organization of distinct processes such as production of raw materials, the development of products, commercialization and other processes, which requires organizational and managerial adjustments. The integration takes place "backwards" when the company has control of part or all of the inputs needed for production and "forward" when it starts to control the commercialization and the distribution process.

Another important competitive strategy widely used especially in moments of market restructuring is the productive diversification whose basis is to avail the corporate assets of the companies to the production of other goods or to operate in new markets. (Vian, Abdo & Lima, 2007).

3 Identified Strategies in the Sugar and Alcohol Sector post-deregulation

Waak, Neves & Moraes (1998) proposed the distribution of the strategies adopted in four groups using as a criteria: behavior towards protectionist measures of the State; marketing action; action related to technological diversification, and organization of partnerships. In the first group the strategic decisions are directly associated to the trend of the units to take risks: some companies prioritize the survival under State protection while others choose for the adoption of the competitive strategies and State detachment. In the second group, referenced to the marketing action are five distinct strategies: increase in scale and production efficiency with an increase of the shares in the international market, differentiation and market segmentation offering portfolio of product options, vertical actions with investment in own brands and retail distribution, alternatives for packaging and ways of presenting the product; a acting expansion in the food market. The technological approach delimits the third group and enables to identify patterns associated with productive diversification. In the fourth group are the companies that adopt strategies related to partnerships and creation of consortia with different strategic lines.

To Paulillo, Vian & Mello (2008) the entrance of multinationals in the sugarcane sector led many companies to invest in changing the organizational structure with professional management in the pursuit of greater competitiveness.

Baccarin, Gebara & Factore (2009) state that the trend towards the vertical integration in the sugar and ethanol industry in Brazil is historic and dates back to the ingenuities of sugar cane of the colonial period. This feature continues to today, since the agricultural and industrial capital belong in large part to the same agent.

The vertical integration strategy in the sugarcane and alcohol sector presents advantages and disadvantages that need to be considered, being able to fit among the advantages the assurance of receiving the raw materials and a greater power in the negotiation together with the independent suppliers and as disadvantages a greater need of capital and land at detriment from the main aim of the business: production of sugar and alcohol (Baccarin, Gebara & Factore, 2009).

Deregulation unleashed sector concentration movement, through M&A as growth strategy, becoming accounted for 80 operations between the years 2000 and 2007 (Baccarin, Gebara & Factore, 2009).

Borges & Costa (2009) studying the M&A processes in the Brazilian production of sugar and alcohol (ethanol), from 1995 to 2008 concluded that such operations represented only a change in ownership of companies, not resulting in increased output, contributing, priority, for internationalization and concentration in the sector.

The adoption of product differentiation and productive diversification strategies enabled add value to and enhance the production capacity (Abdo, Vian & Lima, 2006).

According to Porter (1991) the adoption of the differentiation strategy enables results above the average in an industry. Therefore, the product differentiation in the sugar and alcohol industry is a strategy that provides better conditions, especially to face and overcome the challenges posed by exogenous factors.

The strategy of specialization and production qualification, according to Abdo, Vian & Lima (2006) enables to improve production efficiency through the contribution of resources which occurs in the concentration and centralization processes signaling deep changes in the structure of the sugar and alcohol sector.

To Shikida, Moraes & Alves (2004) the deregulation of the Brazilian sugar and alcohol (ethanol) sector caused the enhancement of competitiveness, supported in the production capacity, product differentiation and cost reduction. Thus the economic and social differentiation and the differences in competitiveness between regions or producers are no longer guiding factors of protectionist policies.

The deregulation required that the production units would structure a model of management system in order to regard new technological and organizational needs aiming the rationalization of commercialization of sugar and alcohol. Marques & Paulillo (2012) consider the creation of commercialization groups to meet the conditions imposed by the distributor of fuels one of the most important strategies resulting from the deregulation process, despite the coordination problems typical in the sector.

Among the actions taken by the companies of this sector in this restructuring period it should be highlighted: 1) the search for increased effectiveness and efficiency in the production of sugar and alcohol 2) the investment in product differentiation – many types of sugars and packaging 3) the enhancement of capacity installed aiming to diversify goods and services produced and explore new markets 4) the Merger and Acquisition operations aimed at expanding and exploring new agricultural regions 5) the search for strengthening the negotiating power towards buyers with the structure of commercialization groups 6) changes in the organizational structure and management model in the search for competitiveness to deal with the inflow of foreign capital in the sector.

One should also mention the vertical integration "backwards", a strategy traditionally used for most of the sector units.

4 Conclusion

The deregulation demanded a period for adaptation to the new scenario, since the plants were accustomed to act in a regulated environment. The deregulation prompted companies to develop strategic actions aiming at survival and development in this new competitive landscape.

Considering the exception of companies that chose to defensive survival strategies under the aegis of the State, most mills, regardless of their size, used a lot of ways of organizational and operational strategies, aimed the industrial and agricultural segment.

The evaluation of the strategies adopted allows to seize the effort expended by the mills to become more competitive, both in the domestic market and in the foreign market and equate the shortcomings of production and productivity built up during the phase in which the sector remained regulated.

We conclude that the process of adaptation and preparation to work in a more competitive environment resulted for most mills in an opportunity to diagnose their strengths and weaknesses points and to progress in technological upgrading and modernization of management models.

5 References

Abdo, et al (2006) Estratégias administrativas e operacionais utilizadas pelas usinas de açúcar e álcool da região de Ribeirão Preto (SP). XLIV CONGRESSO DA SOCIEDADE BRASILEIRA DE ECONOMIA, ADMINISTRAÇÃO E SOCIOLOGIA RURAL. Fortaleza, 23 a 27 de Julho.

Ansoff I (1991) A nova estratégia empresarial. São Paulo: Atlas.

Bacarin JG, Gebara JJ, Factore CO (2009) Concentração e integração vertical do setor sucroalcooleiro no centro-sul do Brasil, entre 2000 e 2007. Informações Econômicas, SP, v.39, n.3.

Barros GSAC, Moraes MAFD (2002). A desregulamentação do Setor Sucroalcooleiro. Revista de Economia Política, vol. 22, nº 2 (86), São Paulo, abril-junho.

Borges ACG, Costa VMHM (2011). Distribuição dos desembolsos do BNDES no setor sucroenergético no Brasil. Estudos Geográficos, Rio Claro, 9(2):73-88, jul/dez.

Borges ACG, Costa VMHM (2009) Fusões e aquisições no setor sucroalcooleiro pós desregulamentação. XXIX ENEGEP - ENCONTRO NACIONAL DE ENGENHARIA DE PRODUÇÃO. A Engenharia de Produção e o Desenvolvimento Sustentável: Integrando Tecnologia e Gestão. Salvador, BA, Brasil, 06 a 09 de outubro.

Certo SC, Peter JP (1993). Administração Estratégica: planejamento e implantação da estratégia. São Paulo: Makron Books, 1993.

Herrera, et al (2005). A competitividade da agroindústria sucroalcooleira do Brasil e o mercado internacional: barreiras e oportunidades. XLIII CONGRESSO DA SOBER- "Instituições, Eficiência, Gestão e Contratos no Sistema Agroindustrial", Ribeirão Preto, 24 e 27 de Julho.

Hooley GJ, Saunders, J (1996). Posicionamento competitivo: como estabelecer e manter uma estratégia de marketing no mercado. Tradução: Luiz Liske; revisão técnica Arão Sapiro. São Paulo: Makron Books, 1996.

Leite SIS (2008). A agroindústria canavieira em Catanduva-SP: evolução e progresso (1954-2005). Temas em Administração: Diversos Olhares, v. 1, n. 1, p. 7 – 13, jan/dez.

Maximiano ACA (2005). Teoria Geral da Administração: da revolução urbana à revolução digital. 5. ed. São Paulo: Atlas.

Miles RE, et al (1978). Organizational Strategy, Structure, and Process. Jr.Source: The Academy of Management Review, v.. 3, n. 3, jul. pp. 546-562. Published by: Academy of Management Stable.

Neves MR, Batalha MO (1997). Desenvolvimento e novas tendências do setor sucroalcooleiro. GEPAI - Grupo de Estudos e Pesquisas Agroindustriais – UFSCar, Niterói/RJ.

Paulillo LF, Vian CEF, Mello FOT (2008). Autogestão, governança setorial e sustentabilidade no complexo agroindustrial canavieiro no século. Revista de Política Agrícola, Ano XVII – nº 1, Brasília, Jan./Fev./Mar.

Porter ME (1991). Estratégia competitiva: técnicas para análise de indústria e da concorrência. Rio de Janeiro: Campus.

Ramos DAR, Souza JG (2005). As transformações do setor sucroalcooleiro e seus impactos na composição orgânica do capital: uma análise do setor no município de Sertãozinho-SP. XLII CONGRESSO DA SOCIEDADE BRASILEIRA DE ECONOMIA, ADMINISTRAÇÃO E SOCIOLOGIA RURAL, Ribeirão Preto/SP.

Shikida PFA, Moraes MAFD, Alves LRA (2004). Agroindústria canavieira do Brasil: intervencionismo, desregulamentação e neocorporativismo. Revista de Economia e Agronegócio, vol. 2, n.3, Viçosa/MG.

Sobral F, Peci A (2008). Administração: teoria e prática no contexto brasileiro. São Paulo: Pearson Prentice Hall.

Turrioni JB, Mello CHP (2012) Metodologia de Pesquisa em Engenharia de Produção: Estratégias, métodos e técnicas para condução de pesquisas quantitativas e qualitativas. Itajubá: UNIFEI.

Vian CEF (2003). Agroindústria Canavieira: estratégias competitivas e modernização. Campinas/SP: Átomo.

Vian CEF, Abdo MD, Lima RAS (2007). Estudos de casos sobre as estratégias administrativas e operacionais utilizadas pelas usinas de açúcar e álcool da região de Ribeirão Preto (SP). A Economia em Revista,vol.15, n.1, Maringá/PR, julho.

Waack RS, Neves MF, Moraes S (1998). Grupamentos estratégicos nas usinas de açúcar e álcool. III SEMEAD. São Paulo, 21 a 23 de outubro.

Yin RK (2005) Estudo de caso: planejamento e métodos. Trad. Daniel Grassi. 3 ed. Porto Alegre: Bookman.

Key Parameters for the Analysis Stage of Internationalisation of Operations[1]

Hanzel Grillo, Josefa Mula[2], Sandra Martínez, Ander Errasti

Abstract: In this paper, we identify the key parameters to consider in a decision model on internationalisation of operations. In order to propose these parameters, the GLOBOPE framework was adopted as the basis of this work. This framework contemplates the three commonest challenges of global operations configuration for industrial manufacturing companies in an internationalisation process, which are: new facility implementation (NFI); global suppliers network development (GSND); multisite production network configuration. We herein provide a set of suitable parameters for NFI and GSND in the analysis stage from strategic, tactical and operational decision levels.

Keywords: Internationalisation of operations, key parameters, new facility implementation, global suppliers network development, analysis stage.

1 Introduction

Martinez (2013) defines internationalisation of operations as the deployment of business resources all over the country itself by locating people and assets to execute primary activities of the value chain. Researchers and professionals have shown a relatively dispersed interest in internationalisation of operations.

This study is based on the works of Errasti (2011), Martinez (2013) and Martínez et al. (2013), which summarise the main contributions made by researchers from the field of internationalisation of operations processes as regards principles, tools and techniques to support managers and professionals in the analysis, design and management process of a global production and logistics network. These contributions are summarised within the framework known as Global Operations (GLOBOPE), which is divided into three main parts: new facility implementation (NFI), global suppliers network development (GSND) and multisite production network configuration (MPNC). The development and implementation of NFI, GNSD and MPNC is structured through the subdivition into stages; analysis, set up, stability, improvement and excellence. In this paper, we focus on the analysis stage of NFI and GSND types. We aim to explore different indicators that could be used in the analysis stage in order to evaluate the suitability for an enterprise or supply chain in the decision making process of internationalising their operations. The main objective is to identify those indicadors in order to set them as a basis for future research directed to develop mathematical analysis and modelling for decision supporting in this area. Here, we are sintetising a revision of each of the references mentioned by Martinez (2013) in the analysis stage for NFI and GSND, where we search for specific indicators. In this context, this study aims to present the resulting set of the main key parameters to consider in the analysis stage of the NFI and GSDN. The rest of the paper is arranged as follows. Section 2 introduces a brief description of related works, meanwhile section 3 presents a quick general introduction of GLOBOPE framework. Section 4 presents the resulting set of indicators obtained after the literature revision. Section 5 presents a discussion over the set of indicators proposed and, finally, section 6 provides the conclusions.

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2 **Josefa Mula** (fmula@cigip.upv.es)
Centro de Investigación en Gestión e Ingeniería de Producción (CIGIP).
Escuela Politécnica Superior de Alcoy,
Plaza Ferrándiz y Carbonell, 2, 03801 Alcoy, Alicante, Spain.

2 Related works

The scientific literature includes a variety of studies that mainly analyse case studies of companies that have had to extend their operations, of either the production or services type, to other frontiers. Andersen (1997) revises theories and conceptual models to establish the supply chain, transaction costs and organisational capacity to enter new markets; it has been established that coherence between theory and the operational level is lacking. Coviello and McAuley (1999) review empirical research works conducted into the internationalisation of small companies in a direct foreign investment context. They identify standards in several dimensions in the various cases they analyse, such as characteristics, methods used, etc. Prasad and Babbar (2000) examine the literature on the structure that internationalisation of operations takes, where a tendency of delimiting the region or country where companies are located, level of industrialisation, etc. is identified in the research works. Etemad (2004) reviews theoretical frameworks that refer to small and medium enterprises (SMEs)' internationalisation, the characteristics that lead companies to undertake internationalisation, and the pros and cons of this process compared to large firms. Sommer and Troxler (2007) analyse outsourcing and offshoring processes from a more empirical perspective by conducting interviews and making evaluations with consultants from several companies who have undertaken both processes. They stress the advantages, risks and impact of the occupational situation in saturated markets. De Toni and Parussini (2010) review the scientific literature on the origins and evolution of the international production network. Other studies focus on the more profound analysis of the specific areas or processes in developing internationalisation. Initially by analysing the internationalisation of four Swedish companies, Johanson and Wiedersheim (1975) describe the process that has allowed them to reach their current international position. Johanson and Vahlne (1977) develop an internationalisation process model of a company that focuses on gradual acquisition, integration and use of knowledge about overseas markets and their growing commitment with the company. Johanson and Vahlne (1990) describe the internationalisation mechanism based on the previous model. Dawson (1994) explains the need for the theoretical explanations of existing frameworks in the internationalisation of operations-related cost paradigm not having so many differences between some companies and others; this work analyses the specific retail case of internationalisation of operations. Eriksson et al. (1997) analyse the relationship between lack of knowledge about markets, businesses and foreign institutions and the subsequent internationalisation process cost. More recent studies present the first theoretical assays to qualitatively and quantitatively analyse the decision made to internationalise. Hammami et al. (2008) determine the importance of characteristics like cost, constraints and decisions in the delocation process problems that must be included in the supply chain's design models. Kedia and Mukherjee (2009) present an analytical framework with the reasons why companies subcontract processes or services in global markets. Aspelund and Butsko (2010) examine decisions made by SMEs to subcontract production operations to low-cost countries, including motivation, location, etc.; they also study the relationship between decisions and subsequent international market expansion. Mediavilla et al. (2012) explore the application of the model of Ferdows (1997) to make good use of overseas plants, which they include in their analysis of the strategic role in global operations networks to extend the scope of the model by applying a road map to gradually improve the plant's role in the global market. Armengol et al. (2014) propose a conceptual model for a representative cost structure associated with internationalisation of operations.

We could cite other similar studies from the existing wide variety, but most describe the internationallisation processes, and do not specifically analyse the evaluation and relevance of the decision to internationalise in depth. Thus, we have based our investigation in the GLOBOPE framework, by going directly to the proposed literature in the analysis stage of NFI and GSND. The objective of this paper is to set up an initial set of measures that, quantitatively, provides the elements needed to develop a decisional model for the analysis of the pertinence of internationalisation of operations.

3 The GLOBOPE framework

Errasti (2011) defines GLOBOPE as a framework for the design and configuration process of a global production and logistic network, which can be a useful management tool for SMEs, strategic business units (SBUs) and steering committees that are responsible for global operations being effective and efficient. According to Martínez et al. (2013), GLOBOPE bears in mind the key decisions of the operations strategy that need to be made about a global production and logistic network configuration and design in the internationalisation process. The framework considers three core challenges relating to operations configuration: NFI, GSND and multisite production network configuration. All the previous problems must be dealt with according to five main stages: analysis, set up, stability, improvement and excellence. In this paper, we consider the analysis stage to identify the key quantitative parameters that allow the detailed evaluation of key decisions that must be made before devising the internationalisation plan.

4 Key parameters for the GLOBOPE-based analysis stage

Martinez (2013) proposes different principles, methods and tools to evaluate the key internationalisation of operations decisions made in the analysis stage. Here we reviewed all these principles, methods and tools, as well as the reference literature proposed. Several parameters were identified, which can be quantifiable to evaluate each key decision. The objective is to obtain an initial basis of the evaluation parameters for the internationalisation of operations process analysis. These parameters could *a posteriori* be interpreted using mathematical programming models, analytical formulations or simulation models based on system dynamics. Tables 1, 2 and 3 provide the results of the review conducted, which was based on Martinez's initial proposal (2013). Key decisions and bibliographic sources according to the GLOBOPE framework were included, and the key parameters were also directly included, which were identified to evaluate the key decision for both NFI and GSDN.

5 Discussion

Table 1, Table 2 and Table 3 show the resulting set list of KPI identified in the literature referenced in the analysis stage for NFI and GSND. We have identified several indicators for each decisional level, and inside of each decisional level, for each specific key decision. Now, we have found that, many of the indicators are participating, simultaneously, in several key decisions along of NFI and GSND. This fact means that, the list could be refined by identifying all these relationships among indicators with the key decisions they could support. Due to that, in order to set a initial basic list of KPIs to develop decisional mathematical models, a refining steps must be conducted to eliminate redundant information by considering that one same KPI could contribute to multiple key decisions. Then, the resulting list fo this work is a valuable starting point because of it states a global set of information, containing all the main parameters to be taken into account. Future research steps must be oriented to structure, summarise and relate them. Once these activities have been done, the mathematical modelling can be developed.

Table 1
Key parameters for the analysis stage. NFI strategic decisions.

Key decisions/sources	Key parameters		
Manufacturing facility location (MacCarthy and Atthirawong, 2003; Abele et al. 2008)	Cost per square meter of construction Distance from relevant markets Potential restructuring and closure costs Government restrictions cost Total production cost	Land cost Total transport cost Material cost Capital productivity Freight rates	Technology cost Capital cost Labour productivity
Facility strategic role (Ferdows, 1997)	Qualified and specialised personnel Access to low-cost production	Availability of subsidies Market proximity	
Integration or fragmentation of productive and logistics operations: Make or buy decisions	Economic value added Technology clock speed Competitive cost structure Customer importance	Total costs Revenues Assets Architecture	Strategic value added Competitive position Capable suppliers Procurement cost
Service delivery strategy • Supply strategy (Poler et al. 2002)	Strategic quality factor of human resources Tactic quality factor of human resources Operational quality factor of human resources	Quality in information Human resources cost Interruptions in decision	Quality of decision
• Manufacturing strategy (Miltenburg 2009, 2005; Martinez, 2013)	Currency cost savings Local production cost Other production costs Effectiveness of learning curves Cost savings due to offshore factories Reliability in due date achieving	Logistic costs Cost of material Cost of overhead Cost of labour Delivery time Innovativeness	Product quality Flexibility Accessibility Learning Mobility Thriftiness
• Purchasing strategy (Trautmann et al. 2009; Gelderman and Semeijn, 2006)	Activity of competence Dominant suppliers conditions Knowledge and volume of purchases Added value of purchases product Degree of aggregation of purchases Profitability of the final product purchase	Relevant supply market Purchase complexity Strategic partnership Ordering cost Purchase difficulty Supplier performance	Assurance of supply Safety stocks Flexibility e-procurement Cost savings Supply risk
Global Operations Network • Distribution network (Abele et al. 2008; Waters, 2003)	Government restrictions cost Distance from relevant markets Potential restructuring and closure costs	Total transport cost Technology cost Total production cost	Material cost Freight rates
• Manufacturing network (Martinez, 2013)	Manufacturing network type Logistic costs per geographic area Scope of the manufacturing network Cost savings due to offshore factories Delivery reliability in due date achieving	Innovativeness Cost of material Cost of overhead Local production cost Other production costs	Cost of labour Delivery time Product quality Flexibility
• Suppliers network (Meixell and Gargeya, 2005; Kraljic, 1983)	Fixed and variable costs Establish local/global suppliers Abundant variety of suppliers Leverage, bottleneck and strategic items Robustness across pre-defined scenarios Production and purchase costs Commodities and special materials	Market penetration Export/import levels, Currency exchange rate Corporate income tax Profit Facility utilisation Functional efficiency	Time horizon Bottleneck items Decentralisation Scarcity supply Losses Sales Tariffs/duties

6 Conclusions

This work reviewed the GLOBOPE framework as a suitable means to analyse the internationalisation of operations process because the literature on this matter is disperse. This analysis was carried out specifically in the analysis stage of the GLOBOPE model. Here key decisions were evaluated before implementing and setting up the internationalisation of operations process. The key parameters that can be employed as a basis to quantitatively evaluate these key decisions were identified. Tables 1, 2 and 3 summarise the possible parameters for each GLOBOPE framework, NFI and GNSD possibility, along with their strategic, tactical and operational decisions. This series of parameters must act as a basis for future research lines in which the most relevant decisions are indentified, and duplicities are refined and eliminated to comprehensively measure each decision. This is done to establish future mathematical or dynamical evaluation models based on empirical or historical data of standards, and on information about the company interested in being internationalised, in order to objectively determine the quantitative criteria of the relevance, or not, of extending operations to other latitudes.

Table 2
Key parameters for the analysis stage.
NFI tactical and operational decisions.

Decisions/sources	Key parameters		
Plant and factory construction or adaptation (Martinez, 2013)	Greenfield: New facilities from the ground		
	Brownfield: Acquisition of existing resources		
Technological level of the facility and automation level of the process (Ferdows, 1997; Corti et al. 2009)	Availability of subsidies	Labour force characteristics	Training facility
	Competitors activity	Proximity to suppliers	Costs
	Access to low-cost production	Macroeconomic factors	Site competence
	Proximity to markets/customers	Local managers availability	Quality of life
	Proximity to headquarters	Legal context	Infrastructure
	Qualified and specialised human resources	Political factors	
Facility material flow design and planning process (Errasti, 2006; Muther et al. 1981; Tompkins, 2010)	Return of assets (ROA)	Variety of suppliers	Customer satisfaction
	Equipment effectively	Stability in production	Supply chain profitability
	Return on investment	In transit stock	Space and energy effectively
	Job satisfaction	Service level in delivery	Security safety
	Sustainability and resilience	Transport cost in supply	Environmental responsibility
	Inventory levels of raw materials	Production sequencing	Housekeeping
	Partnership and communication	Finished product stock	Material control
	Economic Ordering Quantity	Reordering point	Personnel effectiveness
	Stock level in regional distribution centres	Supply price	Material handling
Facility layout design (Muther et al. 1981; Hayes and Wheelwright 1984; Lluís, 2009)	Production quantity and rate	Size of packages (in/out)	Workstations type
	Product design and specification	Cost of direct labour	Required machinery
	Human resources (person/hours)	Accessories costs	Materials flow
	Movements of materials and products	Generated layout cost	Initial investment
	Average weight per shipment (in/out)	Space requirements	Material handling cost
	Seasonal variation of shipments	Similarity operations/process	Product type
	Daily variation of shipments in products	Setup costs	Operational costs
	Quantity/variety of materials and product	Depreciation costs	Installation costs
	Number of trucks (in/out) per day	Capacitation costs	Operating times
	Number of packages issued (in/out)	Production lifecycle	Services
Areas and workstation detailed design (Lluís, 2009)	Amount of required equipment	Required surface	
	Distribution of equipment and workstations		
Procurement, distribution, installation and location of equipment (Knoepfel, 1983)	Total income	Land cost	Salaries
	Depreciation	Interest rate	Risk level
	Operations expense	Total profit	
Procurement tools and jigs (Yurdakul, 2004)	Depreciation on machinery	Setup time of an activity	Selling cost
	Material handling and storage	Direct material cost	Administrative cost
	Machine maintenance and supply	Production planning	On-time shipments
	Time between order and delivery	Direct labour cost	Material utilisation
	Variety of part types manufactured	Process quality	Scrap and rework
	Actual machining time of a typical part	Shipment accuracy	Inventory
	Number of operations per machine tool.	Manufacturing lead time	Lot size
Shop floor management design (Szulanski, 1996)	Eventfulness of knowledge transfer	Reliability of best practices	
	Organisational support to development of transfers		

Table 3
Key parameters for the analysis stage. GSND decisions.

Decisions/sources	Key parameters		
Link between business and purchasing strategy (Slack and Lewis, 2002)	Supply network configuration	Organisational structure	Quality
	Standardisation and improvement	Suppliers	Location
	Responsiveness in time and volume	Variety and flexibility	Costs
Make or buy (Fine et al. 2002)	Economic and Strategic value added	Assets	Architecture
	Competitive cost structure / Total costs	Competitive position	Technology clock speed
	Customer importance	Capable suppliers	Revenues
What and whom to buy? (Kraljic, 1983; Martinez, 2013)	Commodities and special materials	Bottleneck items	Decentralisation
	Leverage, bottleneck and strategic items	Functional efficiency	Scarcity supply
	Reliable short-term and global sourcing	Establish local/global suppliers	Time horizon
	Suppliers quantity and technology	Abundant variety of suppliers	Management cost
Purchase policy for each category (Sarkar and Mohapatra, 2006; Kauffman and Leszczyc, 2005)	Technological capability of the supplier	Profitability of the supplier	Supplier's proximity
	Reputation for integrity/honesty/image	Promise/delivery lead time	Conflict resolution
	IT standards/communication systems	Number of optimum suppliers	Communication openness
	Labour problems at supplier's place	Bidding procedure compliance	Price of products
	Sensitivity to buyer's requirement	Management and organisation	After sales support
	Decision cost to evaluate suppliers	Contribution to productivity	Ability to meet delivery
	Search cost to find and qualify suppliers.	Quality systems at the supplier	Performance history
	Probability to find better suppliers	Production facilities and capacity	Ability to supply items
	Business volume / amount	Financial capability of the supplier	Product quality/reliability
Supplier selection process (Al-Harbi,1998)	Contractor`s new fee	Total profit of the project	
	Total Cost	Expected utility value (EUV)	
Contract management (Al-Harbi, 1998; Turner and Simister, 2001; Holt, 1998)	Cost of changes in product specification	Uncertainty in the product	Total cost
	Cost of the process specification	Uncertainty in the process	Price of contract
	Membership functions for uncertainty	Aggregate score for contractor	Total profit of the project
	Predictive contractor performance	Euclidean distances of clusters	Contractor`s new fee
	Administrative cost	Multiple Regression of variables	Expected utility value
Purchasing strategic objectives for product category (Martinez, 2013)	Quality of products	Productivity-cost	Acquisition per volume
	Delivery exactness	Moral / Security	Product type
Procurement strategy (Martinez, 2013)	Supply characteristics	Demand characteristics	
	Raw materials characteristics	Material requirement planning (MRP)	

References

Abele, E., Meyer, T., Näher, U., Strube, G., Sykes, R., 2008. Global production. Handb. Strategy Implement. Berlin–Heidelberg.

Al-Harbi, K.M.A.S., 1998. Sharing fractions in cost-plus-incentive-fee contracts. Int. J. Proj. Manag. 16, 73–80.

Andersen, O., 1997. Internationalization and market entry mode: A review of theories and conceptual frameworks. MIR Manag. Int. Rev. 27–42.

Armengol, A., Mula, J., Diaz-Madroñero, M., Pelkonen, J. 2014. Conceptual model for associated costs of the internationalisation of operations. Lecture Notes in Engineering and Computer Science 3, 181-188.

Aspelund, A., Butsko, V., 2010. SMALL AND MIDDLE- SIZED ENTERPRISES'OFFSHORING PRODUCTION: A STUDY OF FIRM DECISIONS AND CONSEQUENCES. Tijdschr. Voor Econ. En Soc. Geogr. 101, 262–275.

Corti, D., Egaña, M.M., Errasti, A., 2009. Challenges for off-shored operations: findings from a comparative multi-case study analysis of Italian and Spanish companies, in: Proceedings 16th Annual EurOMA Conference, Gothenburg.

Coviello, N.E., McAuley, A., 1999. Internationalisation and the smaller firm: A review of contemporary empirical research. MIR Manag. Int. Rev. 223–256.

Dawson, J.A., 1994. Internationalization of retailing operations. J. Mark. Manag. 10, 267–282.

De Toni, A., Parussini, M., 2010. International Manufacturing Networks: a literature review, in: 17th Conference EurOMA, Porto.

Eriksson, K., Johanson, J., Majkgard, A., Sharma, D.D., 1997. Experiential knowledge and cost in the internationalization process. J. Int. Bus. Stud. 337–360.

Errasti, A., 2006. KATAIA. Modelo Para El Diagnóstico Despliegue Estrateg. Logística Product. En PYMES Unidades Negocio Gd. Empres. Diss. Tecnun Univ. Navar. Spain.

Errasti, A., 2011. International manufacturing networks: Global operations design and management. Servicio de Publicaciones del Gobierno Vasco. In Eusko Jaurlaritzaren.

Etemad, H., 2004. Internationalization of small and medium- sized enterprises: a grounded theoretical framework and an overview. Can. J. Adm. Sci. Can. Sci. Adm. 21, 1–21.

Ferdows, K., 1997. Making the most of foreign factories. Harv. Bus. Rev. 75, 73–91.

Fine, C.H., Vardan, R., Pethick, R., El-Hout, J., 2002. Rapid response capability in value chain design. Sloan Manage. Rev.

Gelderman, C.J., Semeijn, J., 2006. Managing the global supply base through purchasing portfolio management. Glob. Purch. 12, 209–217.

Hammami, R., Frein, Y., Hadj-Alouane, A.B., 2008. Supply chain design in the delocalization context: Relevant features and new modeling tendencies. Int. J. Prod. Econ. 113, 641–656.

Hayes, R.H., Wheelwright, S.C., 1984. Restoring our competitive edge: competing through manufacturing.

Holt, G.D., 1998. Which contractor selection methodology? Int. J. Proj. Manag. 16, 153–164.

Johanson, J., Vahlne, J.E., 1977. The internationalization process of the firm-a model of knowledge development and increasing foreign market commitments. J. Int. Bus. Stud. 23–32.

Johanson, J., Vahlne, J.E., 1990. The mechanism of internationalisation. Int. Mark. Rev. 7.

Johanson, J., Wiedersheim- Paul, F., 1975. The internationalization of the firm—four swedish cases 1. J. Manag. Stud. 12, 305–323.

Kauffman, R.G., Leszczyc, P.T.P., 2005. An optimization approach to business buyer choice sets: How many suppliers should be included? Ind. Mark. Manag. 34, 3–12.

Kedia, B.L., Mukherjee, D., 2009. Understanding offshoring: A research framework based on disintegration, location and externalization advantages. J. World Bus. 44, 250–261.

Knoepfel, H., 1983. Systematic project management. Int. J. Proj. Manag. 1, 234–241.

Kraljic, P., 1983. Purchasing must become supply management. Harv. Bus. Rev. 61, 109–117.

Lluís, C., 2009. Diseño avanzado de procesos y plantas de producción flexible. Editor.Profit Esp.77–78.

MacCarthy, B.L., Atthirawong, W., 2003. Factors affecting location decisions in international operations – a Delphi study. Int. J. Oper. Prod. Manag. 23, 794–818.

Martinez, S., 2013. Framework for configuring production and logistics networks of SMEs and SBUs within an internationalization process (Dissertation). Universidad de Navarra, San Sebastián, País Vasco.

Martínez, S., Errasti, A., Santos, J., Mediavilla, M., 2013. Framework for Improving the Design and Configuration Process of Global Operations, in: Advances in Production Management Systems. Competitive Manufacturing for Innovative Products and Services. Springer, pp. 471–478.

Mediavilla, M., Errasti, A., Domingo, R., Martínez, S., 2012. Value Chain Based Framework for Assessing the Ferdows' Strategic Plant Role: An Empirical Study, in: Advances in Production Management Systems. Value Networks: Innovation, Technologies, and Management. Springer, pp. 369–378.

Meixell, M.J., Gargeya, V.B., 2005. Global supply chain design: A literature review and critique. Glob. Logist. 41, 531–550.

Miltenburg, J., 2005. Manufacturing strategy: how to formulate and implement a winning plan. Productivity press.

Miltenburg, J., 2009. Setting manufacturing strategy for a company's international manufacturing network. Int. J. Prod. Res. 47, 6179–6203.

Muther, R., Maynard, H.B., Rabada, C.C., 1981. Distribución en planta. Hispano Europea.

Poler, R., Lario, F.C., Doumeingts, G., 2002. Dynamic modelling of decision systems (DMDS). Comput. Ind. 49, 175–193.

Prasad, S., Babbar, S., 2000. International operations management research. J. Oper. Manag. 18, 209–247.

Sarkar, A., Mohapatra, P.K., 2006. Evaluation of supplier capability and performance: A method for supply base reduction. J. Purch. Supply Manag. 12, 148–163.

Slack, N., Lewis, M., 2002. Operations Strategy. Upper Saddle River, 2nd Edition. ed. NJ: Prentice Hall.

Sommer, C., Troxler, G., 2007. Outsourcing and Offshoring: The Consultancies' Estimates, in: Software Engineering Approaches for Offshore and Outsourced Development. Springer, pp. 109–113.

Szulanski, G., 1996. Exploring internal stickiness: Impediments to the transfer of best practice within the firm. Strateg. Manag. J. 17, 27–43.

Tompkins, J.A., 2010. Facilities planning. John Wiley & Sons.

Trautmann, G., Bals, L., Hartmann, E., 2009. Global sourcing in integrated network structures: The case of hybrid purchasing organizations. Glob. Sourc. Value Creat. Oppor. Chall. 15, 194–208.

Turner, J.R., Simister, S.J., 2001. Project contract management and a theory of organization. Int. J. Proj. Manag. 19, 457–464.

Waters, C.D.J., 2003. Global logistics and distribution planning: strategies for management. Kogan Page Publishers.

Yurdakul, M., 2004. AHP as a strategic decision-making tool to justify machine tool selection. J. Mater. Process. Technol. 146, 365–376.

A Questionnaire for the Analysis Stage of Internationalisation of Operations

Vicente Montés, Guillermina Tormo, Josefa Mula[1], Hanzel Grillo

Abstract: In this paper, we formulated an initial questionnaire to ask companies, which have internationalised their operations, about the criteria and decisions that they have adopted during this process. We specifically focused on the analysis stage of two of the main challenges of global operations configuration for industrial manufacturing companies: new facility implementation (NFI) and global suppliers network development (GSND). A representative sample of the companies to send the questionnaire to was also obtained.

Keywords: Internationalisation of operations, questionnaire, new facility implementation, global suppliers network development, analysis stage.

1 Introduction

Internationalisation of operations can be defined as the deployment of business resources over one's own country by the location of people and assets to carry out primary activities of the value chain (Martinez, 2013). Among the main reasons for internationalisation of operations, the following stand out: lower labour costs and low tax rates (Ferdows, 1997); entering new markets (Jarillo and Martínez, 1991); disaggregation of and re-engineering the value chain (Mediavilla and Errasti, 2010); creating new products and distinguished services; diversifying risk among several countries (Thompson and Strickland, 2004); compensating losses in certain regions with benefits from others (Jarillo and Martínez, 1991); economies of scale in production, R&D, distribution and purchasing activities, among others, which implies possibly reducing costs; the need to set up a global transport network among several production plants; making investments (Jarillo and Echezarraga, 1991); gaining prestige (Jarillo and Echezarraga, 1991); and setting up entrance barriers should market opportunities be known, few competitors, few substitution products or companies' strong bargaining power.

Martínez (2013) addresses new facility implementation (NFI) and global supplier network development (GSND) in the decision making of internationalisation of operations processes. NFI and GSND are framed within five main phases: analysis, set up, stability, improvement and excellence.

NFI and its subsequent management require wide-ranging theoretical and practical knowledge on operations management: capacity to manage human resources; purchasing management and replenishment; reaching agreements with local logistics suppliers; designing and developing capacities and after-sales services; the company's production can be exported. An alternative approach to set up new production plants overseas exists and consists in setting up by means of acquiring existing resources in the country considered. This involves exploring resources through; a merges and purchases process; purchasing assets; or an existing business unit.

Overall purchasing management is one of the first steps to be able to define and design GSND. The need to ensure quality control, the logistics purchasing management and mediation implies reindustrialising the process by implications of raw materials, changes in the production process, suppliers, the logistics complex, etc.

In these two fields of study (NFI and GSND), no empirical research works that analyse the results of a series of companies are available which enable the identification of similarities or the key parameters employed during the decision making of internationalisation of operations processes for the ultimate

1 **Josefa Mula** (fmula@cigip.upv.es)
Centro de Investigación en Gestión e Ingeniería de Producción (CIGIP).
Escuela Politécnica Superior de Alcoy,
Plaza Ferrándiz y Carbonell, 2, 03801 Alcoy, Alicante, Spain.

objective of obtaining a quantitative decision-making tool. In order to improve the conceptual model and to develop the quantitative GLOBOP model (Mula, 2014), based on the GLOBOPE framework by Errasti (2011) and Martínez (2013), this article proposes a questionnaire that will obtain information on the key parameters and tools that the surveyed companies are considering in their decision making internationalisation of operations processes in the analysis stage of NFI and GSND. Thus, the paper proposes a questionnaire to ask companies, which have internationalized their operations, about the criteria and decisions that they have adopted during this process in order to use its future utilization, analysis and resulting conclusions in the development of decision support systems.

A sufficiently representative sample of the complete population of companies from the three sectors that are the study objective is determined: textile, footwear and automobile. A sample of 120 companies was found by taking into account several primary and secondary sources. The SABI (Iberian Balance Sheet Analysis System) database helped draw up a list of companies from each sector and to do an approximate population calculation. From all the articles obtained from these sources, a population of 4,999 companies was obtained.

The rest of the paper is arranged as follows: Section 2 centres on the methodology of how the questionnaire to analyse NFI and GSND in their analysis stage was developed. Section 3 presents the devised questionnaire. Section 4 proposes a representative sample of companies that were asked to answer the questionnaire. Finally, Section 5 offers the conclusions drawn.

2 Methodology to Develop the Questionnaire

First of all, a scientific literature review was done, and the works of Errasti (2011), Martínez (2013) and Martínez et al. (2013a), among others, were considered to obtain the principles, methods and techniques that the companies follow to tackle internationalisation of operations processes. The contributions (Martínez et al. 2013b; Andrés and Poler, 2013; Corti and Choudhuri, 2013; Jensen et al. 2013; Netland et al. 2013) that centred on internationalisation of operations were also reviewed to seek the good practices, analysis and design processes, simulation tools, and the revitalising and contingent factors to set up new installations, and to reconfigure and redesign networks (suppliers, distributors, etc.). Other empirical works have considerably contributed to define the variables for the questionnaire (Hayter, 1997; van Dijk and Pellenbarg, 2000; MacCarthy and Atthirawong, 2003; Garrido-Yserte, 2006; Garrido-Yserte y Gallo-Rivera, 2008; Rodríguez et al. 2009; Gutiérrez, 2011; La Torre, 2012). After the literature review, the most relevant items to be considered were selected according to Martínez's questionnaire and conceptual model (2013). After obtaining the items to assess, they were grouped into categories to provide more clarity and understanding for both those who conducted and answered the questionnaire.

3 Questionnaire

The ultimate objective of analysing the questionnaire results will be to compare and relate the parameters that the companies report with those established by the conceptual GLOBOP model for NFI and GSND, which will act as a reference to develop quantitative decision models to help in the decision making of internationalisation of operations processes.

As the intention is to provide a valid tool and to help decision making, the final questionnaire will study the factors that can lead users (the directors of the companies) of the system to employ and accept them. For this purpose, we have taken The Technology Acceptance Model (TAM) (Davis, 1989) and its subsequent adapted version (DeLone and McLean, 1992) as a reference.

Only some location criteria are considered in the questionnaire below (Table 1). Justification lies in these territories possessing certain tangible and intangible characteristics that outline the conditions for the location of economic activities. Although location conditions are hard to measure and weight separately, especially intangible ones, it is worth asking about the subfactors one by one since each decision variable (transport, customers, competitors, etc.) possesses several parameters to be contemplated. Other questions refer to some decisions that companies also have to make when they set up a production plant abroad. The objective of these questions is to know not only the degree of automation in operation plants (technological level), but also the characteristics about the labour available, socio-economic factors, land/buildings, environmental rules, government policies in the country abroad, or support organisations, among others, or if they relate to the suppliers selection process or to the use of tools to support decision making.

The responses are to be provided on a typical Likert-type scale with seven levels of responses.

Table 1
Questionnaire for the analysis stage
on internationalisation of operations.

I. LOCATION CRITERIA								
	Post: **Sector:**							
1	How many years has your company been operating outside Spain?							
2	In which countries?							
3	Product strategy. Do you compete for price or for product differentiation (quality, brand name, etc.)? (mark with "X")	1.- Price 2.- Product differentiation						
4	Indicate the company's degree of automation and technological level in terms of the product or final service (from 1 to 7)	1	2	3	4	5	6	7
5	What part of your company's operations have been internationalised? Indicate all those that correspond to (mark with "X"):	1.- Design 2.- Replenishment 3.- Production 4.- Distribution						
6	How did the company set up in the selected country? (mark with "X")	1. - Purchasing already existing installations and resources 2. - Creating a Joint Alliance (a strategic alliance with the company in that country). 3. - Subcontracting. Suppliers network 4. - Building a new production plant						
7	What was the reason why your company decided to internationalise its operations? (mark with "X")	1.- To cut costs 2.- To extend markets 3.- To extend production capacity 4.- Lack of local products 5.- To improve technology and local processes						
8	What approximate % of the company's volume of operations is being internationalised?							
II. Indicate the relevance of the aspects below for selecting suppliers								
9	The supplier is large in size	1	2	3	4	5	6	7
10	The contract offers good conditions	1	2	3	4	5	6	7
11	There are many suppliers	1	2	3	4	5	6	7
12	The supplier's response time is fast	1	2	3	4	5	6	7
13	The product offer is varied	1	2	3	4	5	6	7
14	Products are of good quality	1	2	3	4	5	6	7
15	The prices of the products are feasible	1	2	3	4	5	6	7
16	The adaptability to the product specifications is good	1	2	3	4	5	6	7
17	The supplier guarantees its products	1	2	3	4	5	6	7
18	The supplier reacts in critical situations	1	2	3	4	5	6	7
19	The supplier offers discounts for volume	1	2	3	4	5	6	7
20	The supplier is accessible	1	2	3	4	5	6	7
21	The supplier uses state-of-the-art technology	1	2	3	4	5	6	7
22	The supplier's production installations are suitable	1	2	3	4	5	6	7
23	The supplier is reliable	1	2	3	4	5	6	7
III. Indicate the relevance of transport in internationalisation of operation processes								
24	The cost of transport is feasible	1	2	3	4	5	6	7
25	The transport offer is varied	1	2	3	4	5	6	7
26	The transport company's service level is good	1	2	3	4	5	6	7
27	Transport is safe	1	2	3	4	5	6	7
28	There are logistics operators							
29	Transport frequency is suitable	1	2	3	4	5	6	7
IV. Indicate the relevance of labour in internationalisation of operation processes								
30	The cost of salaries is feasible	1	2	3	4	5	6	7
31	The process and the contracting/dismissal costs offer facilities and accessibility	1	2	3	4	5	6	7
32	Flexible contracting (temporary/permanent contract/and contract conditions)	1	2	3	4	5	6	7
33	Labour is qualified and specialised	1	2	3	4	5	6	7
34	Few industrial disputes in general	1	2	3	4	5	6	7
35	Plenty of labour available	1	2	3	4	5	6	7

V. Indicate the relevance of the socio-economic factors in the selected overseas country								
36	The country's economic situation is stable (as far as the recession, growth, etc., are concerned)	1	2	3	4	5	6	7
37	Knowledge in many languages is available	1	2	3	4	5	6	7
38	Suitable infrastructures	1	2	3	4	5	6	7
39	Good urban and social equipment	1	2	3	4	5	6	7
VI. Indicate the relevance of the land/buildings factor								
40	The cost of land and construction is feasible or low	1	2	3	4	5	6	7
41	The cost of rent is feasible or low	1	2	3	4	5	6	7
42	Good accessibility now and in the future	1	2	3	4	5	6	7
43	Good quality and varied public services	1	2	3	4	5	6	7
44	Possibility to expand	1	2	3	4	5	6	7
VII. Indicate the relevance of environmental rules								
45	Rules exist and they are easy to apply	1	2	3	4	5	6	7
46	Penalties apply if not fulfilled	1	2	3	4	5	6	7
VIII. Government policies								
47	Tax rates are feasible or low	1	2	3	4	5	6	7
48	Stable government	1	2	3	4	5	6	7
49	Subsidies and aid for investments are available	1	2	3	4	5	6	7
50	Not too much bureaucracy	1	2	3	4	5	6	7
IX. Competitors								
51	Few competitors in the selected country	1	2	3	4	5	6	7
X. Customers								
52	Current customers are easily accessible	1	2	3	4	5	6	7
53	Customers paying is guaranteed	1	2	3	4	5	6	7
54	Introduction to potential markets	1	2	3	4	5	6	7
X. Organisations that support business management								
55	Technology Institutes	1	2	3	4	5	6	7
56	Services providers	1	2	3	4	5	6	7
XI. What tools has your company used to support decision making in internationalisation of operations processes? Mark with an "X"								
57	Microsoft Excel	Yes: No:						
58	ERP (SAP, Axapta, Baan, Navision, People Soft, OpenBravo, etc.)	Yes: No:						
59	Business Intelligence (GOGNOS, etc.)	Yes: No:						
60	Model or tool developed by the company	Yes: No:						
61	Simulation (discrete simulation, systems dynamics, business games, etc.)	Yes: No:						
62	Balanced Scorecard	Yes: No:						
63	Based on the company's experience	Yes: No:						
64	Specialised external company	Yes: No:						
65	None	Yes: No:						

4 Selecting the Sample and Data Sources

Given the characteristics of our research, and the methodology employed, it is necessary to previously select the companies that are the object of this study. From the records of the companies in the SABI database, the sample was selected according to two filter criteria: the first one, operating companies, Spanish companies, the sectors they are active in (textile, footwear and automobile) and to which the companies that observe and promote the project belong. The national classification of economic activities has been considered a reference of their economic activities (CNAE, in Spanish). This filter reveals the total number of companies in Spain, and does not distinguish whether they have affiliated companies overseas or not; the second one, as obtaining only those companies with productive affiliated companies overseas is complicated, only those companies that export and import products, raw materials, have been considered as an approach to internationalisation of operations.

The population of companies considered to be representative in this study includes 4,999 companies for the three sectors contemplated (Table 2).

By assuming a 5% sampling error and a 95% confidence interval, the sample for finite populations would be formed by 120 companies. The sample for each sector has been calculated by maintaining the existing proportion between the sample and its population of companies. Lastly, companies have been selected aleatorily from all the sectors. Checks to see if the companies do indeed have production plants worldwide have been made using their web sites.

Table 1
Representative sample.

	Textile	Footwear	Automotive	Total
Companies	3,027	616	1,356	4,999
Percentage	60.5%	12.3%	27.1%	100.0%
Sample	72.6	14.8	32.5	120

For space reasons, the list of the companies selected for the study sample is not included.

After selected the sample and devised the questionnaire, a pretest will be done with experts on the subject, and also with the companies that collaborate in this project. Later, after making the necessary adjustments, it will be sent to all the directors of operations and finances of all the companies.

5 Conclusions

This paper presents the development of a questionnaire devised to obtain key information to create future quantitative tools for the decision making of internationalisation of operations. To conduct the questionnaire, a literature review and a search for related empirical studies have been done. The obtained items have been arranged so that they make the questionnaire easy to understand by those who answer it and, in turn, reflect the key elements of the conceptual GLOBOP model, which is the basis of this study.

To put the questionnaire into practice, target companies have been found in three sectors (textile, automobile and footwear). This selection has been based on technological criteria. In this way, a representative sample size of the companies immersed in the internationalisation of operations process from the textile, automobile and footwear sectors has been obtained.

It is worth stressing that the conclusions drawn from this questionnaire in the future will help support the development of a decision model for NFI and GSND, which will be previously compared with the conceptual GLOBOPE framework. Then the most important elements selected will act as a base to develop quantitative models for the decision making of internationalisation of operations in the analysis stage.

References

Andrés, B, Poler, R., 2013. Methodology to identify SMEs needs of internationalised and collaborative networks. Advances in Production Management Systems. Competitive Manufacturing for Innovative Products and Services. IFIP Advances in Information and Communication Technology 398, 463-470.

Corti, D., Choudhury, S., 2013. Improving the industrialization of a new product in an international production network: a case study from the machinery industry. Advances in Production Management Systems. Competitive Manufacturing for Innovative Products and Services. IFIP Advances in Information and Communication Technology 398, 495-502.

Errasti, A., 2011. International manufacturing networks: Global operations design and management. Servicio de Publicaciones del Gobierno Vasco. In Eusko Jaurlaritzaren.

Ferdows, K., 1997. Making the most of foreign factories. Harv. Bus. Rev. 75, 73–91.

Garrido-Yserte, R., 2006. Localización y movilidad de empresas en España. Colección EOI Empresas.

Garrido-Yserte, R., Gallo-Rivera, M.T., 2008. La localización y movilidad de las empresas en España. Un análisis empírico. Economía Industrial 367, 67-84.

Gutierrez, D., 2011. International offshoring: impact on spanish manufacturing structure (1995-2005). Papeles de Europa 22, 226-254.

Hayter, R., 1997. The dynamics of industrial location: the factory, the firm and the production system. Wiley.

Jarillo, J.C., Martínez, J., 1991. Estrategia Internacional. Más allá de la Exportación. Mc Graw Hill, Madrid.

Jensen, P.M., Johansen, J., Waehrens, B.V., Shewan-Ul-Alam, Md., 2013. Proposing an environmental excellence self-assessment model. Advances in Production Management Systems. Competitive Manufacturing for Innovative Products and Services. IFIP Advances in Information and Communication Technology 398, 511-518.

La Torre, M.C., 2012. Deslocalización: otro rostro de la internacionalización empresarial. Mediterráneo Económico 21, 181-200.

MacCarthy, B.L., Atthirawong, W., 2003. Factors affecting location decisions in international operations – a Delphi study, International Journal of Operations & Production Management, 23, (7), 794-818.

Martinez, S., 2013. Framework for configuring production and logistics networks of SMEs and SBUs within an internationalization process (Dissertation). Universidad de Navarra, San Sebastián, País Vasco.

Martínez, S., Mediavilla, M., Errasti, A., Santos, J., Mula, J.,M 2013a. State of the art of challenges on international operations management for SMEs. Book of Proceedings of the 7th International Conference on Industrial Engineering and Industrial Management - XVII Congreso de Ingeniería de Organización, pp. 67-75.

Martínez, S., Errasti, A., Santos, J., Mediavilla, M., 2013b. Framework for improving the design and configuration process of global operations. Advances in Production Management Systems. Competitive Manufacturing for Innovative Products and Services. IFIP Advances in Information and Communication Technology 398, 471-478.

Mediavilla, M., Errasti, A., 2010. Framework for assessing the current strategic plant role and deploying a roadmap for its upgrading. An empirical study within a global operations network. Proceedings of APMS Conference, Como, Italy.

Mula, J., 2014. Reporting on GLOBOP: Design and management of global supply chains. Industrial Engineering and Management 3, 3.

Netland, T.H., Mediavilla, M., Errasti, A., 2013. The insignificant role of national culture in global lean programmes. Advances in Production Management Systems. Competitive Manufacturing for Innovative Products and Services. IFIP Advances in Information and Communication Technology 398, 2013, 454-462.

Rodríguez; D., Turrión, J., Velázquez, F.J., 2009. Un enfoque integrado sobre Competitividad y Deslocalización en la Industria Española. Revista de Globalización, Competitividad y Gobernabilidad, 3, (2), 90-107.

Thompson, A., Strickland, A., 2001. Strategic management: Concepts and cases. McGraw-Hill Irwin, Boston.

van Dijk, J., Pellenbarg, P.H., 2000. Firm relocation decisions in The Netherlands: An ordered logit approach. Papers in Regional Science 79, 191-219.

Relationship between Organizational Social Responsibility and Occupational Health and Safety: a review study

Silva SLO[1], Quelhas OLG[2], Meiriño MJ[3], França SLB[4]

Abstract: The intersection between Organizational Social Responsibility (OSR) and Occupational Health and Safety (OHS) proposes an important topic to be addressed in current and future research, to the extent that aspects relating to working conditions are increasingly latent. The research can be characterized as a review study and aimed to collect and analyze articles with the OSR and the OHS issues. In total were analyzed 49 articles published between 1981 and 2014. The study sample corresponds to the documents indexed in Scopus and Web of Science databases. It was observed that the main results of the internal dimension OSR represents 44% of published articles and 53% of these focus on Ergonomics and OHS. Some research gaps appeared after this study, a fact that suggests future research on the subject.

Keywords: Organizational Social Responsibility; Occupational Health and Safety; Sustainability;

1 Introduction

Get injured or be affected by diseases associated with the work may cause the employee to associate these evils to an unsafe work environment, contributing to dissatisfaction, stress and higher turnover. (MCCAUGHEY *et al*, 2013). In addition, fatigue indicators and capacity for work derived from several factors related to working conditions and your organization (METZNER and FISHER, 2010).

However, some employers are not really concerned with the protection of its employees, and even worse, do not even realize that they have a moral responsibility and often legal, to protect their employees (MONTERO *et al*, 2009).

2 Objectives

This article provides the following research objective: "To identify correlations between the concepts of OSR and OHS".

3 Methods

The research can be characterized as a review study and aimed to collect and analyze articles with the OSR and the OHS issues. In total were analyzed 49 articles published between 1981 and 2014. The study sample corresponds to the documents indexed in Scopus and Web of Science databases, accessed on June 7, 2014.

1 **Sávio Luís Oliveira da Silva** (contato@savioluis.com)
2 **Osvaldo Luiz Gonçalves Quelhas**, D.Sc (quelhas@latec.uff.br)
3 **Marcelo Jasmin Meiriño**, D.Sc. (marcelo@latec.uff.br)
4 **Sérgio Luiz Braga França**, D.Sc. (sfranca@latec.uff.br)
Lab. de Tecnologia, Gestão de Negócios e Meio Ambiente.
Escola de Engenharia. Universidade Federal Fluminense. Niterói, RJ, Brasil.

4 Results

As the focus of this work is the relationship between OSR and OHS, it was decided to give special attention to the Internal OSR. Therefore, of the 19 articles dealing with such an approach, 10 refer to Ergonomics and OHS, 3 refer to the Human Resources (HR), 3 discourse on organizational climate, two deal with matters relating to Human Rights and 1 refers to the OSR as strategic management tool.

5 Conclusion

The concept of OSR has consolidated itself as interdisciplinary and multidimensional, giving relevance to relations with internal and external stakeholders (AL-BDOUR *et al*, 2010; FORSMAN-HUGG *et al*, 2013; KOSKELA, 2014). As a result, the concept requires the incorporation to the organization's strategy, with developments in economic hubs, environmental and social operation of organizations (ASIF *et al*, 2009; METCALF and BENN, 2012).

The management of organizational health requires an integrated approach, with a system of multi-dimensional targets, with the participation of internal and external stakeholders and with the understanding that the OHS is a means to ensure competitiveness (ZINK, 2005). According to Hadjimanolis and Boustras (2013), companies should set clear security policies, aimed at creating a positive climate and a culture of risk prevention, emphasizing the commitment of management to the OHS.

The socially responsible management shows its commitment, meeting social needs and going beyond mere compliance with security legislation through positive actions to protect and maintain the well-being of workers (MONTERO *et al,* 2009; HADJIMANOLIS and BOUSTRAS, 2013). However, according to the authors, different perceptions of risk on the part of management and employees may hinder the implementation of an OHS policy. Given the relevance of the problem, there is an interesting field to be addressed in future research.

References

Al-bdour, AA; Nasruddin, E; Lin, SK (2010) The relationship between internal corporate social responsibility and organizational commitment within the banking sector in Jordan. World Academy of Science, Engineering and Technology, v.4, n.7, 262-281

Asif, M; De Brujin, EJ; Fisscher, OAM; Searcy, C; Steenhuis, HJ (2009) Process embedded design of integrated management systems. International Journal of Quality and Reliability Management, v.26, n.3, 261-282

Forsman-Hugg, S; Katajajuuri, JM; Riipi, I; Järvelä, K; Timonen, P (2013) Key CSR dimensions for the food chain. British Food Journal, v.115, n.1, 30-46,

Hadjimanolis, A; Boustras, G (2013) Health and safety policies and work attitudes in Cypriot companies. Safety Science, v.52, 50-56

Koskela, M (2014) Occupational health and safety in corporate social responsibility reports. Safety Science, n.68, 294-308

Mccaughey, D; Dellifraine, JL; McGhan, G; Bruning, NS (2013) The negative effects of workplace injury and illness on workplace safety climate perceptions and health care worker outcomes. Safety Science. v. 51, n.1, 138-147.

Metcalf, L; Benn, S (2012) The Corporation is Ailing Social Technology: Creating a 'Fit for Purpose' Design for Sustainability. Journal of Business Ethics, v.111, n.2, 195-210

Metzner, RJ; Fisher, FM (2010) Fatigue and workability in Brazilian textile companies in diferente corporate social responsibility score groups. International Journal of Industrial Ergonomics. v. 40, n.3, p.289-294.

Montero, MJ; Araque, RA; Rey, JM (2009) Occupational health and safety in the framework of corporate social responsibility. Safety Science. v. 47, n.10, 1440-1445

Zink, KJ (2005) From industrial safety to corporate health management. Ergonomics , v.48, n.5, 534-546

Integrating Strategic Considerations and Value Co-Creation in Project Management

Cohen Y[1], **Rozenes S**[2]

Abstract: While traditional project management advocates sticking to a baseline plan (composed of budget, schedule and specifications) this paper suggests a new dynamic planning approach that includes re-evaluation and optimizes the project's value while allowing strategic changes in the project scope, budget and schedule. The proposed optimization allows taking into account not only the project, but also the long term impact of changes on cash-flows, product reliability, firm reputation, and customer satisfaction. Such changes are not part of the traditional project management approach of sticking to the baseline and eliminating a scope creep. Such a new approach enables dealing with many important changes that occur during long term projects. This is particularly important in projects with large amount of uncertainty where new knowledge is revealed or discovered during the project lifespan, and significant events occur that impact the project or its deliverables. The paper analyses the factors that make this approach desirable and the type of projects where this approach would be especially attractive.

Keywords: Project management; Strategic management; Strategic decision.

1 Introduction

Traditionally, the project management literature has been mainly occupied with the efficient and timely execution of specifications and producing a deliverable artifact or a system. As a result, project management processes and tools are focused on enhancing on time, on budget and according to specifications performance. This approach is tactical, and its sole focus is on efficient delivery of specified outputs. But it clearly neglects the strategic importance of the project realization. The strategic importance of the project is typically obtained only after the project is done. For example, even if project outputs have been delivered efficiently the project can still be ineffective to the funding organization. Examples are the Sydney cross-city tunnel (Zwikael and Smyrk, 2011) and the Los Angeles Metro (Shenhar and Dvir, 2007). Another well-known example is the famous Sydney opera building which was far from being on time and on budget, but is a great success for the long run. Recently, a wider view on the management of projects has emerged, which also discusses the delivery of strategic goals by projects (Gareis and Stummer, 2008; Morris and Jamieson, 2008). Project benefit management research emphasizes the strategic roles of projects in organizations. (e.g., Kolltveit et al., 2007) and defines the benefit management process (e.g., Breese, 2012). Consequently, benefit management is becoming an important research area. Project benefits are "the flows of value that arise from a project" (Zwikael and Smyrk, 2012:11). A project owner is accountable to the project funder/founder for the realization of these target benefits (Zwikael and Smyrk, 2012).

In this paper we lay a conceptual framework for the interface between a project and its strategic considerations.

1 **Yuval Cohen** (yuvalc@afeka.ac.il)
2 **Shai Rozenes** (rozenes@afeka.ac.il)
Department of Industrial Engineering
Afeka Tel-Aviv College of Engineering. 38 Mivtsa Kadesh, Tel-Aviv 69988, Israel.

2 Integrating Strategic Considerations in Project Management

In this section we describe the proposed model. The section describes the effect of changes on cash flow diagrams. A cash flow diagram shows the incoming and outgoing sums of money along the timeline. Often the project is described on the cash flow diagram as an initial investment, and the monthly or annual income in the future years. Figure 1 illustrates this scenario.

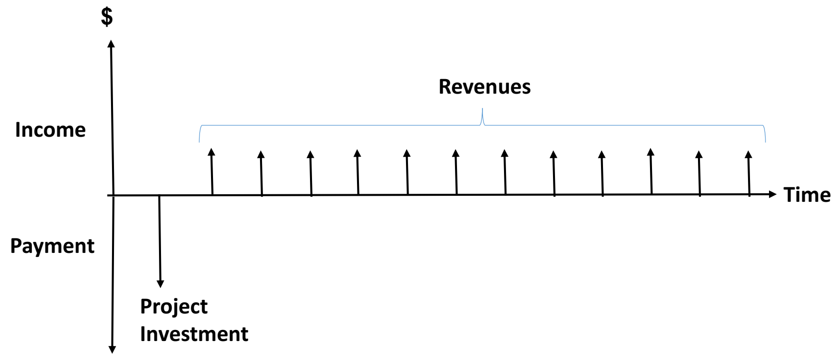

Fig.1
The cash flow related to a specific project.

2.1 Time Related Effects

There are only few ways that time changes may play strategic role. The first of these is the project delay. This means that the project finishes with a delay and the project benefits could not be realized during the delay period. The obvious effect on the cash flow is the elimination of any revenue (and any project benefit) during the delay. Figure 2 illustrates the net effect of simple delay imposed on a project.

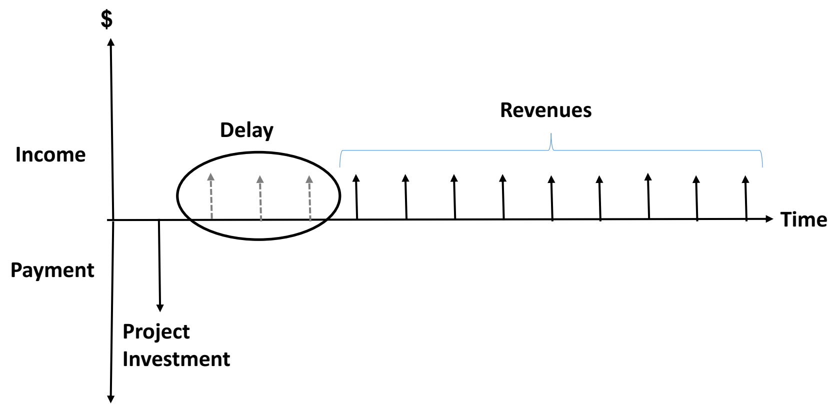

Fig.2 The effect of simple delay on the cash flow related to a specific project.

A delay may be a result of external events or forces, but may also be a strategic decision related to the quality of the project deliverables. In that case, the delay can contribute to the quality of the project. This could be translated directly to better reputation and could also increase the revenues after the project is completed. For example, a delay related to enhancing the external appearance of a restaurant may increase (by certain %) the number of customers and therefore the revenue. The delay may also be related to enhancing the reliability of the project deliverable which result in extension of its profitable life. These two effects are depicted in figure 3.

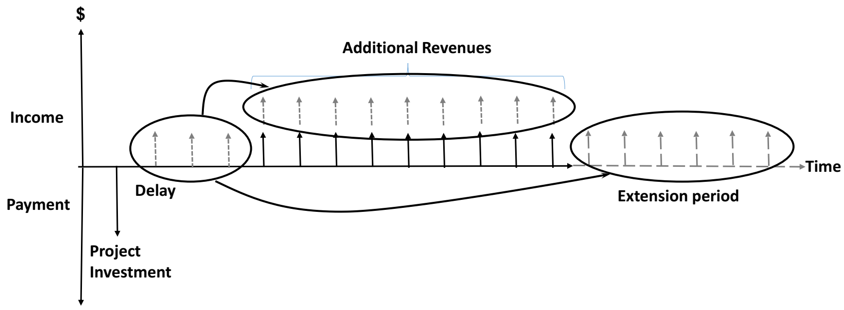

Fig.3
The effect of a delay on the revenues size and period
in a cash flow related to a specific project.

In reality the decisions are more subtle and are taken in the level of detailed activity network. This level also involve uncertainties related to times and cash flows. This level would be described and analyzed with examples in the full paper.

2.2 Budget Related Effects

The project budget is usually displayed on a cash-flow diagram as one amount investment. Just as the time dimension of a project can affect the long-term strategic time span, budget has very similar impact:

- Increasing budget could contribute to the quality of the project deliverable
- Increasing budget may contribute to the reliability of the project deliverable
- Increasing budget may shorten the completion time or counter a delay imposed by external constraints.

Figure 3 depicts the effects of budget changes.

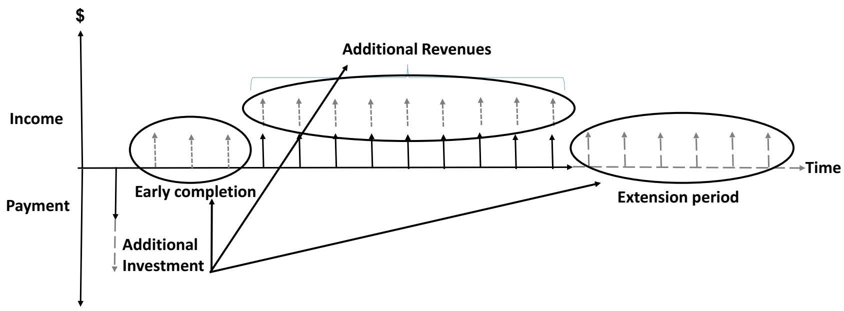

Fig.4
The possible effects of additional budget
on the project's related cash-flows.

In reality the decisions are more subtle and are taken in the level of detailed activity network. This level also involve uncertainties related to costs and cash flows. This level would be described and analyzed with examples in the full paper.

3 Integrating Value Co-Creation in Project Management

Value Co-Creation is a new way of managing the outsourcing of project and the relationship between the project team and the project customer. In this approach, the outsourcing organization (the customer) and the project contractor build mutual partnership for maximizing the project performance and its opportunities.

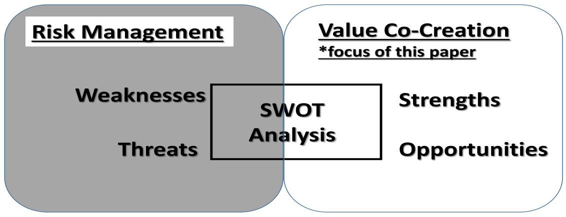

Fig.5
The focus of value co-creation in the SWOT analysis.

In such a framework, the contractor is not left alone to be responsible for on time on budget and on spec. performance, but is rather accompanied by managers from the customer organization in a partnership style team. The major characteristics of such a partnership are:

1. Frequent periodic mutual meetings (contractor and customer organization teams) for update and discussions related to risk management and opportunities.

2. The request for proposal leads for finding a partner and leaves large flexibility related to the actual execution (time, budget, spec.).

3. The budget for the project must include at least four components:

   a. Reserve component (for opportunities)

   b. Second reserve component (for risks)

   c. Partnership incentive component

   d. Baseline execution component (60% to70% of total budget)

Consulting projects are classical projects where value co-creation could be naturally achieved. The full paper would expand on the mechanisms leading the contractor and customer teams into a full-fledged partnership and would illustrate the collaboration on a consulting project.

4 Conclusion

Traditional project management is formed around building a sound baseline plan and sticking to its execution. This mode of thinking emphasizes the threats to the project and foster risk management. In this paper we point at the opportunities side. These opportunities may either come from the strategic understanding of the project team or the partnership between the outsourcing customer company and the project contractor.

5 References

Breese, R. (2012) Benefit realisation management: panacea or false dawn? Int. J. Proj. Manag. 30, 341–351.

Gareis, R., Stummer, M. (2008) Processes and Projects. Manz, Vienna. Kolltveit, B.J., Karlsen, J.T., Grønhaug, K., 2007. Perspectives on project management. Int. J. Proj. Manag. 25, 3–9.

Morris, P.W.G., Jamieson, A. (2008) Implementing strategy through programmes of projects, In: Turner, J.R. (Ed.), Gower Handbook of Project Management, 4th ed. Aldershott, Gower.

Shenhar, A.J., Dvir, D. (2007) Reinventing Project Management: The Diamond Approach to Successful Growth and Innovation. Harvard Business School Press, Boston, MA.

Zwikael, O., Smyrk, J.R. (2011) Project Management for the Creation of Organisational Value.
Springer-Verlag, London.

Social Responsibility: Reflections about the *Mato Grosso* State Certificate

Leitner CP[1], Sznitowski A M[2], Baggenstos S[3], Silva R P[4]

Abstract: This study examines the dissemination and the legitimation of social responsibility through the Certificate of Social Responsibility of the Mato Grosso State (in Brazil). For this, it was identified the main components forming the speech surrounding the event. The research is a qualitative analysis of the applicable law, of the Legislative Assembly (promoter of the event and creator of the law), in the diagnosis of the participants' organizations, of the social reports that
are requested, participation in the event and interviews. The main results show that the Certificate of Social Responsibility of *Mato Grosso* has a strategic approach and is supported by the social report. Through the analysis of social reports and presentation of the examples cases, has been identified that the prioritized stakeholders are the employees, the community and the environment. There is no definition to Social Responsibility given by the Legislative Assembly for the speech, only restriction. Therefore, the Legislative Assembly uses the interpretation of participating organizations and transmits as his. Finally, to receive the certificate only is required from the participating organization deliver the social report and a statement. Thus, the organiza-tion is considered socially responsible by the certificate studied.

Keywords: Organizations; Certificate; dissemination.

1 Introduction

In the organizational universe, the actions taken are increasingly planned to end or minimize any risks. It is also evident the spread of social responsibility in organizations, regardless of field and stakeholders involved. For the COM (2002), Social Responsibility is the business commitment to contribute to sustainable economic development, working with employees, their families, the local community and society at large to improve their quality of life, in ways that are good for both companies as for development. And Ashley (2002) reinforces that organizations should contribute to sustainable development with obligations of moral character, other than those specified by the various laws that are submitted, even if not directly linked their activities. However, studies as Cappellin and Giuliani (2004) indicate that the concept of this theme is different in several respects, indicating a process in development in the search by legitimacy. Under these circumstances, the award by socially responsible actions in the organizations through Certificate delivered by the Legislative Assembly of the state composes the object of this research. The enterprises participate of the award like a way of legitimizing their social responsibility actions.

2 Objectives

The objective of this study is to identify the main elements that compose the discourse produced with the Certificate delivered by Legislative Assembly to disseminate and legitimize social responsibility actions in the organizations of the *Mato Grosso* State.

1 **Camyla Piran Leitner** (camyla.piran@gmail.com)
2 **Adelice Minetto Sznitowski** (adeliceadm@gmail.com)
3 **Salli Baggenstoss** (salli@unemat-net.br)
4 **Ronald Pires da Silva** (olhaolha@olhaolha.com.br)
Dpto. Administração | Universidade do Estado de Mato Grosso.
Av.Ingas, 3300. CEP 78550-000 Sinop / Mato Grosso-Brazil.

3 Methods

To identify the main elements that comprise the involved speech, was conducted a qualitative analysis. The documentary research with Social Reports required of the enterprises participants (between 2006 and 2013) and the Law created for this purpose. Also were analyzed the presentations of the models cases in the event promoted by the Legislative Assembly for delivery of the Certificate. Still interviews were conducted with the organizers.

4 Results

The results showed that to receive the Certificate, organizations need only to deliver the Social Report and also a declaration of good practice, guaranteed by law. In 2013 there were more than 30 companies that participated and received the certificate, between small businesses and large exporters.

5 Conclusion

The desired dissemination with the Certificate of the Social Responsibility does not present a speech own, but is adopted the speech of the participating organizations. Thus it is legitimized the actions taken by them. Employees, community and the environment are featured and they compose the main elements of social responsibility propagated by the Certificate studied.

References

Ashley, P. A. (2005) “A mudança histórica do conceito de responsabilidade social empresarial”. In: ______ (coord.), Ética e responsabilidade social nos negócios. São Paulo

Assembleia Legislativa de Mato Grosso. Edital do Certificado de Responsabilidade Social – 2008/13. Disponível em: http://www.al.mt.gov.br/v2008/Raiz%20Estrutura/responsabilidadesocial/.

Cappellin, P.; Giuliani, G. M. (2004) The political economy of corporate responsibility in Brazil. Business and Society, Suiça, v. 14, n.01

Commission of the European Communities. 2002. Corporate Social Responsibility – Main Issues, MEMO/02/153, Brussels

Instituto Ethos De Empresas E Responsabilidade Social. O que é responsabilidade social. Disponível em: http://www1.ethos.org.br/EthosWeb/pt/29/o_que_e_rse/o_que_e_rse.aspx. Acesso em Maio/2014.

Mato Grosso. Lei n° 7.687, de 25 de junho de 2002. Cria o Certificado de Responsabilidade Social no Estado de Mato Grosso e dá outras providências. Disponível em: http://www.al.mt.gov.br/v2008/Raiz%20Estrutura/responsabilidadesocial/

Sustainability as a success factor in global operations: a survey of car manufacturing supply chains

Akabane[1], Getulio K., Pozo[1], Hamilton, Galhardi[1], Antonio César, Peterossi[1], Helena Gemignani[1]

Abstracts: Since the 1990s, environmental issues have put companies under a growing pressure to reduce their environmental impact, especially in logistics operations. Current research seeks to define green practices in each supply chain segment, to deepen the understanding of how companies formulate their green initiatives and to analyze the logistical bases and results connected with such decisions. This study's sample was three large assembly companies in the automotive segment, with industrial plants located both in the southeast region of Brazil and globally. The results show that the wave of sustainability is a result of more than just the threat of negative publicity, and it is pushing enterprises into the green zone. At the same time, economic instability with oscillating growth is forcing enterprises to concentrate on improving efficiency to compensate for unstable demand and the price volatility of commodities, including water and energy.

Keywords: green logistics, sustainability, supply chain management, environmental impact, globalization.

1 Introduction

Global supply chains introduce additional dimensions such as production outsourcing, infrastructure, inventories, suppliers, customers, cultures, regional economic differences, currencies, and competitive environment policies (Manuj & Mentzer,2008;Schmidt & Wilhelm,2000; Christopher, 2005).

Green supply chain (GSC) strategies refer to enterprises' efforts to minimize the negative impact of supply chains on natural environments. Addressing questions of climatic changes, pollution, and constraints such as non-renewable resources, enterprises are paying attention to stakeholders' demands for corporative citizenship behavior and superior performance (SARKIS, 2001; DE BURGOS JIMENEZ & CESPEDES LORENTE, 2001).

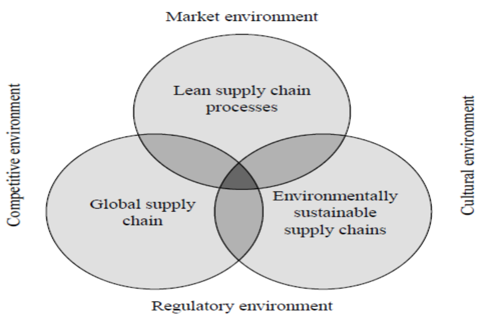

Fig.1
Research domain of green, lean, and global supply chains.
Source: Mollenkopf et al. (2010, p.16).

1 **CEETEPS**-Centro Estadual de Educação Tecnológica Paula Souza - São Paulo – Brazil.

While there are different research groups related to green, lean, and global subjects, few authors pay attention in the intersection of these strategic initiatives (see Figure 1). This question identifies a gap in the literature because enterprises can lose their synergies during the implementation of simultaneous improvements and they do not get important information during incidents of incompatibility between these strategic initiatives. For example, lean and green strategies quite often are seen as compatible initiatives because of their joint focus on waste reduction. Although recently there has been a substantial growth of academic articles that explore practices of GSC management, these still require translation by specialists into how, how many, and which companies can translate these strategic intentions into GSC practices.

2 Literature Review

The questions that surround the future of humanity were clearly outlined in a report published by the United Nations in 1987, in which the term "sustainability" was defined. According to Ittmann (2010), it originates from the Latin word *sustenere* (*tenere*: to maintain; *sus*: on top of). Dictionaries give other meanings for "support," principally "maintaining," "supporting," or "lasting." After the term sustainability was used in the United Nations's report to identify human sustainability on this planet, this definition was enlarged upon by the Brundtland Commission (1987) of the United Nations to include that "sustainable development is development that attends present necessities of the without compromising the capacity of future generations in attending their own necessities."

Nevertheless, from the 1990s onward, environmental issues put companies under growing pressure to reduce their environmental impact, especially in logistics operations. The negative effects of the distribution of goods can damage air quality, generate noise and vibrations, cause traffic jams and accidents, and significantly contribute to global warming. The greenhouse effect provokes climate change more strongly than was imagined in early researches (Ittmann, 2010). It is predicted that transportation of goods in general contributes approximately 8% of total CO_2 (carbon dioxide) global emissions (Kahn Ribeiro & Kobayashi, 2007), so the long-term mission of "sustainable" logistics is the effective reduction of carbon particle emissions in the atmosphere.

Table 2
Emission standards for stress-resistant diesel engines, in grams per kilowatt-hour.
Source: www.nao.org.uk (2010).

Tier	Date of Implementation	CO	HC	NO	PM
Euro I	1992 (>85kw)	4.5	1.1	8.0	0.36
Euro II	1998	4.0	1.1	7.0	0.15
Euro III	2000	2.1	0.66	5.0	0.10
Euro IV	2005	1.5	0.46	3.5	0.02
Euro V	2008	1.5	0.46	2.0	0.02
Euro VI	2013	1.5	0.13	0.4	0.01

[1] CO: carbon monoxide [2] HC: hydrocarbon [3] NO: nitrogen oxide [4] PM: particles per million

For some time now, these effects have been monitored, and new management standards have been introduced. For example, the standards for emissions of stress-resistant diesel engines, known as Euro standards of emission, were developed based on emission projections determined for a calendar of introducing standards, as shown in the chart below (see Table 1). These were to be followed by transport companies with heavy vehicles that have a significant environmental impact (ITTMANN, 2010).

In fact, most global companies are expanding their efforts to integrate environmental dimensions into their business (Carbone & Moatti, 2008). Several studies in the literatures on GSC examined the importance of working through the supply chain with customers and suppliers through environmental initiatives that produce general performance improvement in enterprises (Vachon & Klassen, 2006b).

These initiatives develop the capacity to share knowledge (Vachon & Klassen, 2008) and add resources to obtain competitive sustainable advantages from environmental programs.

Enterprises are re-structuring their supply chains to operate on a global basis, obtaining advantages through international products, in operational factors and capital markets (Manuj & Mentzer, 2008, p. 133). Nevertheless, the management of global supply chains presents several challenges, including important aspects of economic and cultural environments, as well as regulations. Global supply chains accent the importance of managing risk (MANUJ & MENTEZR, 2008).

In this way, green logistics are defined as "efforts in reducing appearances and obtaining a more sustainable balance between economic, environmental, and social objectives [. . .], where all efforts in the field of 'green' logistics are focused on the contributions that secure the sustainability of the planet" (ITTMANN, 2010).

2.1 GSC

GSC management is best defined as "environmental management alignment and integration inside of supply chain management" (Klassen & Johnson, 2004). The research clearly recognizes that enterprises' environmental impact spreads outside their boundaries. In addition, definitions include product design, all manufacturing steps, distribution, and all aspects of reverse logistics (see Figure 2).

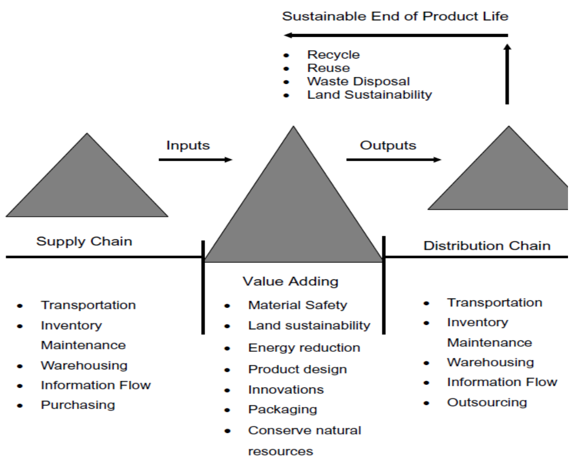

Fig.2
Characteristics of sustainable supply chains
Source: www.greenlogistics.org (2011)

According to Murphy, Poist, and Braunschweig (1996), green logistics principally investigates environmental issues in logistics operations. Murphy and Poist (2000) further explained that green logistics strategies include recycling processes and reuse of materials, as well as reduction of consumption of raw materials in manufacture processes. As a result of this perspective, closed-loop supply chains have received most of the attention in specialized literature (ROGERS, LAMBERT, CROXTON, & GARCIA-DASTUGUE, 2002). Authors also point out that pioneers concentrated their researches on reverse logistics.

In upstream areas, green purchasing can address issues such as production waste reduction, changes to alternative materials with low environmental impact from raw material suppliers, minimization of hazardous materials disposal, and reduction of pollutants emissions. Supplier management is crucial to implementing a green acquisition strategy (Simpson & Power, 2005), and many world-class companies frequently carry out initiatives in order to meet the demands of their socio-environmental responsibilities (BACALLAN, 2000).

2.2 Environmental Impact Evaluation Model

Developed by Albino, Izzo, and Kuhtz (2002), this model is a useful instrument for global enterprises to evaluate the environmental impact of production processes in supply chains. The measurement of performance in GSCM is discussed by Hervani et al. (2005) and Clift (2003); nevertheless, there is little mention of measures that enterprises could adopt to evaluate their carbon footprint in a global context.

One of the most common global benchmarks for environmental initiatives is ISO 14000 certification from the International Organization for Standardization, which requires a series of proceedings to identify environmental aspects of onsite operations, safe handling and procedures for hazardous waste material processing, and compliance with relevant environmental legislation. The ISO 14000 certificate is most commonly adopted by multinational enterprises, which stimulates their suppliers to be certified. Quite often, ISO 14000 standards are also incorporated in supplier selection processes (Chen, 2005; Miles, Munilla, & McClurg, 1999).

3 Methodology

The sample included three international companies in the automotive segment, with industrial plants located in the southeast and south regions of Brazil, in the state of Sao Paulo.

The criterion for choosing these companies was non-probability sampling, which according to Mattar (1996, p. 132) is when the "selection of elements of the population to compose samples depends at least in part on the researcher or interviewer's judgment in the field." In other words, sampling was carried out in accordance with the researchers' judgment, so that specialized interviewees answered 51 items in closed questionnaires and wrote remarks on items if necessary.

4 Survey Results

The results permit a comparison of three large enterprises of the automotive sector in terms of their sustainability efforts. The companies were evaluated using a questionnaire with 51 variables. Each variable came with five options, each attributed a weight from one to five on a Likert scale, where one represented precarious sustainability conditions and five, a maximum of sustainable adaptation. Table 2 presents the scores for each variable and the percentages obtained using these evaluation tools, in which 100% means complete adaptation of the best sustainable practices.

Table 2
Comparison of companies.

INDICATORS	Q	T	ASSEMBLER1		SUPPLIER		ASSEMBLER2	
			P	%	P	%	P	%
GREEN PURCHASE	13	65	53	81.5	49	75.4	53	81.5
GREEN MANUFAC.	10	50	24	48.0	30	60.0	42	84.0
GREEN PROJECT	9	45	35	77.8	43	96.0	35	77.8
REVERSE LOGISTICS	19	95	53	55.8	43*	78.2	61	64.2

The samples confirm that these enterprises have been implementing GSC strategies. The Japan-based company is a few steps ahead, for example, in its level of consideration of different environmental factors. This Japanese company considers a supply of green raw materials highly important when choosing its partner companies.

Nevertheless, as expected, all three companies are more interested in energy consumption and water processing than in service sectors. Likewise, they put a greater emphasis on employees' health and have decentralized most of their production and distribution. They are currently developing initiatives to reduce transport costs but maintaining sustainability criteria, especially in CO_2 emissions.

The data are compared in Figure 3, which shows service percentages for each studied indicator. The level of outsourced enterprises' involvement is high in the supply chain's upstream, as well as subcontracted companies and logistics providers, including bonded warehouses with a more limited dedication to environmental issues as compared to other respondents.

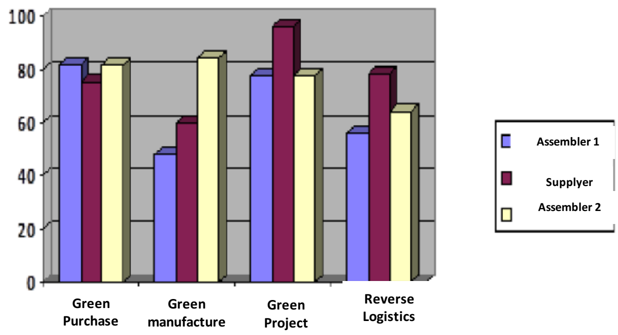

Fig.2
Comparative data.

4.1 Green Logistics

Most of the companies are implementing GSC measures through modifications in transportation operations and logistics, including fleet renovation. In terms of green logistics implementation, the companies include logistics flow optimization and company image improvement, as well as logistics cost reduction and landmark regulations. The degree of complexity of such initiatives and high associated costs are the main disincentives observed for environmental damage reduction.

4.2 Green Purchasing

Suppliers' involvement is crucial for green projects in which enterprises carry out auditing, as they identify and put into practice key performance indicators to monitor suppliers' green performance. Acquisition and manufacturing strategies are functions most affected by environmental issues. Initiatives in product logistics and design show the reverse tendencies in that they receive a low degree of attention from the companies surveyed.

4.3 Green Manufacturing

Two main green initiatives in manufacturing refer to production processes' modification, equipment utilization, and less polluting materials. Closely related to these issues is the process of optimization and lean manufacturing concepts of reducing waste during manufacturing operations.

Besides purely environmental considerations, these processes reflect on issues such as manufacturing cost optimization and operations themselves. Because they undertake direct actions in terms of resources and other parts of production, the companies investigated have secured greater efficiency, as opposed to if they used more onerous methods at the end of the cycle of production. The initial reasons for adopting green manufacturing is, on the one hand, improved financial performance (i.e., cost reduction through optimization and improvement in resource consumption) and, on the other hand, the ability to follow regulations, including current laws. Only assembly plant 2 (see Figure 3) meets these requirements.

4.4 Green Projects

In the sample, the enterprises have been implementing eco-design products and/or manufacturing processes. The Japanese company is still some steps ahead in this area according to the data on adopting a green attitude in the product design phase. The survey results show that, in most cases, green design is applied to products or to their components and packaging. In only a small percentage of cases, this approach has been applied to manufacturing processes in order to reduce energy consumption and waste production.

According to the principle of “from cradle to grave,” most of the companies have adopted green projects to make more easily recycled products. Based on the data, it can be estimated that most of the enterprises have adopted green designs to improve their brand image, to satisfy stakeholders’ demands and increase consumers’ confidence.

4.5 Reverse Logistics

Most of the companies have adopted reverse logistics for product recovery and refurbishment. Half of the reverse logistics operations involve finished products and packaging. Recovering initiatives for both items refers respectively to refurbishing and recovering, as well as recycling and reuse after cleaning or restoration.

The companies that have decided to establish reverse logistics structures are motivated by the desire to “meet consumer expectations,” a reason pointed out by most of the respondents. Reverse logistics is a way for companies to acquire a certain dignity in their market, showing corporative citizenship and reinforcing their positive image and the loyalty of clients and society. The need to respect reverse policies is a third direction that growing numbers of large industries appear to be adopting.

It is interesting to note that a third of the companies surveyed that have adopted sustainable supply chains believe that reverse logistics structures are not that necessary in their market. The degree of complexity and associated difficulties are the second major disincentives for companies that are using reverse logistics. First, the companies think that reverse logistics is complex because it involves a complete cycle structure from initial stimulations, selective collection, sorting, storage, and recycling in order to send products on to the next phase. The second reason is that several intermediaries are integral to each stage of the cycle, increasing the difficulty to finalize such operations.

5 Final Considerations

The survey evidence discussed above justifies continuing present trends in researches, although it will be necessary to enlarge the samples and include other economic segments in addition to those discussed in this paper. On the one hand, there is a need to understand the specific benefits of GSCs. On the other hand, the institutionalization of a “green attitude” deserves renewed exploration.

In fact, a key characteristic of an agile approach is flexibility, while a lean approach means maximum realization with minimum resources. Agility is pursued in a volatile market. Lean operations make sense when demand is predictable, with low variety and high volume. An analysis indicates that these differences in supply chain strategies become more diffuse for GSC issues. Visibility and transparency are needed along supply chains to ensure that all members are aware of threats and opportunities.

More concretely, this research infers that prominent companies are now concentrating on supply chain processes including environmental initiatives that recognize contemporary issues, such as CO_2 emissions, energy shortages, and out of control consumption of natural resources. These are constant, challenging factors in current and future operations.

These initiatives reiterate green logistics, where GSCs are sustainable and will become a pre-requisite in the near future. Environmental pressures and debates on subjects such as climatic change are growing, increasing the emphasis given by governments and consumers to these issues and making them truly critical aspects in business management.

6 References

Albino, V., Izzo, C., & Kuhtz, S. (2002). Input-output models for the analysis of local/global supply chain, *International Journal of Production Economics*.

Bureau of Transportation Statistics. (2007). *Commodity flow survey*. Retrieved from http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/commodity_flow_surveyindex.html

Carbone, V., & Moatti, V. (2008). Greening the supply chain: Preliminary results of a global survey. *Supply Chain Forum: An International Journal*, *9*(2).

Christopher, M. (2005). *Logistics and supply chain management: Creating value-adding networks* (3rd ed.). Harlow, UK: Pearson Education.

Clift, R. (2003). Metrics for supply chain sustainability. *Clean Technologies and Environmental Policy*, *5*(3).

Cooke, J. A. (2008). The greening of Whirlpool's supply chain. *CSCMP's Supply Chain Quarterly*.

De Burgos Jiménez, J., & Cespedes Lorente, J. J. (2001). Environmental performance as an operations objective. *International Journal of Operations & Production Management*, *21*.

Dowell, G., Hart, S., & Yeung, B. (2000). Do corporate global environmental stewards create or destroy market value? *Management Science*, *46*.

Fleischmann, M. (2001). *Quantitative models for reverse logistics*. Heidelberg, Germany: Springer-Verlag.

Florida, R. (1996). Lean and green: The move to environmentally conscious manufacturing. *California Management Review*.

Gilmore, D. (2010, 7 August). How real is the green supply chain? *Supply Chain Digest*.

Golicic, S. L., Boerstler, C. N., & Ellram, L. M. (2010). "Greening" transportation in the supply chain. *MIT Sloan Management Review*.

Green Logistics. (2011). *Research into the sustainability of logistics systems and supply chains*. Cardiff, UK: Consortium of UK Universities.

Havenga, J. H., van Eeden, J., & Simpson, Z. (2010). The state of logistics in South Africa—Sustainable improvements or continued exposure to risk. In D. King (Ed.), *Sixth State of Logistics Survey* (pp. 14–23). Pretoria, South Africa: CSIR Report.

Insight Survey Report. (2008). How mature is the green supply chain? *Supply Chain Monitor*. Vienna: Bearing Point, Inc.

Ittmann, H. W. (2010). *Green supply chains—a new priority for supply chain managers*. Pretoria, South Africa: CSIR Built Environment.

Kahn Ribeiro, S., & Kobayashi, S. (2007). Transport and its infrastructure. In B. Metz, O. R. Davidson, P. R. Bosch, R. Dave, & L. A. Meyer (Eds.), *Fourth assessment report: Climate change 2007—mitigation of climate change* (Chapter five). Geneva: Inter-Government Panel on Climate Change.

Klassen, R. (2001). Plant-level environmental management orientation: The influence of management views and plant characteristics. *Production and Operations Management*.

Manuj, I., & Mentzer, J. T. (2008). Global supply chain risk management. *Journal of Business Logistics*, *29*(1).

Matos, S., & Hall, J. (2007). Integrating sustainable development in the supply chain: The case of life cycle assessment in oil and gas and agricultural biotechnology. *Journal of Operations Management*.

Mattar, F. (1996). Pesquisa de marketing. Sao Paulo, Brazil: Editora Atlas.

McKinnon, A. (2010). Environmental sustainability: A new priority for logistics managers. In A. McKinnon et al. (Eds.), *Green logistics: Improving the environmental sustainability of logistics* (pp. 31–48). London: Kogan.

Melnyk, S. A., Davis, E. W., Spekman, R. E., & Seor, J. (2010). Outcome-driven supply chains. *MIT Sloan Management Review*.

Miles, M. P., Munilla, L. S., & McClurg, T. (1999). The impact of ISO 14000 environmental management standards on small and medium sized enterprises. *Journal of Quality Management*, *4*(1).

Murphy, P., & Poist, R. (2000). Green logistics strategies: An analysis of usage patterns. *Transportation Journal*.

Murphy, P., Poist, R., & Braunschweig, C. (1996). Green logistics: Comparative views of environmental progressives, moderates, and conservatives. *Journal of Business Logistics*.

Rogers, D., Lambert, D., Croxton, K., & Garcia-Dastugue, S. (2002). The returns management process. *International Journal of Logistics Management*.

Schmidt, G., & Wilhelm, W. E. (2000). Strategic, tactical, and operational decisions in multi-national logistics networks: A review and discussion of modeling issues. *International Journal of Production Research*, 38(7).

Schoeman, C., & Sanchez-Rodriques, V. (2010). Green logistics and sustainability. In D. King (Ed.), Sixth State of Logistics Survey (pp. 45–51). Pretoria, South Africa: CSIR Report.

Simpson, D., & Power, D. (2005). Use the supply relationship to develop lean and green suppliers. *Supply Chain Management: An International Journal*.

Ubeda, S., Arcelus, F. J., & Faulin, J. (2010). Green logistics at Eroski. A case study. *International Journal of Production Economics*.

U.S. Environmental Protection Agency. (2007). *Inventory of U.S. greenhouse gas emissions and sinks: 1990–2005*. Retrieved from http://epa.gov

Zhu, Q., & Cote, R. P. (2004). Integrating green supply chain management into an embryonic eco-industrial development: A case study of the Guitang Group. *Journal of Cleaner Production*, *12*.

Entrepreneurship And Innovation: a study between Brazil and Finland

Okano MT[1], Vendrametto O[2], Santos OS[3], Fernandes ME[4]

Abstract: The main aim of this project is to study how entrepreneurship and innovation are taught in the universities comparing Finland and Brazil and what methods are using to get this subject. To achieve the objective of this research, firstly was a survey of the literature on the entrepreneurship and innovation, business modeling, business planning, Canvas business model and Design Thinking. The study achieved its objective; the use of entrepreneurship and innovation in multidisciplinary work encourages students because it brings the reality of the labor market into college.

Keywords: entrepreneurship; innovation; Brazil; Finland;

1 Introduction

Developing countries are increasingly finding that entrepreneurship and innovation are the ways to speed up their developments and initiate or encourage technological development.

The educational institutions such as Universities, Colleges and Colleges of Technology, has two main roles in this process, to guide and train entrepreneurs and provide technological knowledge and encourage innovation. There was thus completing the triple helix model of innovation with universities, government and industry.

The objective of this research is to see how the teaching innovation and entrepreneurship in Fatecs is aligned with the Universities of Applied Sciences in Finland through the use of methods and current methodology.

The choice of Fatecs (Technology Colleges) of the state of Sao Paulo, due to the fact that the state of Sao Paulo have the largest network publishes Technical Schools and Colleges of Technology through the Paula Souza Center. The Centro Paula Souza is a municipality of the State of São Paulo, linked to the Department of Economic Development, Science, Technology and Innovation (SDECTI). The institution manages 218 State Technical Schools (Etecs) and 64 Colleges of Technology (Fatecs), gathering over 283 thousand students in technical courses of medium and higher technological level, in more than 300 municipalities.

Already in Fatecs, more than 70,000 students are enrolled in 71 technological undergraduate courses in various fields such as Construction, Mechanical, Computer Science, Information Technology, Tourism, among others. Beyond graduation, are offered graduate courses, technology upgrade and extension. The choice of Fatecs (Technology Colleges) of the state of Sao Paulo, due to the fact that the state of Sao Paulo have the largest network publishes Technical Schools and Colleges of Technology through the Paula Souza Center. The Centro Paula Souza is a municipality of the State of São Paulo, linked to the Department of Economic Development, Science, Technology and Innovation (SDECTI). The institution manages 218 State Technical Schools (Etecs) and 64 Colleges of Technology (Fatecs), gathering over 283 thousand students in technical courses of medium and higher technological level, in more than 300 municipalities.

1 **Marcelo Tsuguio Okano** (marcelo.okano@fatec.sp.gov.br)
FATEC Barueri. São Paulo. SP. Brazil.

2 **Oduvaldo Vendrametto** (oduvaldov@uol.com.br)
Paulista University. São Paulo. SP. Brazil.

3 **Osmildo Sobral dos Santos** (osmildosobral@yahoo.com.br)
Potiguar University. Natal. RN. Brazil.

4 **Marcelo Eloy Fernandes** (marceloeloyfernandes@gmail.com)
FATEC Barueri. São Paulo. SP. Brazil.

Already in Fatecs, more than 70,000 students are enrolled in 71 technological undergraduate courses in various fields such as Construction, Mechanical, Computer Science, Information Technology, Tourism, among others. Beyond graduation, are offered graduate courses, technology upgrade and extension.

The choice of Finland is due to the process that went for evolution of entrepreneurship and innovation. The student revolution was part of a wider reconsideration of the proper relationship between government and business. This had started in 2008, when the Finnish government shook up the universities (and created Aalto) in an attempt to spur innovation. But it was speeded up by Nokia's problems. Finland had become dangerously dependent on this one company: in 2000 Nokia accounted for 4% of the country's GDP. The government wanted to make the mobile-phone giant's decline as painless as possible and ensure that Finland would never again become so dependent on a single company (The Economist, 2013).

The Finns created an innovation and technology agency, Tekes, with an annual budget of [euro] 600m and a staff of 360. They also established a venture-capital fund, Finnvera, to find early-stage companies and help them get established. The centre piece of their innovation system is a collection of business accelerators, partly funded by the government and partly by private enterprise, that operate in every significant area of business and provide potential high-growth companies with advice and support from experienced businesspeople and angel investors (The Economist, 2013).

2 Literature Review

2.1 Entrepreneurship and Innovation

Traditionally, teaching and research have been the university's main missions. This has gradually changed with the emergence of disciplines like biotechnology, increased globalization, reduced basic funding, and new perspectives on the role of the university in the system of knowledge production. Innovation is increasingly seen as an evolutionary process that involves different institutional spheres, or sectors, in society (Rasmussen et al., 2006).

Although innovation and entrepreneurship generally go hand in hand, forming a distinction between the two concepts is possible. The definitions for entrepreneurship may vary; however, one of the most popular works on the subject defines this concept as the process of identification, evaluation and implementation of business opportunities (Shane & Venkataraman, 2000; Soriano & Huarng, 2013).

Entrepreneurship is a milestone on the road towards economic progress, and makes a huge contribution towards the quality and future hopes of a sector, economy or even a country. Entrepreneurship is as important in small and medium-sized enterprises (SMEs) and local markets as in large companies, and national and international markets, and is just as key a consideration for public companies as for private organizations. Entrepreneurship helps to encourage the competition in the current environment that leads to the effects of globalization (Soriano & Huarng, 2013).

Innovation is a tool for entrepreneurs and thus innovation is a specific instrument of entrepreneurship (Drucker, 1985).

Universities have an important role in the formation of entrepreneurs, since the transmission of knowledge to the formation of the individual as entrepreneur. This process has taken various forms, but it is generally assumed that technological advances are created by faculty and research staff and diffused to society through a technology transfer process, either through licensing of the technology to established firms or through the creation of new spin-off firms. Technology Licensing (or transfer) Offices (TLOs), incubators, and science parks have in turn been created to facilitate such technology transfer (Rothaermel et al., 2007).

Shane and Venkataraman (2000) define entrepreneurship as the "scholarly examination of how, by whom, and with what effects opportunities to create future goods and services are discovered, evaluated, and exploited" Entrepreneurship activity, in general terms, positively impacts economic growth because it is necessary to have a group of persons willing to assume risk, using their funds to generate new firms and business. This is the best way to achieve a sustainable economic growth (NISSAN et al., 2011).

The definition takes into account the economic agents‟ behavior. For this reason, entrepreneurship doesn't mean an occupation but an activity that considers the different circumstances and aspects of a person.

Entrepreneurships must consider uncertainty and obstacles inherent in the business creation process.

They must have information or ideas about efficient production processes, as well as new organizational forms. This doesn't mean entrepreneurs had to have attended special academic courses about management. They must have the idea and they can ask information or advice from experts to execute the idea.

The entrepreneurs can be also encountered in big firms. In this case, they are named "entrepreneurs"" or "corporate preneurs" (Arendt and Brettel 2010).

The entrepreneurship factor also includes persons that search information or ideas about efficient production processes, as well as new organizational forms. Taking into account these ideas, different types of entrepreneurships can be considered (Nissan et al., 2011).

First is the innovator, following Schumpeter's (1911, 1950) thesis. Schumpeter considers that entrepreneurship activity implies innovation in the introduction of a new product, organization or process, generating a destruction process. The innovator creates new industries and for this reason he causes relevant structural changes in the economy. Second is the entrepreneur that takes advantage of profit opportunities (Kirzner, 1973, 1999). Third, uncertainty element must be taken into account (Knight, 1921). And fourth, productive and nonproductive entrepreneurships must be also considered (Baumol, 1990).

2.2 Business Modeling X Business Planning

A business plan is a document that describes (in writing) what the goals of a business and what steps should be taken so that these objectives are achieved, reducing the risks and uncertainties. A business plan allows you to identify and restrict your mistakes on paper rather than commit them in the Market (ROSA, 2004).

According to Leschke (2013), the target students lack sufficient business background and experience to research, analyze, or construct a reasonably complete or credible business plan, and it would be unfair to expect this of them. At this stage of their development, students need to be encouraged to be more inventive, creative, open-minded and divergent, as opposed to converging on the details of a particular plan. While understanding and appreciating what is involved in preparing a business plan is important, knowing its purpose, format, tone and content is sufficient. These students are better served by developing skills relevant during the earlier stages of the entrepreneurial path (i.e., idea generation, concept development, opportunity assessment and business modeling) and developing the fundamental discipline of considering a broad set of options and making a thoughtful, informed choice before proceeding.

In our experience, we adopted business modeling instead of business planning. Osterwalder (2004, 2008 and 2010) introduced the business model canvas methodology to provide an efficient means of capturing completely the key aspects of how a firm might approach a particular business proposition. The business model canvas, depicted in Figure 1, is comprised of nine "building blocks" that encompass a relatively complete and comprehensive set of business planning dimensions. Completing the canvas (i.e., creating bulleted lists of descriptors within each building block) to document how a firm might approach a particular opportunity constitutes a business model and the process of generating a number of alternative models is business modeling.

2.3 Design Thinking

The SAP Design Services Team (DST) was created in 2005 by Hasso Plattner, Chairman and Chief Software Advisor, to improve the design of SAP software solutions as well as provide the organization with the means to scale up its adoption of design thinking. Design thinking is a term used to describe how designers typically approach problem solving. Beginning with a holistic, ''3608'' understanding of the problem, including customer's needs (explicit and tactic), the end-user's environment, social factors, market adjacencies, and emerging trends, etc., design thinking looks beyond the immediate boundaries of the problem to ensure the right question is being addressed.

Using interdisciplinary teams, design thinking incorporates diversity and leverages different paradigms and tool sets from each profession to analyze, synthesize, and generate insights and new ideas. The interdisciplinary nature of design thinking also ensures that innovations are naturally balanced between the technical, business, and human dimensions.

The design thinking approach also encourages teams to create ‘‘project war rooms’’ and to work visually using pictures, diagrams, sketches, video clips, photographs, and artifacts collected from their research to create immersive work environments that allow the team to gain deeper, more intuitive empathy and understanding of their users’ needs. Using rapid iterative development cycles, teams build rough, ‘‘throw-away’’ prototypes for validation with end-users and project stakeholders.

The team is challenged to risk failure by pushing the limits of both their own capacity as well as the capabilities of the technology and the boundaries within their organization. Using artifacts to express ideas, the final deliverable in the design thinking approach is a prototype that can be used for communication, alignment, and living requirement specifications to provide clarity and transparency during the production of the solution.

2.4 Elevator Pitching

According Stewart (2013), the elevator pitch is not a high-speed regurgitation of what you do for all types of clients or all of the firm's practice areas. By design, the elevator pitch is meant to be a succinct expression of what you do in a way that demonstrates the benefit to the recipient.

The elevator pitch gets its name from the short ride in an elevator, so keeping with that concept it needs to be brief and concise. At best, it should be two to three sentences and take less than thirty seconds to deliver. Remember that not all elevator rides are long. Your goal should be to explain what you do as it relates to the individual you are addressing, if possible (Stewart, 2013).

By definition, an elevator pitch is an overview of an idea, product, service or project that is designed to initiate a conversation. When developing an elevator pitch, there are several things to keep in mind (Stewart, 2013).

The elevator pitch, sometimes known as the elevator speech, is a short summary that quickly defines a product or service and its value proposition. A successful pitch induces the listener to make a decision sought by the speaker. The pitch is usually approximately 30 seconds, never more than two minutes (Denning & Dew, 2012).

3 Methodology

To achieve the objective of this research, firstly was a survey of the literature on the entrepreneurship and innovation, business modeling, business planning, Canvas business model and Design Thinking. Secondly, based on literature review, we developed the questionnaire. Thirdly, we realized an exploratory survey, qualitative nature, to verify the proposed workflow. We used interviews as tool to get informations with managers of six universities, three of them are brazilians and the others are finnish.

4 Results

As results, we identified the following process or methods used to teaching entrepreneurship or innovation as shown in table 01, and which universities are using these one.

Table 01
process or methods used to teaching entrepreneurship.

Process or Method	Brazilian Univ 01	Brazilian Univ 02	Brazilian Univ 03	Finnish Univ 01	Finnish Univ 02	Finnish Univ 03
Canvas Business Model	yes	yes	yes	yes	yes	yes
Design Thinking	yes	yes	yes	yes	yes	yes
Prototype	yes	yes	yes	yes	yes	yes
Elevator Pitching	yes	yes	yes	yes	yes	yes
Startup contest	yes	yes	yes	yes	yes	yes
Business Planning	yes	yes	yes	yes	yes	yes
Student Association for entrepreneurship or innovation	No	No	No	yes	yes	yes
Specific room for entrepreneurship or innovation (war room)	No	No	No	yes	yes	yes
Coworking area	No	No	No	No	No	yes

5 Conclusion

We found that the Finalndia this ahead of Brazil to the teaching of entrepreneurship and innovation, but we are in the right track because we use the methods they.

The study achieved its objectives, the use of entrepreneurship and innovation in multidisciplinary work encourages students because it brings the reality of the labor market into college.

The methods such as Canvas and Design Thinking assist in shaping ideas and strategies, the weak point is the item innovation, because students still do not realize the importance of innovation in choosing unpublished projects.

It is amazing value given not only education, but other sectors as well. Companies like Nokia we all know, is the result of efforts in these areas involving education and encouraging innovation. Including the range of economic boost of Finland was the result of the emphasis placed on education and persistence.

References

Baumol, W.J. “Entrepreneurship: productive, unproductive and destructive”, Journal of Political Economy, Vol. 98 No. 5, pp. 893-921. (1990),

Centro Paula Souza. Faculties of Technology of Sao Paulo State. Available in: http://www.centropaulasouza.sp.gov.br/Cursos/Fatec/ (2014)

Denning, Peter J., Dew Nicholas, communications of the acm. ACM vol. 55, no. 6 (June 2012)

Domingo R. S., Kun-Huang H., Innovation and entrepreneurship in knowledge industries, Journal of Business Research, Volume 66, Issue 10, October 2013, Pages 1964-1969,

Einar R., Øystein M, Magnus G., Initiatives to promote commercialization of university knowledge, Technovation, Volume 26, Issue 4, April 2006, Pages 518-533

European Commission (2003), Entrepreneurship in Europe, COM 2003 final, European Commission, Brussels.

Farino´s, J.E., Herrero, B. and Latorre, M.A., “Corporate entrepreneurship and acquisitions: creating firm wealth”, International Entrepreneurship and Management Journal, Vol. 7 No. 3, pp. 325-39. (2011)

Kirzner, I.M., Competition & Entrepreneurship, University of Chicago Press, Chicago, IL. (1973)

Leschke, J. BUSINESS MODEL MAPPING: APPLICATION AND EXPERIENCE IN AN INTRODUCTION TO ENTREPRENEURSHIP COURSE. Journal of entrepreneurship Education. 2013

Martin, Bruce C. McNally, Jeffrey J. Michael J. Kay, Examining the formation of human capital in entrepreneurship: A meta-analysis of entrepreneurship education outcomes, Journal of Business Venturing, Volume 28, Issue 2, March 2013, Pages 211-224

Matthew Holloway,"How tangible is your strategy? How design thinking can turn your strategy into reality", Journal of Business Strategy, Vol. 30 Iss 2/3 pp. 50 – 56. (2009)

Nissan, E., Galindo, M.A. and Mendez, M.T., “Relationship between organizations, institutions, entrepreneurship and economic growth process”, International Entrepreneurship and Management Journal,Vol. 7 No. 3, pp. 311-24. (2011)

O'Connor, A conceptual framework for entrepreneurship education policy: Meeting government and economic purposes, Journal of Business Venturing, Volume 28, Issue 4, July 2013, Pages 546-563

Osterwalder, E. (2008). The Business Model Canvas, (www document) Retrieved October 29, 2011 from http://www.nonlinearthinking.typepad.com

Osterwalder, E. and Y. Pigneur, et al (2010). Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers, Wiley, 2010.

Osterwalder, E.. The Business Model Ontology - A Proposition in a Design Science Approach. Unpublished PhD Thesis, University of Lausanne, Lausanne, CH. (2004)

Paasio, P. N. K.,"Entrepreneurship in Finnish universities", Education + Training, Vol. 49 Iss 1 pp. 56 – 65 (2007)

Rosa, Cláudio Afrânio. Como elaborar um plano de negócio / Organizado por Flávio Lúcio Brito; colaboradores Haroldo Mota de Almeida, Luiz Antônio Nolasco dos Santos, Mauro de Souza Henriques. - Belo Horizonte: SEBRAE/MG, 2004. (In Portuguese)

Rothaermel, F.T., Agung, S.D., Jiang, L., University entrepreneurship: a taxonomy of the literature. Industrial and Corporate Change 16, 691–791. 2007.

Sao Paulo. São Paulo State. Available in: http://www.saopaulo.sp.gov.br/en/conhecasp/ (2014).

Schumpeter, J.A. The Theory of Economic Development, Oxford University Press, New York, NY. (1911),

Schumpeter, J.A. Capitalism, Socialism and Democracy, Harper & Brother Publishers, New York, NY. (1950),

Shane, S., Venkataraman, S., The promise of entrepreneurship as a field of research. Academy of Management Review 25, 217–226. 2000.

Soininen, J., Martikainen, M., Puumalainen, K., Kylaheiko, K. Entrepreneurial orientation: Growth and profitability of Finnish small and medium-sized enterprises. Int. J. Production Economics 140, 614–621, 2012.

Stewart, Brenda. "Are you ready for the chance of a lifetime? Developing your elevator pitch." Young Lawyer July-Aug. 2013. Academic OneFile. Web. 27 Dec. 2014. Document URL http://go.galegroup.com.ez87.periodicos.capes.gov.br/ps/i.do?id=GALE%7CA337529375&v=2.1&u=capes&it=r&p=AONE&sw=w&asid=2ea21af755ab24aa979a687f51e4827c

The Economist. "If in doubt, innovate; Entrepreneurs." The Economist 2 Feb. 2013: 10(US). Academic OneFile. Web. 28 Dec. 2014

Social Innovation Research Centers: Focus, Objectives and Trends

Menegotto MLA[1], Camargo, ME[2], Pereira, EP[3]

Abstract: The present paper aims to review the literature studies on Social Innovation, and its evolution in the period from 1965 to 2015. In this sense, researches have been developed in order to encompass this emerging theme. In order to increase knowledge on the scientific production related to this issue, this work analyzes the characteristics of publications in the Science Direct database and Scopus database from 1965 to 2015. The work characterizes as exploratory and descriptive, which seeks to deepen the analysis of scientific literature on social innovation, its actors, process, authors and directions of future research. The main results of the study can show that social innovation centers are focus ed on research and action; and the centers created after the 2010 act as interdisciplinary and more focused on research. Another relevant finding is that this centers seeking direct its actions to the market and to sustainable objectives.

Keywords: Social Innovation, Research Centers on Social Innovation, Sustainability.

1 Introduction

The economic changes occurred in the last decades increased the relevance of innovation and as a result it lead to a generation of new solutions (Rollin & Vicent, 2007). By his side, innovation is a part of the social change process or modernization of the society, and according to Ogburn (1937), resulting from these processes the society has different associations, with different proposes, that can be among individuals or different companies with similar interests which they realize that from its association they gain strength before the conflict caused by the competitiveness and global problems (André &Abreu, 2006; Cajaiba-Santana, 2013).

The result of the synergy between the actors of the production chain accelerates economic growth, especially in developing countries, which increases the number of competitors, extrapolating the local demographic region, becoming world (Ossani, 2013). Thus, the space is optimized for innovation and as a result there is the generation of solutions (Rollin & Vicent, 2007). The literature states that innovation in turn is a component of the processes of social change and modernization of society, and according to Ogburn (1937), as a result of these forms of associations processes, different arrangements, between individuals or companies with similar interests realize that after its unification gain strength before the conflict and global problems (Aandré & Abreu, 2006; Cajaíba-Santana, 2013).

Within this framework, we identified the research problem: the search for studies on the process and entities who study social innovation as well as its origins, focus and objectives.

1 **Margarete Luisa Arbugeri Menegotto** (margamenegotto@hotmail.com/Margarete.menegotto@ua.pt)
Doutoranda do Programa de Pós graduação em Administração
University of Caxias do Sul, Brazil / University of Aveiro, Portugal.
Bolsista da CAPES/PDSE – Processo no BEX 3535/14-2.

2 **Maria Emilia Camargo** (Kamargo@terra.com.br)
Programa de Pós Graduação em Administração University of Caxias do Sul, Brazil.

3 **Maria Elizabeth Pereira** (melisa@ua.pt)
Dept. of Economics, Management and Industrial Engineering and Research Unit GOVCOPP.
University of Aveiro, Portugal.

2 Literature Review

One of the first references to the concept of social innovation dates back to the late 1960 (Juliani et al, 2014). The characteristics and potential that this issue reached later came to be developed and to take shape from the end of the 1990s, with the creation of innovation centers social and growth of research on how such innovations could help in solving social problems and improving the quality of life (Juliani et al, 2014).

Social innovation is a new idea or an improved idea that simultaneously meets social needs and creates new relationships. It is a phenomenon capable of raising the capacity to act in society (Murray et al., 2012). It is observed that in companies social changes are related to stakeholders. In social innovation, the relationship is more complex, since the social innovation has the need to satisfy the interest of the company, the community, donors, volunteers, government, ie, it is necessary to manage different priorities and in some conflicting moments (Lettice & Parekh, 2010).

Social innovation provides means by which reinvent, recalibrate and introduce greater resilience in institutions (Huddart, 2010). It is as part of a broad movement of a knowledge-based society, where innovation is widespread and enriched by its share (Bepa, 2011). This can take two distinct and complementary perspectives according to the impacts of social innovation: process and outcome (Nicholls & Murdock, 2012). The process impact acquires contours similar to the open innovation concept proposed by Chesbrough (2003; 2006). While the result is performance-based social innovation translated through the "social value" generated (Mertens & Marée, 2012).

Considering social innovation from the perspective of a process, the interactions between social actors promote the meeting and integration of resources and complementary capabilities in collaborative mode interactions (Healey, 1997). In their studies Moulaert and Mehmood (2010) and Volckmann (2010) state that the actors of social innovation are mechanisms that allow efforts "scaffolding" and intermediation for structuring and providing governance to the people who participate in the innovation process.

It is observed that the initiative for social innovation born from social demands (Schachter, Alcántara & Matti, 2012), and that the effort to the junction of the actors is much tougher because of the increased number of components and complexity of form and organizing network (Juliane et al, 2014). By their side, Rollin and Vincent (2007) add the capabilities of the actors involved and the outcome of the social innovation process.

3 Methodology

This study was developed from a bibliometric research. According to Flick (2004), a bibliometric research is understood as a quantitative technique and statistical measurement of production rates and dissemination of scientific knowledge through content analysis techniques (Bardin, 2009), as well as a set of laws and empirical principles that contribute to the establishment of the theoretical foundations of information science (Guedes & Borschiver, 2005).

We tried to direct and expand knowledge regarding the research centers for social innovation, its actors and future research directions, by analyzing the characteristics of the publications in the Science Direct and Scopus databases in the period from 1965 to 2015, a period of fifty year old. The extraction of the sample is segmented from search procedure using as key words: social innovation delimiting the search for the period under analyze. After analyzing the publications containing the Innovation Centers, the data were worked using of three basic laws: Bradford's Law, Lotka's Law and Zipf's Law (Vanti, 2002).

Fig.1
Three basic laws.

Law	Charectiristics
Bradford	“allows to establish the core and the areas of dispersion on a particular subject in the same set of magazines (Vanti, 2002, p. 153).
Lotka	view with a probability function productivity (Maltrás Barba, 2003).
Zipf	relates to the measurement of the frequency of occurrence of words in various texts. Thus generated is an ordered list of terms of a particular subject or subject. (Vanti, 2002)

According to Bardin (2009), once the corpus of research is defined, the next step is proceeding to the preparation for the content analysis, that in our case it to analyze the established innovation centers in the follow categories: Research Centers of Social Innovation and as subcategories the Social Innovation Centers. For both, were used the following: the name of the Centre; the place (city and country); the internet site; the year of constitution; and the institution and focus of the research center.

4 Application and Discussion of Results

Juliane et al (2014) highlight the relevance of the innovation centers as other important actors in the development of social innovations. The social innovation centers constitute groups of persons or organizations, institutions of education and governmental initiatives, which act in a collaborative way in a common space for a common goal.

LEI DE BRADFORD : It was found that the first research center was established in 1986 and over the next decade was created only two centers. In contrast the last 5 years shows to be a subject who is on the rise worldwide due to the dispersion of the location of the centers.

LEI DE LOTKA : In surveys carried out a result that stands out is the geographical coverage of research on the subject, and in this study the locations that stood out were in England, the United States and Canada. Also located was a research center in Latin America, more specifically in Brazil.

LEI DE ZIPF : It was found that the publication of the last decade is more than 50% of the publications which leads to assume that there is a greater interest in the subject in modern times.

Fig.2
Research Centers of Social innovation.
Source: adapted from Juliani et al (2014).

Research Centre Name	City –country	Internet Site	Since
CRISES	Toronto – Canadá	http://crises.uqam.ca/presentation-pt	1986
ZSI - Zentrum for sozial innovation	Vienna – Austria	https://www.zsi.at/en/home	1990
Fundação Porto Social	Porto – Portugal	http://bonjoia.org/en/projects/projecto/55	1995
Nesta	Londres – Inglaterra	http://www.nesta.org.uk/	1998
INSEAD - Stanford	San Francisco CA – EUA	http://csi.gsb.stanford.edu/	1999
Impumelelo	Several cities – South Africa	http://impumelelo.org.za/	1999
HARVARD Ash Center Project on social innovation	Toronto - Canadá e Nova Iorque – EUA	http://socialinnovation.ca	2004
The Young Foundation	Londres – Inglaterra	http://youngfoundation.org/	2005
LIEN	Singapore	http://lcsi.smu.edu.sg/	2006
SELUSI	Aveiro – Portugal	http://www.seforis.eu/en/selusi/about	2008
The Australian centre for social innovation – TACSI	Adelaide – Australia	http://www.tacsi.org.au/	2009
world Vision Institute	Friedrichsdorf – Alemanha	http://www.worldvision-institut.de/	2009
SIERC	Auckland - Nova Zelândia	http://sierc.massey.ac.nz/	2010
HARVARD	Boston – EUA	http://www.ash.harvard.edu/Home/Programs/Innovations-in-Government/Social-Innovation	2011
Bertha CSI	Cape Town – Africa	http://www.gsb.uct.ac.za/s.asp?p=389	2011
CIS - Centro de Inovação Social do Porto	Oporto – Portugal	http://www.cisporto.pt/	2011
SIM	Istambul – Turky	http://www.en.sosyalinovasyonmerkezi.com.tr/	2012
Gawad Kalinga	Philipines	http://gk1world.com/gkcsi	2013
CAIS - Centro de apoio inovação social	Florianópolis – Brasil	http://www.icomfloripa.org.br/icom/cais/	2014
INSEAD Social Innovation Centre	Europe, Asia, Abu Dhabi	http://centres.insead.edu/social-innovation/who-we-are/index.cfm	-
Boston College	Boston – EUA	http://www.bc.edu/content/bc/schools/gssw/csi.html	-

Based on the research done through the sites of innovation centers the internet and in the identification of the main goals of each one of the innovation centers established after 2010 (figure 2 and figure3), we can infer that interdisciplinary research predominate, as well as it involvement with local activities sectors, and related with local and international educational institutions.

In the analyzed research innovation centres is observed the trend to the development of a framework comprehension on empirical, theoretical and politics fundaments necessary for the development of the field of social innovation. It is noticed that there is the use of multidisciplinary and interdisciplinary which could increase the social development of the territory.

Fig.3
Research Innovation Centers Established after 2010.
Source: Prepared by the author.

Research centre name	City-country	Established	Main proposal	Objectives of the Research Centre
SIERC	Auckland - Nova Zelândia	2010	Search	conduct, support and disseminate research that contributes to the advancement of social innovation and entrepreneurship in New Zealand and internationally
CIS - Centro de Inovação Social do Porto	Porto – Portugal	2011	Research and action	goal is to promote the implementation of innovation projects and social entrepreneurship in the city of Porto.
HARVARD	Boston – EUA	2011	Research and teaching	provide a practical platform to share the stories and lessons of exciting innovators of non-profit sectors, public and philanthropic.
Bertha CSI	Cape town - Africa	2011	Research and teaching	Emerging markets finance, investment and trade; Social innovation and sustainability; and value-based leadership
SIM	Istambul - Turquia	2012	Research and action	Consulting and Training for New Services Project Social Innovation Advisory and training services within the Social Business Advisory and Oversight Services camp for young entrepreneurs
TEPSIE	Aarhus - Dinamarca	2012	Search	TEPSIE is a research collaboration between six European institutions that seek to understand the empirical foundations and theoretical and policies for the development of the social innovation field in Europe.
Gawad Kalinga	Philipines	2013	Action	It is a developer ecosystem business aimed at building a culture of social entrepreneurship.
CAIS - Centro de apoio inovação social	Florianópolis - Brasil	2014	Action	The program proposes to undertake activities to promote institutional development (ID) of civil society organizations (CSOs) in order to improve the quality of services they offer. The program operates in promoting DI CSO providing training for preparation of institutional development plans (IDP)
INSEAD Social Innovation Centre	Campus na Europa, Asia, Abu Dhabi	-	Research and teaching	It is a comprehensive platform for interdisciplinary research, education, projects and engagement in the area of Business in Society.
Boston College	Boston – EUA	-	Research and action	It is a comprehensive platform for interdisciplinary research, education, projects and engagement in the area of Business in Society.

5 Conclusions

One of the main findings leads to the need for diversification of social sciences in research and facilitation of social innovations. The proper adjustment of self-organization in social science is relevant to allow a deliberate relationship with users of the knowledge generated by the social sciences in a sense of interdisciplinary research. Although there are different approaches, concepts and methods, such intentions resemble to the usual signs of advanced research in natural sciences and economics on social innovation and business innovation in scope of process and outcome.

In fact, social innovations could take two distinct and complementary perspectives according to the social innovation impacts: process and outcome (Nicholls & Murdock, 2012). For the first impact, social innovations acquire some contours similar to the open innovation concept proposed by Chesbrough (2003; 2006). In the second case, the result constitute the performance of social innovation translated through the "social value" generated (Mertens & Maree, 2012), through co-creation or co-designers of innovative ideas, processes, or products in multidisciplinary environments (Cunningham et al, 2012). For this to be really evident and worked it is necessary to make a knowledge management within each link in the production chain, as well as within each of the organization sector.

The interdisciplinary research on Social Innovation lead to the development of entrepreneurs, public policies more efficient, as well as institutional development plans, and accelerates the economic growth of the territory.

The present work indicates that future researches in this field should be developed in an alternative approach based on a framework theory of social innovation which benefits families and companies. For individuals, it allows to increase the economic growth and the development and welfare of populations; and for the companies, to rank it in terms of their strategies, their relationships and their organization's performance. It points to the need to carry out a number of projects already undertaken by the measurement research centers, and the impact they have caused in the local and global economy.

6 References

Dod J (1999) Effective Substances. In: The dictionary of substances and their effects. Royal Society of Chemistry.Available via DIALOG. http://www.rsc.org/dose/title of subordinate document. Cited 15 Jan 1999

ANDRÉ, I; ABREU, A. (2007); Dimensões e espaços da inovação social. Finisterra: Revista portuguesa de geografia, v. 41, n. 81, p. 121-141.

BARDIN, L.(2009) Análise de Conteúdo. Lisboa, Portugal; Edições 70, LDA.

BEPA - Bureau of European Policy Advisers. (2011): Empowering people, driving change. Social Innovation in the European Union. European Communities. Luxembourg.

CAJAIBA-SANTANA, G. (2013); Social innovation: Moving the field forward. A conceptual framework, Technol.Forecast. Soc. Change. Disponíve http://dx.doi.org/10.1016/j.techfore.

CHESBROUGH, H. (2003). Open Innovation: The New Imperative for Creating and Profiting from Technology, Harvard Business School Press, Boston, MA.

FLICK, U. (2004)Uma introdução à pesquisa qualitativa. Porto Alegre: Bookman.

GUEDES, V. L. S.; BORSCHIVER, S. (2005)Bibliometria: uma ferramenta estatística para a gestão da informação e do conhecimento, em sistemas de informação, de comunicação e de avaliação científica e tecnológica. Salvador, VI CINFORM – Encontro Nacional de Ciência da Informação, dez. 2005.

JULIANI, D. P.; JULIANI, J. P.; SOUZA, J. A. HARGER E. M. (2014) Inovação social: perspectivas e desafios Social innovation: perspectives and challenges. Espacios. Vol. 35 (Nº 5) Pág. 23.

LETTICE; F.; PAREKH, M. (2010); The social innovation process: themes, challenges and implications for practice, Int. J. Technology Management, Vol. 51, No. 1.

MALTRÁS BARBA, B. (2003). Indicadores de Producción. In: MALTRÁS BARBA, Bruno. Los Indicadores Bibliométricos: fundamentos y aplicación al análisis de la ciencia. Gijón, Ediciones Trea.

MERTENS, S; MARÉE, M. La (2012) « performance » de l'entreprise sociale Définition et limites d'une évaluation monétaire. Revue internationale P.M.E. : économie et gestion de la petite et moyenne entreprise. Volumen 25, número 3-4, p. 91-122.

OSSANI, A. (2013). A Inovação Social Como Processo e Resultado da Governança da Colaboração Interorganizacional. Universidade do Vale do Rio dos Sinos. Retrieved from http://biblioteca.asav.org.br/vinculos/000009/00000927.pdf

POL, P.; VILLE, S. (2009); Social innovation: Buzz word or enduring term. The Journal of Socio-Economics, v. 38, p.878–885.

ROLLIN, J.; VINCENT, V. 2007. Acteurs et processus d'innovation sociale au Québec. Le Réseau Québecois en Innovation Sociale. Disponível em: www.uquebec.ca/ptc/rqis/node/53.

VANTI, N. A. P. (2002)Da bibliometria à webometria: uma exploração conceitual dos mecanismos utilizados para medir o registro da informação e a difusão do conhecimento. Ciência da Informação, Brasília, v. 31, n. 2, p. 152-162, maio/ago.

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The SWOT Analysis as a Method to Study the City

Ros-McDonnell D[1], de la Fuente-Aragón MV[2], Ros-McDonnell[3]

Abstract: Several City definitions identify the four important aspects of it: the physical reality, subject to governance and governed by an administrative organization, ia large concentration of people, and the economic activities. The current trend of humanity of gathering in urban settings forecasts that in the coming years the size and density of cities will increase. Therefore, it is necessary to have simple and practical tools to study and learn the real situation and condition of cities. The aim of this article is to expose the main factors to consider in the SWOT analysis of a city, and show the multiple aspects and the complex casuistry of each factor than we have to take into account during the exam of urban areas.

Keywords: SWOT analysis, Urban analysis, City.

1 Introduction

The cities are composed by numerous aspects with different characteristics. The Spanish Royal Academy defines city as “a set of buildings and streets, governed by a council, whose dense and large population is usually dedicated to non-agricultural activities” (RAE, 2001). The content of this definition identifies four important aspects of a city: it is a physical reality, it is subject to governance and governed by an administrative organization, it has a large concentration of people, and it presents own economic activities.

The above description gives us a fixed image of the city, isolated in time. But the study of a city also needs to consider its evolution and transformation, the interactions among their different factors, and the relationships of the city with the environment.

The current trend of humanity of gathering in urban settings forecasts that in the coming years the size and density of cities will increase. Over the 50% of the population lives in cities today, with the problems arising from this situation. Moreover, the dynamics of the urban reality cause a variety of circumstances within its perimeter. Therefore, it is necessary to have simple and practical tools to study and learn the real situation and condition of cities.

The aim of this article is to expose the main factors to consider in the SWOT analysis of a city, and show the multiple aspects and the complex casuistry of each factor than we have to take into account during the exam of urban areas.

2 The City. Factor of Analysis

"The city is a complex set of interactions, in which deals contradictory logics" (Panerai et al., 1983). Each conurbation is a social manifestation as a result of life, of acting, of all citizens who are or have been part of the current or past society, in constant evolution. The main factors to consider are: the physical reality, the population (the inhabitants), the system of government, economic activities, and the relationships among them.

1 **Diego Ros-McDonnell** (diego.ros@upct.es)
Grupo de Investigación “Proyecto y Ciudad”. ETS Arquitectura y Edificación.
2 **Ma Victoria de la Fuente-Aragón** (marivi.fuente@upct.es)
3 **Lorenzo Ros-McDonnell** (lorenzo.ros@upct.es)
Grupo de Investigación “Gestión e Ingeniería de Organización”.
ETSII. Universidad Politécnica de Cartagena. C/Dr. Fleming, s/n. 30202 Cartagena (Spain).

2.1 Physical Reality

The first perception of the city is the reality, the set of material elements that compose it. The city has two categories of spaces, public space and private space, the two spaces are mutually selective and complementary. The public space, also called social space or collective space, is a continuous surface, and it is the emptiness of the city. It is formed by spaces connected among them, which a network. And it is an area freely accessible that belongs to the community. The private space, also called built space, is a discontinuous and compartmentalized surface, and it is the full of the city. This space consists of blocks and buildings built therein, and they are restricted spaces.

This complex reality is only understandable through the relationship between the built environment (private space) and social space (public space). The study of both spaces can reveal the reason for their existence. This point of view matters if we can identify patterns and rules that allow the understanding of the scope analyzed, as well as the global and local levels. The abstraction of the reality described is called urban structure or physical structure of the city. The elements to consider are: the communications network or urban fabric, public buildings, the network of green zones and residential areas.

1. Communications network: the different characteristics of the communication roads, management, supported functions and traffics, size, scale, relevant sites, relationship with the environment, classifies the roads, rank them (ranking order) and form a more or less clear structure, the urban fabric.

2. Public buildings: Public buildings are distinguished by their appearance, nature and function. They are particular items, urban centers, places of exception or differentiation of the urban fabric. Public buildings act at two levels, as a global part of the urban structure, and as a local part locally, because of its uniqueness and program, they have their own relationship with the public space, with the block and with the plot.

3. The network of green zones are notable sites of public spaces, places of superficial character with dimensions that allow relationship activities which can not be performed on the roads. The green zones have vegetable and tree-covered elements, characteristics of sunlight and behavioral conditions against wind.

4. The residential areas are the result of the superposition of two logics, corresponding to the plots and the derived one from block shape, its parcel division and building types. To identify different homogeneous urban fabric it involves the characteristics of each area.

2.2 Governance

The Latin term "civitas" included, among other meanings of town, the space of civilization and of Law, which appears in opposition to "silva", as the dark kingdom, the wild, the uncivilized (Carrero de Roa, 2010). That is, to consider the city as a group of people organized under the laws that establish the rights and duties of each member of the community, and they regulate the relationship between all actors and entities that constitute the city.

Throughout history, there have been various government and political systems, with different institutions, administrative processes, legal regulations and a multitude of relationships between the various members and social agencies.

For any urban analysis (in general), and the SWOT analysis of urban areas (in particular), it is basic to know the governance model of the city, the institutions, the administrative processes, the legal system and the set of regulations, rules, and their operation, the normal practice and their advantages and limitations, the social objectives of the authorities, besides system aspects like effectiveness, ability, diligence, honesty, security and crime, and social interests, among other objectives.

Along this process, we should answer questions like:

What form of government ruled the city?, Are the institutions effective?, How much time is needed to solve any administrative procedure?, Are the procedures regulated ?, Is the sequence of administrative processes known?, What is the legal regime/system?, Is the system clear and open, or is it cloudy and opaque?, Is there a system to control the management or administration?, Is the citizen participation possible in the making-decision system?, Who is in charge?, Who decides?, Is the management collegial?, Is there a legal body?, Is the legal framework respected?, Are citizens interested in new initiatives?, Are citizens active / passive?, Is there any planning?

These and many other questions can help us to determine the characteristics and circumstances of the governance system.

2.3 Population and Demography

The city is the place where people lives, it makes no sense the existence of a city without people. We can presume the original purpose of the city was to give a safe place tailored to the needs of its inhabitants, so it is essential to determine the characteristics of the population.

The specific circumstances of citizens define their needs. Such simple issues as a population pyramid provides a wealth of information. A city with a very wide population pyramid at the base and progressive and rapid decrease in height indicates the abundant supply of young people, and involves the immediate demand for services and equipment necessary to cover the needs of this kind of population (essentially schools and sports facilities), and in the short and medium term it will result in a remarkable urban growth, either through expansion and colonization adjacent to the city or territory through densification of the existing city overloading the residential fabric, with a consequent increase in all types of services and urban facilities.

A pyramid of aging population (with a narrow base and wider at height) involves the shortage of young people and elderly citizens abundance. Consequently it will be essential those services needed to meet the demands of the elderly, nursing homes, geriatric services or health facilities, and to adapt the conditions of the urban environment to the movement limitations imposed by the passing years. It also indicates the loss of population in the medium term, the depletion of the sector and the decay of urban areas affected.

Besides the number of people (with their corresponding gender population pyramid) it is useful to keep in mind other aspects, population trends and statistics, including: demographic change, increasing or decreasing the number of neighbors by intervals of time, birth rate, mortality rate, marriage rate, and number of children per family, number of persons per family, the cultural level, income level, the main economic activities, principal training or professional dedication, the unemployment rate, homogeneity or heterogeneity residents, floating population, ethnicity, existence of marginality, distribution of the inhabitants in the analyzed sector, presence of immigration or emigration. In short, all those circumstances of the analyzed population will determine the current status of the inhabitants and could anticipate future situations.

2.4 Economic Activities

Economic activity is inseparable from the city. "In any civilization urban life has been developed independently of business and industry. The diversity of weather, race and religion, as well as times, do not affect the urban life, [...]"(Pirenne, 1985). That's right, a conurbation can only survive by importing all kind of products (food, raw materials, manufactured products, energy resources, among others, that are produced or manufactured outside the urban area. Moreover, such importation should match the export of goods made in it.

The import-export mechanism between the city and its environment is a continuous and necessary relationship. Business and industry are essentials to sustain this mutual subordination, importations ensure supply of goods, and exportations generate revenues, and without them the city would disappear.

2.5 Factors' Combination

For a broader vision to make the SWOT analysis, it is necessary to bear in mind the relationships among the factors (before described): physical reality, governance, population and demography, and economic activities. Physical reality is the stage where the population develope all economic activities that occur there and done under the system of government established. In turn, the reality is a result of the action itself and the other three factors in previous performances. All factors have relationships among them.

3 Method

The SWOT analysis is a well-known strategic planning tool in the business world, where it is used to determine the level and circumstances of a company to make a diagnosis to facilitate decision-making to improve the competitive position of the company in the market.

Given the characteristics of this survey tool: flexible, dynamic, reflective, graphic, synthetic, easily understandable, effective, and that allows a feedback analysis process, which makes the SWOT analysis into an optimal working process for defining the status of an urban system.

Before carrying out the SWOT analysis, it is necessary to define the scope of study, the procedure, and to differentiate the geographic areas of analysis.

The complexity of the city, the numerous factors to consider, and the variety that offers a city it can significantly complicate the SWOT analysis of the whole set. When an urban environment presents a large heterogeneity, there are two procedures to facilitate the study.

The first method is a cross-sector SWOT analysis. This method lies in dividing city into homogeneous parts and then, we will perform the SWOT analysis for each of them, considering all factors, especially those to characterize each relevant area, and finally we will make up the SWOT analysis of the entire city.

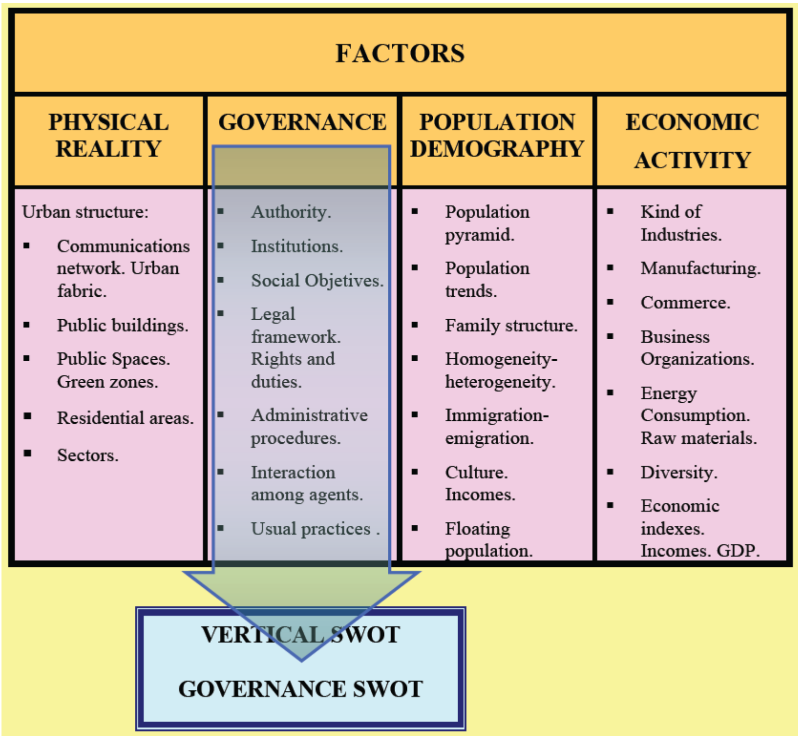

Fig.1
Factors of a Vertical SWOT analysis.
Example of a Governance SWOT.

The second method is a vertical SWOT analysis (or by factors). This method consists in a SWOT study for each factor, independently of the other factors in the whole town. Later, we will compose the SWOT analysis for the set of factors.

Regarding the knowledge of the state of the city, given the superficial and geographical character of the city, the cross-sector SWOT analysis often provides the clearest results. The second method, the vertical SWOT analysis is particularly suitable when we try to know some specific aspects of the city.

As for the geographical areas under analysis, we can establish the specific field and the incidence environment.

The specific field, also called specific environment, or simply the field analysis, is the surface area, which coincides with the geographical area over which the SWOT analysis will be performed.

The incidence environment, also called general environment, it is a more abstract space and less controllable than the specific environment. It is the outer surface of the specific field, and it presents the issues which affect or may affect, in a relevant way in the specific environment, due to their relationship or characteristics.

The SWOT analysis in the urban field, is a means for determining the relevant factors that affect the durability of the city (factors which exist in the specific field and in the incidence environment), for specifying the state of the urban system, for structuring the diagnosis and, in general, to constitute the basis for decision-making and the drafting of urban plan documents.

The SWOT analysis determines the Strengths, Weaknesses, Opportunities and Threats, which can be defined as:

Strengths are those elements and characteristics of an urban system that provide strength and durability to the system. The capabilities that ensure its balance, sustainability and durability.

Weaknesses are those elements and specific factors into the urban system, which cause fragility and that unbalance the system. The constraints that make vulnerable, unstable and unsustainable the urban system.

Opportunities are the external factors to the specific area of study that enhance the strength and durability of the system. Also we can consider opportunities some future actions to provide solidity to the system.

Threats are the external factors to the specific area of study which cause fragility and unbalance the system. Also we can consider as threats all future actions and those specific factors that if they are not corrected, can increase the fragility or may even cause the collapse of the urban system.

As previously outlined, the issues to be studied are very numerous, and they respond to very different origin and causes. Given the characteristics of the urban system, we can define the following families: physical environment, infrastructures network, buildings, facilities and equipment; governance; population and demographics; activities and processes, and all the interactions among them.

Finally, the over time affects the urban environment, so that makes it a changing and evolving system. The physical environment is degraded by the impact of environmental conditions, weather, temperature changes and water cycle, among others. The life of urban systems significantly exceeds man's life, who take part in its construction, generation after generation. Over time, all the elements change: techniques, needs, activities, social patterns, urban centers, extension or buildings, both public and private.

4 Results

The present work shows the SWOT analysis as a suitable method for studying the city, both their current state and their possible future circumstances, in order to facilitate a decision-making process to ensure the quality of life in the city, based on a balanced and harmonious development. This procedure allows, from the point of view of urban study, identify the constituent elements of the studied agglomeration, the interactions between the elements, the establishment of the state of the system, the identification of the factors that contribute strength and durability to the system, and those factors that cause fragility and vulnerability.

The aim of this article is to expose the main factors to consider in the SWOT analysis of a city, and show the multiple aspects and the complex casuistry of each factor than we have to take into account during the exam of urban areas.

5 References

Carrero de Roa M (2010) Fundamentos de urbanismo una perspectiva sostenible. Ojo x hoja Editora, Oviedo

Panerai P, Depaule JC, Demorgón M, Veyrenche M (1983) Elementos de análisis urbano. Instituto de Administración Local, Madrid

Pirenne H (1985). Las ciudades de la edad media. Alianza Editorial, Madrid.

Real Academia Española (2001) Diccionario de la Lengua Española – 21ª ed. Editorial Espasa Calpe SA, Madrid

Tax Planning Applied to Small Brazillian Companies of Building Sector

Pessoa R[1], Medeiros R[2], Souza R[3]

Abstract: This papers goal is to analyze the best tax organization applied to small Brazillian companies of building sector from tax planning appliance. To perform this research, it was necessary the simulation among the allowed Taxation Schemes to small companies acording to brazillian laws. The results shows the economiac feasbility in two main regimes, being the relation among billing and hand labor the main determinants in the best regime choice, being Simples Nacional regime a most recomended for most revenue range allowed in laws.

Keywords: Tax avoidance; Tax planning; Building Sector.

1 Introduction

The brazillian building increases about 4,5% a year and most of these due to the increasing of small businesses, representing 2% of all small businesses, but with the average income per company is R$ 652.328,00, according to SEBRAE (2013, p. 19). In a country of Brazils porch which has a 36,42% of Gross National Product – GNP provenient from taxes collection (Amaral et al., 2013), the economy in taxes management is aright a competitive advantage. The brazillian law, however, allows the tax avoidance, which is a option able to reduce, retain and even avoid the companies taxes payment, due to the law or gaps in it.

2 Objectives

This papers goal is to analyze, from a tax planning appliance, the best Taxation Scheme applied to small brazilian companies of building sector, considering the annual company revenue.

3 Methods

The research template was the Tax Planning defined by Fabretti (2011, p.312) "The study made preventively, it means, before performing the administrative act, searching it legal and economics efects and the less coust legal alternatives". To it, had made two simulations in Taxation Schemes allowed in Brazil to Small companies. It is: The *Lucro Presumido* and the *Simples Nacional* regimes.

The first performed simulation was in *Lucro Presumido* Regime, had considered the taxes provided by Law number 9.249/95, adding to other plus by Laws number 10.833/03 and Supplementary Law number 116/2003. The second simulation was performed in *Simples Nacional* regime, ascertaining the conditions described in Annex IV from Supplementary Law number 123/06, which presents an unique aliquots

1 **Ricardo dos Santos Pessoa** (rdsp.adm@gmail.com)
Universidade Federal do Amazonas, Depart. de Contabilidade,
Av. General Rodrigo Octávio, 6200 - Coroado I, 69077-000, Manaus - AM, Brazil.
2 **Rafael Lima Medeiros** (rafa.comp_adm@hotmail.com)
Faculdade Boas Novas - Departamento de Administração
Av. General Rodrigo Otávio, 1655 - Japiim, 69077-00, Manaus - AM, Brazil.
3 **Ranniery Mazzilly Silva de Souza** (ranniery34@globo.com)
Universidade do Minho – Escola de Economia e Gestão (EEG).
Gualtar, 4710, Braga, Portugal.

which modifies according to revenue and covers the taxes already applied to *Lucro Presumido* Regime. Beyond than Taxation Scheme, the Tax Planning also considered for the two regimes the burden on the payroll.

4 Results

The results showed the *Simples Nacional* regime as the most economically viable to 18 aliquots presentes in the Annex IV from Supplementary Law number 123/06 which covers revenues in range of R$ 180.000,00 to R$ 3.240.000,00. Though, in two aliquots was observed advantages in opting for *Lucro Presumido* Regime once the rate among payroll and net revenue don exceed, repectively 1,73% and 8,97% to the revenue convered by the range R$ 3.240.000,01 to R$ 3.420.000,00; and R$ 3.420.000,01 to R$ 3.600.000,00.

5 Conclusion

The application of the tax planning showed the tools feasbility presented by Fabretti (2011, p.312), identifying the *Simples Nacional* regime as the best regime to almost every revenue range, however, showing the conditions which the *Lucro Presumido* regime is economically viable, overturning the myth that the *Simples Nacional* Regime is, in all cases, more advantageous that the *Lucro Presumido* Regime, providing, this way, to the building managers, the best choice to their business.

References

Fabretti, LC (2011) *Contabilidade Tributária*. São Paulo, Atlas, 2011.

Amaral, GL, Olenike, JE & Amaral, LMF (2013) Evolução da carga tributária brasileira e previsão para 2013. *IBPT*. Available: http://www.ibpt.com.br [Acess 23 december 2014].

Sebrae (2013) *As Pequenas Empresas do Simples Nacional*. Brasília, Brasil.

OR, MODELLING AND SIMULATION

[Extended Abstracts]

Managing Continuing Projects: Optimizing the Version-Release Policy

Cohen Y[1], Etgar R[2], Gelbard R[3]

Abstract: The current methodology of project scheduling focuses mainly on the concept of a project as a one-time concentrated effort. However, the typical R&D project is not a one-time effort, but a continuing effort divided to several releases. A Continuing Technology Development (CTD project) is divided into several intermediate projects leading to product Releases. Each release is composed of several new features, and the development of each feature requires a set of activities. Current planning methodologies ignore the unique characteristics of the CTD projects. The scheduling goal of a CTD project is to acquire the highest possible net present value (NPV) by scheduling the project activities and thus gaining higher values to early releases, by means of search techniques. A multiple group particle swarm optimization (MGPSO) for determining such schedule is proposed in this paper. Since the solution space of the scheduling is discrete, we modified the particle position representation, particle movement, and particle velocity to better suit MGPSO for this problem.

Keywords: Project; Scheduling; Release; NPV; Operations research; Particle swarm optimization.

1 Introduction

The basic definition of a project, upon which the methodology of project scheduling has been researched during the last decades, is of a one-time concentrated effort, with a finite duration and well-defined goal. While this concept applies to most large-scale projects, in most Hi-Tech organizations (and various others), the typical project has many intermediate products. For example, most software companies release new versions (releases) every few months. In order to do so, the project teams are working on version X+1, X+2 etc. even before the release of version X. We call this type of R&D projects Continuing Technology Development (CTD) projects. These projects, which are very common in R&D, display some basic characteristics that are different from "regular project" and therefore generate a need for a unique methodology

This paper deals with determining the scope of work (SOW) and the schedule of releases in CTD projects.

A typical CTD project, such as software development, does not end with the release of the software to the market. Instead it continues to the next version and the one after, etc.

The current methodology of project scheduling does not provide tools for determining the number or the timing of product releases nor for defining the scope of the product releases. There is an urgent need in the market for a methodology to help CTD project manager build a good schedule based on relevant objective functions. The differences (and similarities) between 'regular' and CTD projects are depicted in Table 1.

1 **Yuval Cohen** (yuvalc@afeka.ac.il)
Dept. of Industrial Engineering.
Afeka Tel-Aviv College of Engineering. 38 Mivtsa Kadesh, Tel-Aviv, 69988, Israel.
2 **Ran Etgar** (ran.etgar@gmail.com)
3 **Roy Gelbard** (r_gelbard@yahoo.com)
Business Administration Dept. Bar-Ilan University, Ramat-Gan, Israel.

Table 1
CTD vs. 'regular' project.

Subject	'Regular' projects	CTDs
Duration	Finite – There is an prior condition for the project ending	Non-finite. The project may have many releases until there is no market value.
Goal	Project termination	Many goals – one for each release
General nature	Non-repetitive	Non-repetitive
Structure	Inter-connected activities (net)	Inter-connected activities (net)
Critical path or chain	Very important – determines objective	No importance as may change with the change of release dates
Content	Fixed – capacity determines duration	Release dates determine content
Activity importance	All activities have the same importance – needed for project goal	Different activities have different importance, depending on the versions and features
Bottle neck	May be any resource, depending on the importance of the activities Usually the most utilized resource	Depends on the release.

The main requirement from the CTD scheduler is to increase the value of releases. The requirement is to include very high value features in the near release, thus making the coming product more attractive. This desire, combined with the resource limitation, creates a difficult scheduling problem – the scheduler must decide which features should be included in the coming release and which will be postponed to one of the next ones (and to which one exactly). Release of a feature in an earlier version carries higher value then the same feature release in later version. The profit to the organization rises as the feature is included in an earlier version. This is due to two reasons - Early revenues (increase product desirability and thus increase sales and also forwarding sales cause higher value due to interest considerations) and the ability to provide the product to the market earlier, thus reduce unwanted competition.

2 Literature Review

For solving the Max-NPV problems, different solutions have been offered. Russell (Russell A. H., 1970) proposed a nonlinear mathematical model for maximizing NPV and then solved it by using first sentence of Taylor series.

Grinold (Grinold, 1972) converted Russell's model to a linear mathematical model and proposed two solutions for the Max-NPV in AOA network without resource constraints. Doerch and Patterson (Doersch & Patterson, 1977) proposed a planning mathematical model with zero-one in the state of budget limitation. Smith-Daniels and Aquilano (Smith-Daniels & Aquilano, 1987) continued Russell's work and considered expanded the problem for the general case of both negative and positive cash flows. Elmaghraby and Herroelen (Elmaghraby & Herroelen, 1990) presented a method known as Elmaghraby interpolation for resolving Max-NPV problems with at least 20 nodes and 190 activities that were solved in a very short time. Yang et al. (Yang, Talbot, & Patterson, 1992) took the approach of integer programming and successfully solved small to mid-size projects. Sung and Lim (Sung & Lim, 1994) researched the case where cash inflows and outflows are given and availability restrictions are imposed on capital and renewable resources. Sepil and Ortac (Sepil & Ortac, 1997) showed that the method does not necessarily offer an optimal solution.

The concept of time-dependency of the nominal magnitude of the cash flows was researched by Shtub, LeBlanc and Etgar (Etgar, Shtub, & LeBlanc, 1996) who claimed that in real-life project it is likely to assume that the cash flows are constant (due to common policies of bonus/penalties). They presented a simulated annealing (SA) based heuristics for solving this problem and later (Shtub & Etgar, 1997) presented a branch & bound algorithm with exact results and showed (using a set of 168 random problems) that the SA algorithm solutions were close to optimality. They also examined the special case of linear time-dependency (Etgar & Shtub, 1999) and used it for a bound for the general dependency case. Vanhoucke et al. (Vanhouke, Demeulemeester, & Herroelen, 2001) continued Etgar and Shtub's research and presented a recursive search algorithm for the same problem. Two years later (Vanhoucke, Demeulemeester, & Herroelen, 2003) they presented another version with fixed deadlines. Mika, Waligora and Weglarz (Mika, Waligora, & Weglarz, 2005) took another approach to the problem by considering the case of multi-mode activities, followed by Waligora's work on discrete-continuous cash flows (Waligora, 2008).

Hartmann and Briskorn presented a survey and classified the different problems of Max-NPV (Hartmann & Briskorn, 2010).

Neumann and Zimmermann (Neumann & Zimmermann, 2000) argued that the Max-NPV is merely a part of a wider multicriteria problem and combined the Max-NPV with resource-leveling objective. They exami-ned and compared 17 heuristics.

During the recent years some researchers started exploring the stochastic nature of the Max-NPV problem. Sobel, Szmerekovsky and Tilson (Sobel, Szmerekovsky, & Tilson, 2009) checked the influence of the stochastic nature of activity duration on the project NPV. Creemers, Leus and Labrecht (Creemers, Leus, & Lambrecht, 2010) used a continuous-time Markov decision chain on project scheduling with NPV objective and exponential activity durations. In the same year (Wiesemann, Kuhn, & Rustem, 2010) the problem was expanded to include stochastic cash flows as well (both cash flows and durations have discrete distribution). Finally (Ucal & Kuchta, 2011) took a novel approach to this problem by using fuzzy logic methods.

3 Illustrative Case Study

The aforementioned problem of determining the CTD release SOW can be demonstrated in the simplified project depicted in Fig. 1. In this A-O-A project network the features are depicted in squares. For simplicity, there is only one resource type, which has only 2 units available. The resource requirements and activities durations are depicted in Table 2.

Table 2
Duration and resource requirement.

Activity	Duration	Resource units	Activity	Duration	Resource units	Activity	Duration	Resource units
{S,1}	1	2	{3,7}	1	1	{11,12}	2	2
{S,2}	1	2	{4,6}	1	1	{11,13}	1	1
{S,11}	1	1	{4,10}	1	1	{12,14}	2	1
{S,16}	1	1	{5,6}	2	2	{13,14}	1	2
{1,3}	1	1	{5,15}	2	1	{13,15}	2	2
{1,4}	2	1	{8,9}	2	1	{14,15}	1	2
{2,5}	2	1	{8,15}	1	1	{16,17}	1	2
{2,8}	2	1	{6,7}	1	1	{17,18}	2	1

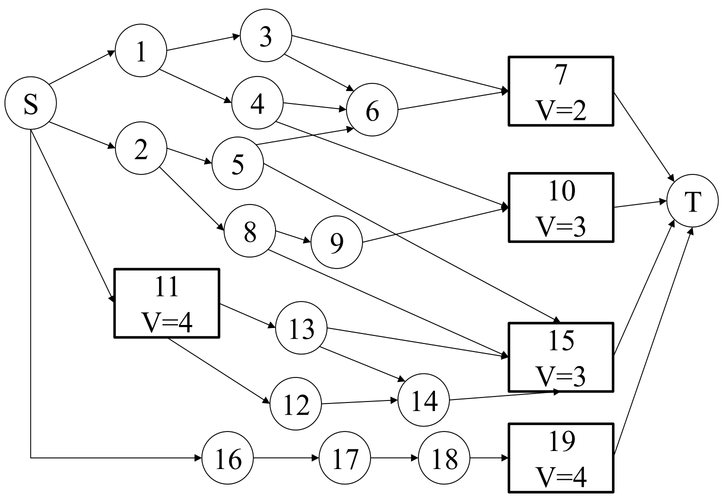

Fig.1
A simplified for Project network containing regular nodes (circles) and features (squares) to be chosen for a specific release.

Trying to schedule the project with current "conventional" tools will lead to the optimal solution described in **Erro! A origem da referência não foi encontrada.**

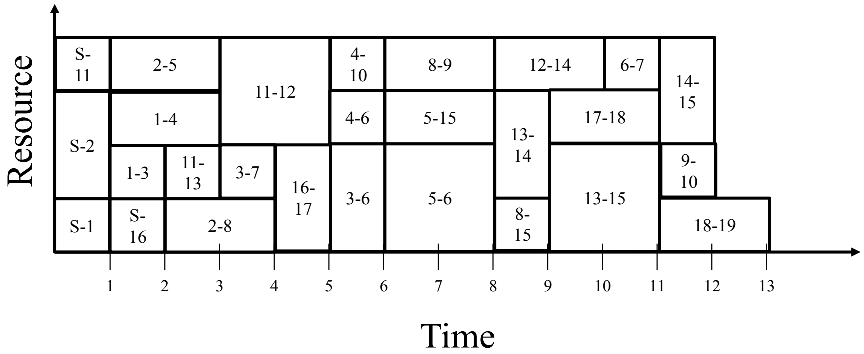

Fig.2
Minimum duration schedule for figure 1.

However, let us consider the features' values and assume that feature 7 has a value of $2, feature 10 has a value of 3$ and features 11, 15 and 19 have the corresponding values of $4, $3, $4. Also, there is a version release planned for time unit 3 and another one planned for 7, the optimal schedule changes dramatically. As early features realization is more lucrative, so if we consider the first release to have full value (100%) and the second one having only 50% value, it is easy to see that Figure 3 provides a much better solution, in which the Net Present Value (NPV) is higher, though the project lasts longer.

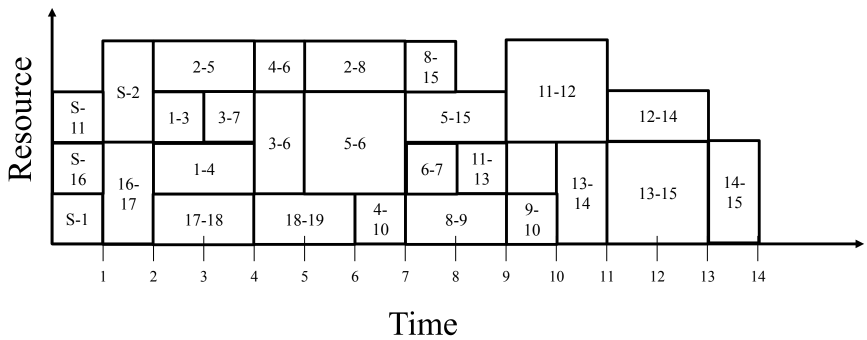

Fig.3
Maximum NPV duration schedule for figure 1.

This example, though extremely small and containing some arbitrary assumptions demonstrates the different objectives faced by the scheduler and therefore the need for new tools.

The NPV factors that were introduced may seem rather arbitrary. These coefficients are derived from the effect of market conditions and interest rates. In this work we assume that these factors have exponential time-dependency (as is the case of interest), that is: $\beta(\tau) = e^{-\alpha\tau}$ Where α , the discount factor, is derived from the interest rate (r):

$$e^{-\alpha} = \frac{1}{1-r} \quad (1)$$

4 Mathematical Formulation

Because of the discrete nature of the problem, the objective function is:

$$\text{MAX} \quad \sum_{\forall v \in V} \left[\beta(\tau_v) \cdot \left(\sum_{\forall f \in \mathcal{F}} \mathrm{a}_f \cdot x_{f,v} \right) \right] \tag{2}$$

Where $x_{f,v}$ are the scheduling control factors:

$$x_{f,v} = \begin{cases} 1 & \tau_{v-1} < t_f \le \tau_v \\ 0 & otherwise \end{cases} \tag{3}$$

Subject to the regular technical precedence constraints:

$$t_j - t_i \ge d_{i,j} \qquad \forall \{i,j\} \in \mathcal{A} \tag{4}$$

Where $\mathcal{A}$ is the set of all activities.
And the classical resource constraints:

$$\sum_{\{i,j\} \in S_t} \rho_{r_{\{i,j\}}} \le \rho_r \qquad \forall r \qquad t = 1 \ldots t_{max} \tag{5}$$

It is easy to see that this problem is NP hard, by reducing the problem to either the knapsack problem or the minimum duration-limited resources project scheduling problem.

Regarding this problem as a mere scheduling optimization problem has several Disadvantages:

- Complexity – even the simple example depicted, creates a rather hard problem to solve. An optimal solution for a medium size problem is by far more complex.

- Partial modeling of the real problem: the mathematical formulation fails to encompass the full details of the problem. Typically there are no cash flows directly involved (as no one can accurately determine the cash flows derived from a specific feature). However, there is indeed a value for each feature that needs to be assessed.

The problem complexity renders all exact solutions as impractical for large scale problems; therefore we resolved to search techniques. A Multi Group Particle Swarm Optimization (MGPSO) approach was chosen for this research and preliminary results are promising and presented below.

5 Conclusions and Preliminary Results

To solve the problem we chose 30 networks of 90 activities, and 30 networks of 120 activities from the benchmark database of networks: PSPLIB [23]. We randomly chose several activities to represent features and we generated for the features random values of worth. We than had to assign combinations of features to specific releases. As explained above, this requires an efficient search technique. As a search technique we chose Multi Group Particle Swarm Optimization (MGPSO) for clustering the features into effective releases. The best known NPV solution was considered to be the 100% solution, and we compared the mean solutions gained in multiple runs to the best known solution. Figure 4 compares the MGPSO (PSO) results against other heuristics: (1) Random search (S-random), (2) Greedy algorithm based on release time (G-length), (3) Greedy algorithm based on NPV (G-profit), (4) Randomization around the relaxed problem: optimal RCPSP (L-random). As could be seen, the results are promising.

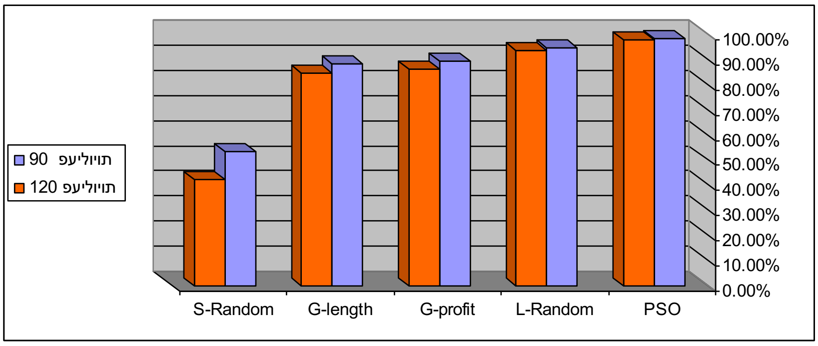

Fig.4
Preliminary results comparing the mean performance to the best known solution.

References

Doersch, R. H. and Patterson, J. H. (1977) Scheduling a project to maximize its present value: A zero-one programming approach, *Management Science*, **23**(8), 882-889.

Elmaghraby, S. E. and Herroelen, W. (1990) The scheduling of activities to maximize the net present value of project, *European Journal Of Operational Research*, **49**(1), 35-49.

Etgar, R., Shtub, A. and LeBlanc, L. J. (1996) Scheduling projects to maximize net present value - the case of time dependent, contingent cash flows, *European Journal of Operational Research*, **96**(1), 30-36.

Etgar, R. and Shtub, A. (1999) Scheduling project activities to maximize net present value - the case of linear time-dependent, contingent cash-flows, *International Journal of Production Research*, **37**(2), 329-339.

Grinold, R. C. (1972) The payment scheduling problem, *Naval Research Logistics Quarterly*, **19**(1)123-136.

Hartmann, S. and Briskorn, D. (2010) A survey of variants and extensions of the resource-constrained project scheduling problem, *European Journal of Operational Research*, **207**(1), 1-14.

Mika, M., Waligora, G. and Weglarz, J. (2005) Simulated annealing and tabu search for multi-mode resource-constrained project scheduling with positive discounted cash flows and different payment models, *European Journal of Operational Research*, **164**(3), 639-668.

Neumann, K. and Zimmermann, J. (2000) Procedures for resource leveling and net present value problems in project scheduling with general temporal and resource constraints, *European Journal of Operational Research*, **127**(2), 425-443.

Russell, A. H. (1970) Cash flows in networks, *Management Science*, **16**(5), 357-373.

Sepil, C. B. and Ortac, N. (1997) Performance of the heuristic procedure for constrained project with progress payment, *Journal of the Operational Research Society*, **48**, 1123-1130.

Shtub, A. and Etgar, R. (1997) A branch and bound algorithm for scheduling project to maximize the net present value: the case of time dependent contingent cash flows, *International Journal of Production Research*, **35**(12), 3367-3378.

Smith-Daniels, D. E. and Aquilano, N. J. (1987) Using a late-start resource constrained project schedule to improve project net present value, *Decision Sciences*, **18**, 617-630.

Sung, C. S. and Lim, S. K. (1994) A project activity scheduling problem with net present value measure, *International Journal of Production Economics*, **37**(2-3), 177-187.

Vanhouke, M., Demeulemeester, E. and Herroelen W. (2001) Scheduling projects with linearly time-dependent cash flows to maximize the net present value, *International Journal of Production Research*, **39**(12), 3156-3181.

Vanhoucke, M., Demeulemeester, E. and Herroelen, W. (2003) Progress payments in project scheduling problems, *European Journal of Operational Research*, **148**(3), 604-620.

Waligora, G. (2008) Discrete–continuous project scheduling with discounted cash flows—A tabu search approach, *Computers & Operations Research*, **35**(7), 2141-2153.

Yang, K. K., Talbot, F. B. and Patterson, J. H. (1992) Scheduling a project to maximize its net present value: An integer programming approach, *European Journal of Operational Research*, **64**(2), 188-198.

Smart Cities development fostered by ESCO organizations growth: opportunities and barriers in major European Union countries

Morcillo Bellido J[1], Prida Romero B[2]

Abstract: Smart Cities have gotten worldwide attention as one of the most promising paths in the search of Sustainability, and Europe is one of the geographical areas where more attention are receiving, both as best practices implementation and interesting academic research area. Within the Sustainability improvement that Smart Cities could bring to citizens and companies, one relevant area that is gaining continuous priority is linked to issues connected to energy efficient management, and in particular the formation and development of collaborative relationships to improve energy management, that we have called ESCO. This study analyzes and compares the formation of ESCO type organizations in four European Union (EU) major countries and the challenges they are facing in their development, trying also to highlight some recommendations to reduce current barriers than hamper their development, in particular in Spanish ESCO projects.

Keywords: Smart Cities, Sustainability, ESCO in EU countries, Spanish ESCO.

1 Introduction

Smart City term has focused the attention of many researchers, politicians and businessmen in recent years, and since 1990s many cities have begun to work on initiatives that would drive them in that direction, so in the Digital Agenda of the European Commission (EC), as EU executive board, cities are considered as innovation drivers in areas such as environment, energy, health and innovation.

The concept of Smart Cities includes different meanings, beyond that associated with an improvement in the city reputation linked to marketing objectives. Many researchers and politicians understand that its meaning is more related to the search for innovation in the use of new technologies and process improvements implementation that could drive to an efficient, safe and ultimately livable city. During last decade, Smart City term has been used frequently to describe technological projects developed in cities aiming to move quickly into connectivity, communications and information technologies (Roller and Waverman, 2001), however in last few years a wider movement has been appeared including elements beyond communications networks and connectivity solutions like energy management (Glaeser, Berry, 2006; Caragliu, 2011). This can be seen as more representative of what this paper´s authors consider will be the Smart Cities in the future, and it has been capture in the European Union (EU) plans and deployed through the European Innovation Partnership published in summer 2012. The goal of the initiative is to increase transition speed towards more sustainable environments on top of searching for friendly environment to increase quality of life. Studies such as those developed by Kousky and Schneider (2003), Bulkeley and Kern (2006), Sippel and Jessen (2010) and Croci et al. (2010) show that authorities have started to take strategic decision and implementing policies that would improve energy efficiency, both for reasons of energy saving and climate change impact.

1 **Jesús Morcillo Bellido** (morcillo@ing.uc3m.es)
2 **Bernardo Prida Romero** (bprida@ing.uc3m.es)
Escuela Politécnica Superior. Área de Ingeniería de Organización.
Universidad Carlos III de Madrid.
Avenida de la Universidad no 30, 28911 Leganés (Madrid), Spain.

2 Objective and study methodology

The study seeks to understand to what extent Smart Cities have developed strong foundations to support future development on efficient use of energy when this is based on new collaboration models like so called Energy Service Companies (ESCO), to understand the current development of those type of organization in four major European countries like Germany, France, Italy and Spain and to elaborate potential recommendations for better Spanish ESCO development. To carry out this prospective study, in an area still not too much developed, authors have mainly used qualitative research methods (interviews and study of good practices in the sector) that Eisenhardt (1989) and Gummenson (1991) advise as appropriate for the exploration of innovative aspects in organizational management as the specific case of Smart Cities formation and new relationships derived from its needs to improve energy efficiency management. Information has been obtained by: i) in-depth interviews with six senior corporate managers belonging to four organizations (Philips, Endesa, Logica and Telvent-Schneider Electric) , all of them strategically oriented to energy efficiency and very active in European Smart Cities projects, ii) analysis of data and "good practices" considered as references, through information provided by Spanish National Association of Energy Efficiency (ANESE) members and iii) analysis of European Union (including analysis, forums, conferences, papers, ...) published data.

Regarding in-depth interviews, all of them have been performed during last three years using semi-structured surveys in two or three meetings per person and questions were mainly focused on collecting of their huge experience in ESCO projects, aiming for deeply understanding of major opportunities and roadblocks they have experienced.

3 European Union cities and energy issue. ESCO formation

In European´s Smart Cities initiatives usually had a strong technological content that used to be based on connectivity and communication, but this should not overshadow other key Sustainability areas relevancy, such as those related to the efficient use of energy. Among others, some reasons (Woods and MacKinnon, 2014) should be carefully considered: i) cities cover only 2% of the surface of the Earth, but they are responsible for 80% of global GDP and over 70% of energy consumption and therefore a similar volume of emissions, ii) energy efficiency is providing to governments new practical ways to reduce both their strategic energy dependence, operational costs reduction and also significantly emissions reduction, iii) in addition, economic Sustainability increased through energy efficiency and reduce operating integral costs. Authors of this paper consider that this economic Sustainability improvement could boost other Sustainability angles (environmental and social). Within EU programs there is a clear support for partnerships between private and /or public organizations to achieve very significant energy integral savings (usually 20% to 60%) by integrated energy management ESCO type projects. Thus in recent years there have been companies entering into agreements with other organizations to optimize their energy management, ensuring service level, improving integral costs and getting an integral result far better than acting alone. These companies are so called "Energy Service Company (ESCO)" and they invest in more efficient technologies and installations, maintain them and eventually fund, seeking maximum cost efficiency and ensuring agreed service level (Vine, 2005). As Hartley (2005) points out, these practices constitute a type of "horizontal collaborative innovation".

4 ESCO development analysis in EU major countries

To understand if ESCO collaborative relationship is being developed properly in Spain versus other similar countries in the EU and potential areas of improvement, authors of this paper have decided to compare Spanish ESCO evolution till 2014 with two similar, in economics terms, countries (France and Italy) and with other country (Germany) which, in many aspects, is one of the engines of EU in terms of energy saving due to its size and business practices.

For better understanding of countries partnerships helps to understand type of contracts that regulate ESCO relations: a) Energy Supply Contract (DC or ESC), in which the ESCO provides the customer transformed energy (heating, hot water, etc.) in a specific facility managed by ESCO itself (Bertoldi and Rezessy, 2005). ESCO usually retain ownership of equipment, assumes the risk of energy price and installation performance. One type of contract, within this category, is called "chauffage", b) Energy performance contract (EPC) with two alternatives: i) "Shared savings", when ESCO supports the technical risk but the financial risk is kept by the customer, assuring that ESCO get as revenue a portion of the savings if any, ii) "Guaranteed savings", the client assumes the credit risk, but the ESCO guarantees a certain level of savings. If the ESCO does not meet the promised savings, they must pay the difference (vs. agreement) to customer, c) Build-Own-Operate-Transfer (BOOT), in which the ESCO designs, builds, finances and operates the equipment installed during a specified period. At the end of that period equipment reverts to customer, and d) Integrated Energy Contracting (IEC) is a model that combines EPC and ESC and tends to increase the level of savings by a better operations planning from project definition till ultimate details (Bleyl, 2012).

France starts early the twentieth century to develop municipal water and electricity supply contracts (Marino et al., 2010), which few years later were spread to central districts heating projects (Duplessis et al., 2012), from there comes "chauffage projects" denomination. From that milestone, it started the development of a local collaboration culture in energy management highly differentiated from other EU countries. The success of these projects was based on a large services standardization that made them easily replicable. The total market volume of ESCO projects is estimated at 3,200 million euros, of which EPC projects would be approximately 3% (EC, 2012) and there are more than 350 companies active in the sector (Duplessis et al., 2012). Till last decade ESCO services were performed only by specialized companies and large utilities were not allowed to be active in these activities (Leroy and Chanussot, 2009), but after market liberalization they also compete by offering ESCO services. In fact, nowadays market is basically formed by large companies which offer comprehensive energy services and other building maintenance services and some specialized companies (Marino et al., 2010). Biggest French ESCO market is the public sector buildings and private industries. French energy agency which provides financial support to perform energy audits could be considered as a facilitator/motivator factor for French market development. Only condition is that audits should be the basement for real ESCO projects. Regarding the barriers that may be identified, both the budgetary constraints of public entities as main ESCO client and problems caused in the implementation of opportunistic projects can be considered as such.

Germany leads EU ESCO services in terms of market maturity and model spread (Marino et al., 2010). German market value could be estimated at 5,000 million euros (Seefeldt et al., 2013), and it is mostly based - about 80% - in ESCs contracts (EC, 2012) although the EPC agreements already account for about 8% of turnover. Between 500 to 550 companies are engaged in ESCO projects including engineering firms, energy suppliers, ESCO companies and other specialized enterprises (Seefeldt et al., 2013). Most common type of agreement is the Energy Supply Contracting (ESC), which dominates market for buildings and equipment, and some top large multinational companies are usually managing these contracts. ESC projects are small and especially dedicated to public sector but also could be identified in offices, commercial buildings and residential areas. This type of projects may obtain between 15-20% of energy savings using mainly renewable energy technology as they are more focused on reducing greenhouse emissions than on getting huge amount of savings. In Germany, even though the legislation is more advanced than in other EU countries, ESCO organizations usually complain that is quite inconsistent and unclear and argue that ESCO projects often have problems due to the complexity of the procedures to manage project parts procurement, lack of clarity in public tenders and low spread of standards norms and procedures (Boonekamp and Vethman, 2010). On the other hand, there is a financial sector readiness and with high predisposition to finance ESCO projects because they are considered reasonably foreseeable (Bunse et al., 2010).

Due to country size and level of economic development, Italian market would be considered as developed within the EU, but Italian ESCO market is far from French and even more from German markets, both in terms of size and good practices (Bertoldi, Boza-Kiss and Rezessy, 2007; Marino et al., 2010). Experts believe that its size and growth rate is far below to what could be expected (EC, 2013). The Italian market value is estimate at a value around 500 million euros, with 3000 companies registered like ESCO at the local regulatory agency, but only just over 10% have obtained the necessary licenses to carry out comprehensive projects. The market is dominated by a few large companies that are subsidiaries of large multinationals, although there is a multitude of small businesses trying to be active with the expectation of potential future market take off (Chiesa, Chiaroni and Fratinni, 2011). Large energy companies performing ESCO activities are mainly focus on large volume projects in the public sector (especially hospitals) and most common solutions are related to renewable energy, lighting and air conditioning (Chiesa, Chironi and Frattini, 2011). Most common contracts are very similar to the well-known “chauffage” and EPC types, both adapted to the Italian peculiarities. Some barriers to further development of the ESCO model could be identified: i) public sector lack of attention to energy efficiency benefits promotion, ii) overall low priority perception for energy efficiency actions in public and private sectors, iii) high difficulty for long-term projects financing, iv) high level of skepticism about collaborative projects ESCO type benefits, and v) high level of risk perception in these projects, due to lack of figures and conditions transparency (EC JCR 2013).

In Spain, although ESCO market is still relatively small, it is progressively growing and increasing the best practices (Morcillo and Prida, 2014), and mainly based on energy efficiency programs carried out in the period 2005-2010 where collaborative ESCO knowledge was largely spread and heavily promoted by national and regional authorities. Factors such as energy high cost and public promotion programs greatly helped and warm up ESCO projects development, mainly in areas like street lighting applications and public offices and hotels in the private sector. There is no a clear figure of the number of ESCO companies in Spain and there are different data sources that propose totally difference values even contradictory. Institute for Energy Diversification and Saving of Energy (IDAE), as national energy agency, has registered 900 companies in its data base that recognize potential business interest in ESCO projects, while business associations integrated by companies really active in energy saving field projects gather a much lower number of registered members. It could be estimated than 25 to 30 companies cover almost the whole ESCO market, as main contracts dealers with final customers and the rest of companies are second or third tier suppliers. Market value could be estimated in 2014 around € 650 million with a growth of 10% over the previous year. Public streets lighting ESCO projects are getting attention due ESCO attractiveness and serious municipality difficulties to refurnish cities through new investments. But this also could imply a great risk for ESCO sector as represents a rather opportunistic attitude, as politicians could decide to move debts from public to private balance sheets and this is not advisable since ESCO concept was developed to improve processes no to change liabilities ownership. As examples of fairly practices - rapidly growing - are those related to hotels, corporate buildings business, sports facilities and large industrial facilities, mostly based on contracts ESC in the public sector and EPC in the private sector. As issues blocking ESCO development in Spain could be mentioned: i) difficulty to include long-term contracts aspects that could influence project´s outcome and are not easily controllable (such as weather or company activity deviations), and also ii) noteworthy opportunist customer vision, especially nowadays in public entities, which perceive such a type of collaboration as a way to "outsource investment" or "transfer” energy management risks to others, forgetting that the result in energy management does not come only by better management but also improving services use and ways of working.

5 Conclusions

It could be inferred that there is a clear need for the Smart Cities progress in the area of energy efficiency, and ESCO organizations expansion could act as its engine through long term energy collaborative projects, to improve cities Sustainability. However, ESCO type projects are not getting from governments and large companies same level of interest than other Smart Cities programs, like for instance mobility and connectivity programs. One reason may be linked to higher public visibility of programs such as those related to the electric car or "internet of things". Although these difficulties, ESCO projects are growing in EU major countries including Spain, and it could concluded that they are emerging as a key factor on the path to cities Sustainability. Among the countries studied (France, Germany, Italy and Spain) there are notable differences due to experiences and even particular starting points. Thus, Spain and Italy are countries where these collaborative models in energy management were virtually unknown or very marginal ten years ago, while ESCO partnerships has long history in Germany and France, with a long tradition in "chauffage" like agreements and this has a clear influence on current industry development. It is a common barrier in all studied cases the difficulties created due to unclear, and sometimes contradictory, legislation that regulates this type of relations and this could be closely linked to perceived risk, being projects that sometimes last for 10 or 20 years.

In some countries, particularly in Spain but also in Italy, final customer perception is still poor in term of confidence. These projects involves a relationship that should be very collaborative and open during many years and there is certain reluctance in many companies to work closely sharing internal information with partners. In some countries this aspect is less worrying if agreements are concerned to standard contracts that have been developed over many years and with very clear regulations (Germany and France). In Spain, it will take time to build good experiences in this type of relationship and broad dissemination of "best practices" is critically required.

Also in Spain, there is currently a tendency in which ESCO projects are originated by the public sector as energy saving programs, nevertheless - due to public debt problems - would be advisable no to use ESCO project to “make up” municipalities financial risk but as collaborative improvement initiative to optimize service processes and increase energy efficiency within cities. It could also be concluded that for wider Spanish ESCO development would be very favorable the availability of financial entities capable to understand this business model and to accept long term projects pay-back, such in other EU countries.

6 References

Bertodi P, Rezessy S (2005) European Energy Service Companies Status Report 2005. European commission, Joint Research Center publications.

Bertoldi P et al (2006) Energy service companies in European Countries: current status and development strategy to foster their development. Energy Policy 34: 1818-1832.

Bertoldi P, Boza-Kiss B, Rezessy S (2007) Latest development of Energy Service Companies across Europe – An European ESCO update. European Commission, Joint Research Center publications.

Bleyl J (2012) ESCO market development: business models, innovations and lessons learned. Presented at IEA DSM Workshop, April 2012, Trondheim.

Boonekamps P, Vethman P (2009) ChangeBest project. National Report on Energy Service Efficiency Business in the Netherlands. Enery Research Centre of the Netherlands.

Bulkeley H, Kern K (2006) Local government and the Governing of Climate Change in Germany and UK. Urban Studies 43 (12): 2237-2259.

Bunse M et al. (2010) ChangeBest project. National Report on Energy Service Efficiency Business in the Netherlands. Enery Research Centre of the Netherlands.

Caragliu C et al (2011) Smart Cities in Europe. Journal of Urban Technology, vol. 18, No. 2, April 2011: 65-82.

Chiesa V, Chiaroni D, Fratini F (2011) Energy efficiency in Italy: business models, technological solutions, barriers and opportunities development. Politecnico di Milano.

Croci E, Melandri E, Molteni T (2010) A comparative Analysis of Global City Policies in Climate Change Mitigation: London, New York, Milan, Mexico City and Bangkok, IEFE Bocconi University Working Paper nº 32.

Duplessis B, et al. (2012) An empirical typology of energy Service nased on a well-developed market. France. Energy Policy 45 (June): 268-76.

EC - European Commission – Joint Research Center (2012) ManagEnergy Capacity Buildings: SEAP Oriented Towards a Fossil Free Energy System. Workshop summary, Denmark.

EC – European Commission – Joint Research Center (2014) ESCO market report 2013.

Eisenhardt K M (1989) Building theories from case research. Academy of Management Review, vol. 14, No. 4: 532-550.

Gummesson E (1991) Qualitative methods in management research. London: SAGE Pub-lications Ltd.

Hartley J (2005) Innovation in governance and public services: past and present. Public Money and Management, 25 (19): 27-34.

IEC (2014) Orchestrating infrastructure for Sustainable Smart Cities white paper. International Electrotechnical Commision, Geneve, 2014.

Kousky C, Schneider S H (2003) Global climate policy: what cities lead the way?, Climate Policy ¾: 359-372.

Langlois P, Hansen S (2012) World ESCO outlook. Fairmont press.

Leroy J, Chanussot L (2009) European Energy Service Initiative – Framework Conditions for Energy Performance Contracting National Report, France.

Marino A, et al. (2010) Energy service Companies Market in Europe, Status Report 2010. European Commission, Joint Research Center.

Morcillo J, Prida B (2014) ESCO formation as key success factor for Smart Cities: Spain case analysis. Proceedings 8th Conference on Industrial Engineering and Industrial Management, Málaga (Spain), July 2014.

Roller L H, Wavermann L (2001) Telecommunications Infrastructure and economic development: A Simultaneous Approach, American Economic Review: 91:4.

Seefeldt F, et al. (2013) Marktanalyse und markbewertung owie erstellung eines konzeptes zur marktbeobachtung fur ausgewählte dienstleinstungen im bereich energieeffizienz – Revised final report. Berlin

Sippel M, Jenssen T (2010) What about local climate governance? A review of promise and problems. Munich Personal RePEC Archive Paper 20987.

Vine E (2005). An international survey of energy service company (ESCO) industry, Energy Policy 33: 691-704.

Woods E, Mackinnon L (2014) Smart cities and Energy Cloud: reshaping the energy landscape.

Approaches for Collaborative Networks Simulation: A review

Andres B[1], **Poler R**[2]

Abstract: Collaborative networks (CN) are characterised by being complex systems, highlighting the need of considering simulation approaches to support the resolution of CN models. Three relevant simulation approaches are identified for its application in the context of CN models: Discrete Events Simulation, System Dynamics and Agent Based Simulation. Each simulation approach is briefly described and compared with each other, with the main aim of aiding on the task of selecting the most appropriate simulation approach to address the modelling process, in the context of CN.

Keywords: simulation approach, collaborative networks, discrete event, system dynamics, agent-based simulation.

1 Introduction

Complex systems are characterised by (i) its decentralized nature, in which the system behaviour arises from the self-organization of its components without these being controlled by any extrinsic entity to the system, (ii) the presence of loops of causality and nonlinear feedback, and (iii) the fact that it contains several self-contained units that can interact, evolve and adapt their behaviour to changes in the environment (Vicsek 2002). Collaborative networks (CN) consist of a wide range of decentralised and heterogeneous entities each one carrying out different processes and activities to provide goods or services to final customers (Camarinha-Matos and Afsarmanesh 2008). Furthermore, each organisation defines its own objectives and formulates its own strategies. This heterogeneity makes CN complex systems, involving that in most cases it would very difficult to adequately model and solve them mathematically (Izquierdo et al. 2008). Consequently, CN require the use of ad-hoc methodologies, models and tools to tackle problems and succeed in identifying proper and optimal solutions (Castilla and Longo 2010). It is at this point where simulation approaches come into play. In the light of this, the paper is organized as follows: Section 2 highlights the importance of relying on simulation approaches to solve complex systems. Three simulation approaches are described focusing on its application in CN: Discrete Event Simulation (DES), System Dynamics (SD) and Agent Based Simulation (ABS). These approaches are jointly compared in Section 3. Finally, the conclusions derived from the review are proposed in Section 4.

2 Collaborative Networks Simulation Approaches

Concerning the CN application area, simulation deals with (i) managing with the complexity associated, (ii) supporting the decision making process, and (iii) assessing the key factors for the CN (profits, customers' service or competitiveness). The construction of "WHAT-IF" CN scenarios will allow decision makers to obtain optimised solutions with less costs and time. Extending the work of (Shannon 1975), the construction of simulation-based models in CN will be useful when: (i) the CN model cannot be formulated in a mathematical notation, (ii) the CN model can be mathematically formulated but there are no resolution methods, (iii) the CN model can be expressed in a mathematical notation and there exist methods for its resolution, but these are costly, tedious and time consuming, and (iv) the objective is to build experiments to compare different scenarios of the CN, and these experiments cannot be carried out

1 **Beatriz Andres** (beaanna@cigip.es)
2 **Raul Poler** (rpoler@cigip.upv.es)
Research Centre on Production Management and Engineering (CIGIP),
Universitat Politècnica de València (UPV).
Centre d'Innovació i Investigació. Calle Alarcón, 03801 Alcoy, Spain

in a real supply network. Simulation-based models allow modellers to (i) understand the causes and effects of the modelled systems behaviour, (ii) introduce temporal aspects in the activation processes, evaluate possible delays or define durations of the simulated processes, (iii) model and observe the system behaviour when external or internal factors change, and identify the consequences associated. The generation of simulation models will enable to extend de obtained conclusions to a real system. Three are the main approaches used in supply networks simulation-based modelling: Discrete Event Simulation (DES), System Dynamics (SD), and Agent Based Simulation (ABS).

2.1 Discrete Events Simulation

DES simulation approach has its origin in the evolution of the General Purpose Simulation System (GPSS) proposed by (Gordon 1961). DES simulation approach considers individual entities each one with specific attributes, which determine their behaviour along the simulation process (Tako and Robinson 2012). In DES the entities (seen as passive objects representing people, machines, messages, tasks, etc.) enter the system, visit some of the states and then the entities leave the system. State changes occur at irregular discrete points of time (Siebers et al. 2010). DES plays a significant role in modelling supply networks, especially in the tactical level; works worth to mention in the context of supply networks are (Lee et al. 2002) (Kleijnen and Wan 2007). One characteristic of DES is that it includes stochastic elements where randomness is generated through the use of statistical distributions (Kleijnen 2005). The lack of representation of continuous processes, the lack of reflecting continuous processes and the higher complexity for detailed models are the drawbacks associated to DES (Lee et al. 2002) when applied in CN.

2.2 System Dynamics

Forrester is considered the precursor of System Dynamics (SD), which has its starting point in the Industrial Dynamics (Forrester 1961). The SD is based on the feedback control theory, decision-making processes, experimental approaches and computational developments (Campuzano and Mula 2011). Forrester developed the SD method as a set of tools and an approach to simulate complex systems, such as the CN; allowing understanding the structure of a system and identifying how the intrinsic control policies operate. Since its appearance, SD has been widely studied and disseminated in multiple research areas, such as defence (Cooper 1980), ecosystem (Wang and Eltahir 2000), social systems (Lane and Husemann 2008), socioeconomic systems and transportation (Liu, Triantis, and Sarangi 2010), strategy management (Gary, Kunc, and Morecroft 2009), knowledge sharing (Luna-Reyes et al. 2008), resource allocation (Lee, Ford, and Joglekar 2007), disruptions (Williams, Ackermann, and Eden 2003) or supply network (Campuzano, Mula, and Peidro 2010). In the study context CN, SD allows building (i) CN models based on previous situations faced by decision makers; (ii) CN dynamic models that are able to self-regulate their activities through feedback loops; and (iii) models using the computer as a supporting tool to compute models through simulating different CN scenarios in a short time and at low cost.

2.3 Agent Based Simulation

ABS approach was developed in the nineties as a novel tool to deal with problems that were not completely satisfactorily solved through using DES and SD, such as complex systems of CN (Siebers et al. 2010). Nevertheless, ABS paradigm has still limited its application in the academic community. According to (Siebers et al. 2010) ABS approach is the process of designing an Agent Based Model (ABM) of a real system to conduct experiments with this model for the purpose of understanding the behaviour of the system and/or evaluating various strategies for the operation of the system being modelled. ABS allows representing complex systems (i.e. CN) though the use of a collection of agents (i.e. enterprises, decision makers) that are programmed according to a set of behaviour rules and objectives that allows them to have control over themselves though making their own decisions. In ABS based-models, the basic components of the real system are explicitly and individually represented in the model (Edmonds 2002). ABS systems are characterized by comprising multiple autonomous, heterogeneous and independent agents, each one with their own objectives, and are generally able to interact with each other and with their environment. Each agent has the capacity to evolve over the time and adapt to new environmental conditions or objectives. One of the fundamental points of agent-based simulation is the concept of emergence in which the agents' behaviour is modelled at the individual level, and the global behaviour emerges as a result of the interactions with many individuals, each one following its own behaviour and rules; corresponding to a bottom-up modelling approach (Holland, 1998).

3 Simulation Approaches Comparison

The literature brings some works making pairwise comparisons between the simulation approaches. DES approaches are mostly compared with SD ones (Maidstone 2012) (Tako and Robinson 2012). Other authors focus on contrasting the usability and application between SD and ABS (Borshchev and Filippov 2004), (Izquierdo et al. 2008), (Macal 2010), (Maidstone 2012). While some other authors work analysing DES paradigm versus ABS approaches (Borshchev and Filippov 2004) (Siebers et al. 2010) (Maidstone 2012). To the best of our knowledge, there are no research works jointly comparing the three approaches. In the light of this, Table 1 is proposed giving an overall view of the three simulation approaches, DES, SD and ABS. The research carried out has also allowed identifying how common is the use of *multimethod* approaches in which different simulation approaches are combined modelling a unique system more accurately (Balaban and Hester 2013): (ii) SD and ABS, ABS interact in an environment, in which certain variables evolve following a SD (Borshchev and Filippov 2004), (ii) SD and DES, DES can be used to model local production planning or sequencing activities of an enterprise while SD can capture the long terms effects caused by the disruptions in production planning (Rabelo et al. 2005) or (iii) DES and ABS. The process flow is modelled from a DES perspective and autonomous active entities in ABS approach, displaying proactive behaviours (Siebers et al. 2010).

Table 1
Simulation approaches comparison: DES vs. SD vs. ABS.

	Discrete Event Simulation	**System Dynamics**	**Agent Based Simulation**
Use appropriateness	Convenient when the evolution of the entities state depends on the occurrence of asynchronous discrete events over the time. It is recommended to use in more detailed models. Mainly used to study the detailed operations of a supply network under uncertainty and/or to evaluate the expected performance measures with a high level of accuracy. Useful in problems which the processes can be well defined with queuing simulations. It focuses more the individual behaviour of entities.	Convenient when the modeller has a previous knowledge of the complex system to be modelled and the objectives to achieve with the modelling process. Appropriate when taking a 'distant' perspective where events and decisions are seen in the form of patterns of behaviour and system structures. It is recommended as a better choice in the high stages of decision making when less detailed models or results are required. It is mostly used for supply network analysis and policy formulation. It focuses more on flows around networks than on the individual behaviour of entities. Allows predicting the behaviour of the system just by looking at the structure.	ABS simulation performs the abstractions directly on the basic components of the system. If the abstraction of the emergence process cannot be carried out in a scientifically valid way given the modelling objectives, then it is more appropriate to explicitly model the emergence process by ABS simulation approach to study the model in detail. Allows modelling populations of diverse individuals (i.e human behaviour models) having a variety of behaviours and interactions. It focuses more the individual behaviour of entities.
Decision Making Level	Modelling problems at an operational level.	Modelling problems at a strategic level to deal strategic issues and policy analysis.	Modelling problems at operational and tactical level. Strategic levels of operation are less used.
Degree of centralisation	Centralised. There is one thread of control. Entities are described as passive objects and the rules that drive the system are concentrated in the flowchart blocks.	Centralised. Useful to model systems consisting of homogeneous entities, dominated by general laws, uniform in time and space (as the physical laws). SD is used in entities that can be modelled correctly in a centralized way.	Decentralised. Each agent has its own thread of control. Describe the process from the entity's viewpoint, thus decentralize (some of) the rules. Therefore it is useful in more complex systems, characterised by high degrees of localization and heterogeneity of its individual components, and dominated by local information exchange processes, asymmetric and decentralized information (like most social systems).
Level of Abstraction	Low. It does not normally represent systems at an aggregate level. Tends to look at the smaller detail of a system (microscopic).	High. The abstraction is done at the system level. System variables (usually aggregated) and causal relationships that link them. Takes a holistic approach of systems, integrating many subsystems. Tends to take a more overall perspective (macroscopic).	Low. The abstraction of the system basic components is individually done on each basic component, not the whole system (mesoscopic).
Complexity of the systems modelled	Low level of abstraction makes the process of modelling more detailed and therefore more complex.	Higher degrees of abstraction lead to lower complexity models, facilitating its implementation, analysis and interpretation.	The low level of abstraction makes the constructed model to be scientifically more rigorous but considerably more complex.
Definition of observable variables	Observable variables.	Most models focus on observable variables of the aggregate system. Aggregate variables of the system. Flow, stock and auxiliary variables (delays).	The definition of the agents behaviour is not necessarily determined by aggregate variables of the system, but can be based only on local information.
Entities behaviour to take decisions	Passive. The behaviour of the entities in the model is determined by the system. Passive entities implies that something is done to the entities while they move trough the system; intelligence (i.e., decision making) is modelled as part in the system.	Passive. Individual entities are not specifically modelled, but instead they are represented as a continuous quantity in a stock. Use of feedback loops to represent the effects of policy decisions. Represents a dynamic view of the cause and effect relationships among the system elements.	Active. Internal to the entities. Active entities, or agents, can take themselves the initiative to do perform the decision-making. Intelligence is represented in each individual agent (objects, enterprises, people). Specific attributes are assigned to each agent, which determine what happens to them throughout the simulation. Decisions emerge from the micro decisions of the individual agents. Autonomous (self-directed) agents follow a series of predefined rules to achieve their objectives whilst interacting with each other agents, as well as the environment.

Table 1
Simulation approaches comparison: DES vs. SD vs. ABS.
(continuation)

	Discrete Event Simulation	System Dynamics	Agent Based Simulation
Modelling approach	Process oriented. Top-down modelling approach focused on modelling the system in detail.	Process oriented. Top-down modelling approach focused on modelling the system from a global perspective and high level of abstraction.	Individual based. Bottom-up modelling approach focused on modelling the entities and interactions between them
Mathematical approximation	Generally stochastic in nature, where randomness is generated through the use of statistical distributions. Being stochastic in nature, it provides different results on different runs. Can use input distributions to model random behaviour.	Generally deterministic and variables usually represent average values. Being deterministic in nature, it provides the same results run after run, so only needs to be run once.	Generally stochastic feature. Can use input distributions to model random behaviour.
Evolution over the time	The system is modelled as a network of queues and activities where state changes occur at discrete points of time.	The system is represented as a set of stocks and flows where the state changes occur continuously over time.	The system is modelled considering that state changes occur at discrete points of time.
Time steps	State changes occur at irregular discrete time steps.	State changes are continuous, approximated by small discrete steps of equal length.	State changes occur in a defined steps of discrete time.
Data Requirements	Requires gathering more detailed data. Input distributions are often based on collect/measured (objective) data.	Minimal data requirements to build a model. Input distributions are often based on theories or subjective data	Requires gathering more detailed data to model the agents' behaviour. Input distributions are often based on theories or subjective data
Validation	Established rules for validation	Established rules for validation	Validation rules cannot be directly transferred to ABS
Applications in SC context	Supply network structure Replenishment control policies Supply network optimisation Distribution and transportation planning SC integration Information sharing Inventory planning management Planning and forecasting demand Production planning and scheduling	Logistics Inventory planning Market evolution Bullwhip effect Disruptions SC integration Information sharing Inventory planning management Planning and forecasting demand Production planning and scheduling	Production planning and scheduling Information flow Risk management SC coordination Inventory, Production, Transportation Bullwhip effect SC configurations
Tools Availability	High software maturity. The scientific community has experience on the software. Increasing computer power and evolving user interfaces led the DES software to progressively move towards 'drag and drop'. Languages, such as the Simul8, emerged to make the process accessible and cost effective for all business sizes. Management tools are really applied.	High software maturity. The process of designing a SD model is simpler, partly because formal models are usually less complex, and partly due to the availability of software tools at very high level. The ease of construction and analysis of system dynamics models using "drag and drop" tools has been one of the main reasons for its immense popularity in the scientific community.	Low software maturity. The scientific community is less familiar with software. Tools using object-oriented programming languages (i.e. Java, C ++) allowing extensibility to model more agents and behaviours. Only one commercial tool Inspired in Java (AnyLogic). Software is more focused to academic. Software is too technical for mass adoption and difficult to integrate into teaching.
Simulation software	AnyLogic Arena Enterprise Dynamics NetSim ProModel SIMUL8 Witness	AnyLogic DYNAMO NetLogo Powersim Stella iThink Vensim	ABLE (Agent Building and Learning Environment) AnyLogic JADE (Java Agent DEvelopment Framework) MASS (Multi-Agent Simulation Suit) NetLogo SeSAm (Shell for Simulated Agent Systems) Swarm

4 Conclusions

This paper discusses the use of different simulation approaches to support the modelling and resolution process of complex systems, such as the CN. Three simulation approaches are considered as relevant to the scope of our purpose: DES, SD and ABS. The choice of one or the other simulation approach depends on the conceptual difference from which one views the problem and the features that characterises the system, which in fact define the requirements of the modelled complex system. Moreover, the modellers' familiarity with the used software must be considered. SD allows to model continuous process while DE and ABS are more used to model in discrete time. Another feature that differs from one simulation approach to another is the level of abstraction. Whereas SD allows representing models with higher levels of abstraction and causal dependencies, ABS and DES considers higher levels of detail in the representation of individual entities/agents. Focusing on the available tools, AnyLogic (AnyLogic 2015) simulation software must be highlighted due to the multidisciplinary offered enabling to use the same tool to simulate in the three simulation approaches.

5 References

AnyLogic. 2015. “AnyLogic.” Retrieved (http://www.anylogic.com/).

Balaban, Mariusz, and Patrick Hester. 2013. “Exploration of Purpose for Multi-Method Simulation Inthe Context of Social Phenomena Representation.” Pp. 1661–72 in Proceedings of the 2013 Winter Simulation Conference, edited by R. Pasupathy, S.-H. Kim, A. Tolk, R. Hill, and M. E. Kuhl.

Borshchev, Andrei, and Alexei Filippov. 2004. “From System Dynamics and Discrete Event to Practical Agent Based Modeling: Reasons, Techniques, Tools.” in The 22nd International Conference of the System Dynamics Society. July 25 - 29, 2004, Oxford, England.

Camarinha-Matos, L. M., and H. Afsarmanesh. 2008. Collaborative Networks: Reference Modelling. Springer International Publishing.

Campuzano, F., and J. Mula. 2011. Supply Chain Simulation. A System Dynamics Approach for Improving Performance. Springer London Dordrecht Heidelberg New York.

Campuzano, Francisco, Josefa Mula, and David Peidro. 2010. “Fuzzy Estimations and System Dynamics for Improving Supply Chains.” Fuzzy Sets and Systems 161(11):1530–42. Retrieved December 29, 2014 (http://linkinghub.elsevier.com/retrieve/pii/S0165011409005296).

Castilla, I., and F. Longo. 2010. “Modelling and Simulation Methodologies, Techniques and Applications: A State of the Art Overview.” International Journal of Simulation & Process Modelling 6(1):1–6.

Cooper, K. G. 1980. “Naval Ship Production: A Claim Settled and a Framework Built.” Interfaces 10(6):20–36.

Edmonds, B. 2002. “The Use of Models - Making MABS More Informative.” Pp. 15–32 in Multi-Agent-Based Simulation. Lecture Notes in Computer Science. Berlin: Springer-Verlag.

Forrester, J. W. 1961. Industrial Dynamics. Cambridge, MA: MIT press.

Gary, M. S., M. Kunc, and D. W. Morecroft. 2009. “System Dynamics and Strategy.” System Dynamics Review 24(4):407–29.

Gordon, G. 1961. “A General Purpose Systems Simulation Program.” Pp. 87–104 in Proceedings of EJCC, edited by McMillan NY. Washington D.C.

Izquierdo, LR, JM Galán, JI Santos, and R. Olmo. 2008. “Modelado de Sistemas Complejos Mediante Simulación Basada En Agentes Y Mediante Dinámica de Sistemas.” Revista de Metodologia de Ciencias Sociales 16(16):85–112. Retrieved January 8, 2015 (http://e-spacio.uned.es/revistasuned/index.php/empiria/article/view/1391).

Kleijnen, J. P. C. 2005. “Supply Chain Simulation Tools and Techniques: A Survey.” International Journal of Simulation and Process Modelling 1(1-2):82–89.

Kleijnen, Jack P. C., and Jie Wan. 2007. “Optimization of Simulated Systems: OptQuest and Alternatives.” Simulation Modelling Practice and Theory 15(3):354–62. Retrieved February 3, 2015 (http://linkinghub.elsevier.com/retrieve/pii/S1569190X06000931).

Lane, D. C., and E. Husemann. 2008. “Steering without Circe: Attending to Reinforcing Loops in Social Systems.” System Dynamics Review 24(2):37–61.

Lee, Young Hae, Min Kwan Cho, Seo Jin Kim, and Yun Bae Kim. 2002. “Supply Chain Simulation with Discrete–continuous Combined Modeling.” Computers & Industrial Engineering 43(1-2):375–92. Retrieved (http://linkinghub.elsevier.com/retrieve/pii/S0360835202000803).

Lee, Z. W., D. N. Ford, and N. Joglekar. 2007. “Effects of Resource Allocation Policies for Reducing Project Durations : A Systems Modelling Approach.” Systems Research and Behavioral Science 566(October 2006):551–66.

Liu, S., K. P. Triantis, and S. Sarangi. 2010. “A Framework for Evaluating the Dynamic Impacts of a Congestion Pricing Policy for a Transportation Socioeconomic System.” Transportation Research Part A: Policy and Practice 44(8):596–608. Retrieved December 29, 2014 (http://linkinghub.elsevier.com/retrieve/pii/S0965856410000698).

Luna- Reyes, L. F., L. J. Black, A. M. Cresswell, and T. A. Pardo. 2008. “Knowledge Sharing and Trust in Collaborative Requirements Analysis.” System Dynamics Review 23(3):265–97.

Macal, C. .. 2010. “To Agent-Based Simulation from System Dynamics.” Pp. 371–82 in Proceedings of the 2010 Winter Simulation Conference, edited by B. Johansson, S. Jain, J. Montoya-Torres, J. Hugan, and E. Yücesan.

Maidstone, Robert. 2012. “Discrete Event Simulation , System Dynamics and Agent Based Simulation : Discussion and Comparison.” System 1–6.

Rabelo, Luis, Magdy Helal, Albert Jones, and Hyeung-Sik Min. 2005. “Enterprise Simulation: A Hybrid System Approach.” International Journal of Computer Integrated Manufacturing 18(6):498–508. Retrieved (http://www.tandfonline.com/doi/abs/10.1080/09511920400030138).

Shannon, R. E. 1975. Systems Simulation: The Art and Science. PrenticeHall, Englewood.

Siebers, P. O., C. M. Macal, J. Garnett, D. Buxton, and M. Pidd. 2010. “Discrete-Event Simulation Is Dead, Long Live Agent-Based Simulation!” Journal of Simulation 4(3):204–10. Retrieved February 11, 2015 (http://www.palgrave-journals.com/doifinder/10.1057/jos.2010.14).

Tako, Antuela a., and Stewart Robinson. 2012. “The Application of Discrete Event Simulation and System Dynamics in the Logistics and Supply Chain Context.” Decision Support Systems 52(4):802–15. Retrieved February 2, 2015 (http://linkinghub.elsevier.com/retrieve/pii/S0167923611002211).

Vicsek, T. 2002. “Complexity: The Bigger Picture.” Nature 418(6894):131–131.

Wang, G., and E. a. B. Eltahir. 2000. “Ecosystem Dynamics and the Sahel Drought.” Geophysical Research Letters 27(6):795–98. Retrieved (http://doi.wiley.com/10.1029/1999GL011089).

Williams, T., F. Ackermann, and C. Eden. 2003. “Structuring a Delay and Disruption Claim: An Application of Cause-Mapping and System Dynamics.” European Journal of Operational Research 148(1):192–204.

Modeling for Measuring the Performance of Managment Innovation in National Retail

Catelan VD, Marques KFS, Naimer SC, Siluk JCM, Werner L[1]

Abstract: Innovation is now recognized as an essential factor for the competitiveness of organizations inserted in strategy and linked directly to organizational performance. In this context, the study aims to identify aspects that contribute to the management of innovation by setting a scenario of the retail network by sketching a current overview of innovation, identifying the relevant dimensions related to innovation, strategic actions, challenges and benefits conquered. As for the procedures, the research is characterized as a descriptive bibliography and as to the qualitative and quantitative nature, it was carried out through a case study and a multi-criteria analysis, held in one of the largest electronics chains in Brazil, in the four regions of operation. From the development of modeling and its application in the network studied, it was possible to verify the critical factors of success, from the management of innovation, which through the multi-criteria analysis and application of measurement method, Key Performance Indicators (KPI), made it possible to identify the prioritization of factors and distinction regarding organizational performance in the context of the evaluated dimensions.

Keywords: insert words. Retail Management; Strategic Management; Business competitiveness; Organizational diagnosis; Performance Evaluation.

1 Introduction

The last decades show a period of profound change in the global scenario. In Brazil, the social and economic changes are a reflection of the growth of income and a higher consumption of the population. To stay in a new and dynamic market full of new paradigms, the companies search for tools and innovative processes, becoming strategic in actions and differentiated in management. The adoption of management innovation by entrepreneurs can be used to obtain various factors, such as, increased competitiveness, customer retention, innovation, growth, profitability, aiming a superior and sustainable performance in the retail industry.

Based on these considerations, it is clear that the adoption of actions and practices aimed at implementation strategies through innovation management in retail, can be seen, in addition to its many benefits, as a means of competitive advantage.

The performance measurement theme or organizational performance has received increasing attention in the last ten years due to pressure suffered by companies to present results (Fernandes, 2006; Correa; Junior, 2008). Thus, the development of a Performance Measurement System is seen as a key factor in supporting the management, it may encourage making the right decisions and the time of the organization's operations and create opportunities for the corporate management of the company the diagnosis of the main strengths and weaknesses, providing opportunities for innovation and high performance (Siluk, 2007). In this sense, this paper's main objective is to measure the level of performance in innovation management in domestic retail, from the dimensions leadership, culture and strategy.

1 **Veronica Dalmolin Catelan** (veronica_vdc@hotmail.com)
Kelen Scherolt (kelkelh@yahoo.com.br)
Simone Caberte Naimer (simone.naimer@live.com)
Julio Siluk (jsiluk@ufsm.br)
Liane Werner (werner.liane@gmail.com)
UFRGS - Universidade Federal do Rio Grande do Sul.
UFSM -Universidade Federal de Santa Maria.

Several studies have noted that many leaders know the importance of innovation in management, but few use it, mainly by insecurity for the same (Morris, 2011), so the research attempts to cooperate towards the retail sector, bridging the gap of doubts and insecurities several managers on how to manage innovation in retail, focusing on how you work the management of innovation in the retail network. Thus, there was the diagnosis of one of the largest networks of retail companies of electronics in Brazil Magazine Luiza, with the managers of the network of the four working regions, it was verified the process of innovation management of the network.

2 The Process of Measuring the Performance of Innovation Management in Retail

Retailers face the daily challenge to differentiate themselves from their competitors, as the pace of market changes, competitiveness, innovation and the maturing of consumer´s view have been increasing steadily (Predebon; Zogbi, 2008; Parente, 2009; Mattar, 2011).

In this context it becomes important to stress the importance of the context of the management of innovati-on for competitiveness. Find many different ways to get the innovation quickly and economically is the main type of constant competitive advantage in the twenty-first century, and the "competitive advantage is the ability of a company to work in one or more ways that competitors can´t or will not follow " (Kotler, 2008).

For companies to ensure competitive advantage from the balance between the dimensions of innovation, the correct evaluation of the organization's performance should be viewed and directly related to the organization's ability to achieve its goals using the resources in an efficient and effective way (Kaplan; Norton, 2008; Silva ed, 2010; Tisott ed, 2011).

Being considered as a current need in various areas of Engineering and Administration applications, the complex solving of decision making requires the involved knowledge about the topics addressed, enabling at the end the creation of committed results with a lower degree of subjectivity and imprecision among the various existing possibilities for action (Gomes; Gomes, 2012; Parmenter, 2010).

Thus, the multi-criteria approach aims to support the decision-maker at the time of performing the hierarchy between two or more alternatives, considering the facts and events relevant to the reality studied through quantitative models to clarify this kind of favoritism proposed (Almeida; Costa, 2003; Gomes; Araya; Carignano, 2004; Ensslin; Montibeller; Noronha, 2001).

3 Methodology

For the development of the modeling of the performance of innovation, the study was conducted based on a compliance of ten methodological steps, as shown in Figure 1, initiated by the literature about innovation processes and measurement of organizational performance, where it was possible to identify the critical internal points to retail that require monitoring of management.

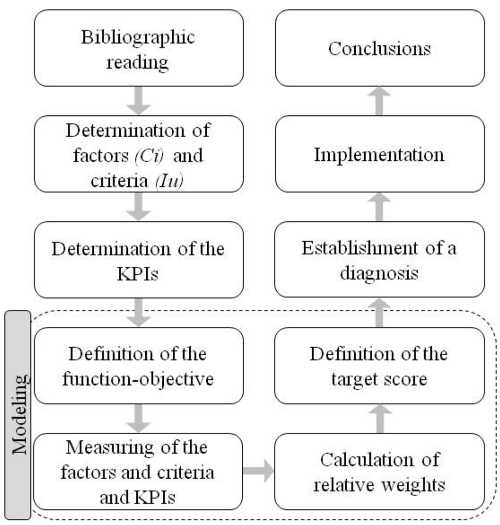

Fig.1
Step methodological proposals for research.
Source: Authors

The following were assigned variables that represent at the end the degree of performance in innovation management in the company under study, being structured on two levels: factors (C_i) and criteria (I_u) as shown in Figure 2. In this development of modeling, it was first considered the management assumptions, which were extracted as key factors: leadership, culture and strategy.

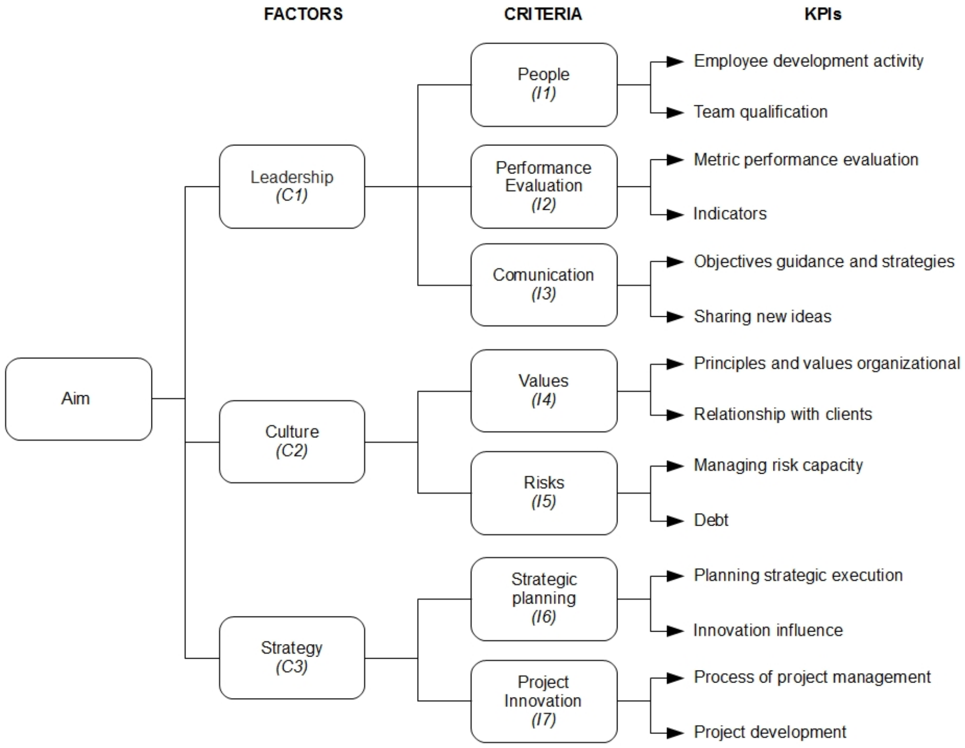

Fig.2
Hierarchical Structure for supporting the determination of KPIs.
Source: Authors

The definition of the factors were carried out studies from Carlomagno and Scherer (2009), Sebrae (2009), Morris (2011) and seven criteria, finally there was the definition of KPI that made possible the measurement, based on Porter (2009), Scherer and Charlemagne (2009), Cotec Portugal (2007), Tidd, Bessant and Pavitt (2008) which list the dimensions that serve as a guide organizational practices aimed at managing innovation.

As for the development itself of modeling, this is proposed starting from the approach to the only criterion of synthesis, which is initially required the development of the global objective function V_{obj}, so that it is able to express the situation of undertakings in relation to the context, established from the mathematical method provided by the Equation (1.1),

$$\mathrm{V_{obj}} = \frac{\sum_{i=1}^{n} \mathrm{C_i}}{3} \tag{1.1}$$

It is necessary to check both the condition of the three C_i factors considered to measure the context, as shown in Equation (1.2),

$$\mathrm{C_i} = \mathrm{w_i} * \frac{\sum_{i=1}^{n} \mathrm{I_u}}{\mathrm{NI_u}} \rightarrow \forall\, u \subset i \tag{1.2}$$

Where w_i is the relevance of each criteria in relation to the whole, $NI_u$is the total amount of criteria characteristic I_u, which are the criteria laid down in the second level of the hierarchical structure, measured from the definitions proposed by Equation (1.3).

$$\mathrm{I_u} = \mathrm{w}_u * \sum_{\mathrm{f}=1}^{\mathrm{n}} \frac{\mathrm{KPI_f}}{2} \rightarrow \forall\, f \subset u \qquad (1.3)$$

Consequently, the determination of I_u is directly related to the result obtained by measuring i of KPI_f, ∀ f∈ {1,2, ..., n}, generated as metrics established at the time of definition of KPIs and following the proposal described by mathematical Equation (4), designed using the α scale based on the Likert, from a maximum of five to the minimum one, with intermediate values 2, 3 and 4 able to forward the opinion of the interviewee about the indicators$\forall\ e \in \{1, 2, \dots, n\}$,

$$KPI_f = \beta_\mathrm{f} \rightarrow \beta_\mathrm{f} \propto \text{fator escala } \alpha \qquad (1.4)$$

Being opinions expressed from the values assumptions β_e as the variation limits proposed by α. For Almeida (2003) the best way to consider sustainability as a source of competitive advantage, is to formulate and implement strategies to establish the critical impacts of the organization on the dimensions of sustainability and the ways in which these impacts affect the performance of the operations of companies. Based on this view, we can say that the company must ensure the sustainability of its business, contributing to the overall sustainability from the three levels discussed in modeling.

As for the determination of w_y weights, according to Equation (1.5) it has been proposed to use standard techniques that truly represent the preference of decision maker, such as the Simple Attribute Rating Technique (SMART) and Swing Weighting, based on the assumptions of Guitouni and Martel (1998), Clemen and Reilly (2001) and Pöyhönen and Hamalainen (2001) so that the first dedicated by Edwards (1971), performs this process by directly decreasing order of importance for each of them, the last place to which is assigned, generally a value of 10 and, from this, values are listed in an increasing order according to the degree of behavioral discrepancy existing between them (Figueira; Greco; Ehrgott, 2005).

As for the technique named by Swing Weighting logic value assignment occurs in reverse, starting from the same ordering system, identifying which has greater importance, as for adopting a value of 100, performing the same process to the other, by reaching a value able to resume the item less relevant in relation to the hierarchical system level in question, the difference found in each interval set back according to the characteristics of both (Gomes; Gomes, 2012).

$$\mathrm{w_y} = \frac{\sum_{\mathrm{x}=1}^{\mathrm{n}}\left(\mathrm{R}_{\mathrm{y}_1} + \mathrm{R}_{\mathrm{y}_2}\right)}{\mathrm{n}} \qquad (1.5)$$

Where x is relative to each of the companies to be verified, $\forall\ x \in \{1, 2, \dots, n\}$ and $y = \{i, u\}$ on a generic representation of the levels considered to represent the weights of the elements in the hierarchical structure of which were determined by obtaining the values for the calculation of multicriteria methods Swing Weights (R_{y_1}) and SMART (R_{y_2}), based on the opinion of decision-makers, according to Equations (1.6) and (1.7)

$$\mathrm{R}_{\mathrm{y}_1} = \frac{\mathrm{F}_{\mathrm{y}_1}}{\sum_{\mathrm{y}=1}^{\mathrm{n}} \mathrm{F}_{\mathrm{y}_1}} \begin{cases} \mathrm{F}_{\mathrm{y}_1} = 16{,}67\mathrm{b} - 16{,}67 \\ \mathrm{F}_{\mathrm{max}_1} = 100 \\ \mathrm{F}_{\mathrm{min}_1} = 1 \end{cases} \qquad (1.6)$$

$$\mathrm{R}_{\mathrm{y}_2} = \frac{\mathrm{F}_{\mathrm{y}_2}}{\sum_{\mathrm{i}=1}^{\mathrm{n}} \mathrm{F}_{\mathrm{y}_2}} \begin{cases} \mathrm{F}_{\mathrm{y}_2} = \mathrm{F}_{(\mathrm{y}-1)_2} + \mathrm{FR}_{\mathrm{y}_2} \rightarrow \mathrm{FR}_{y_2} \propto \text{scale factor } \partial \\ \mathrm{F}_{\mathrm{min}_2} = 10 \end{cases} \qquad (1.7)$$

Being $\mathrm{F}_{\mathrm{y}_1}$ and F_{y_2} concerning proportional scores, b corresponding to the order of each factor given by the interviewee and directly FR_{y_2} related to the scale factor ∂, based on the determination of values for each those as a Likert scale that ranges from a minimum of 1 to a maximum 10. Finally, to become possible to perform comparisons of the results in all the methodological steps, you must set the target for each of these, according to the determination of a value that has as behavior increasing proportional change or descending on the level of strictness expected to measure that, if it was suggested based on the level of demand certifications that were addressed in the course of this research and broadly agreed with the company managers the amount equivalent to 90%. To step diagnostic companies, it was implemented through a structured closed interview, consisting of 14 questions, each related KPIs, and this applied with the executive managers also considered in this research as decision makers, which together assigned the factors and criteria weights necessary to carry out the relativity of its values. The data obtained from the diagnosis were transferred to a database using Microsoft Office Excel® software.

As for the proposal of practical application, we sought to carry out the research with the main branches of the 4 regions of operation of Magazine Luiza network. Based on the population of 273 branches, has been defined sample of 4 major branches of the network, distributed in each of the regions (South, Southeast, Midwest and Northeast) listed by the number of employees, setting an accessibility sample.

4 Analysis of results

Aiming to test the proposed model, the application of the study was on Magazine Luiza´s network, as the main activity is in constant contact with the dimensions of innovation, which increasingly becomes relevant to the way this sector is developing.

Table 1 shows the relativity of the factors under study from the application of diagnosis, and decision-makers judged the relationship between the factors and criteria to the degree of equal importance towards the measured system.

Table 1
Results for the relativization of factors and criteria.
Source: Authors

Fators	South Region	Southeast Region	Midwest Region	Northeast Region	Total
Leadership	**33%**	**33%**	**33%**	**33%**	**33%**
Culture	**33%**	**33%**	**33%**	**33%**	**33%**
Stradegy	**33%**	**33%**	**33%**	**33%**	**33%**
Criteria	South Region	Southeast Region	Midwest Region	Northeast Region	Total
People	**21%**	**18%**	**12%**	**16%**	**17%**
Performance Evaluation	**24%**	**18%**	**18%**	**14%**	**19%**
Comunication	**8%**	**14%**	**6%**	**14%**	**11%**
Values	**12%**	**8%**	**10%**	**6%**	**9%**
Risks	**4%**	**11%**	**6%**	**4%**	**7%**
Strategic Planning	**21%**	**25%**	**26%**	**22%**	**24%**
Project Innovation	**12%**	**16%**	**14%**	**11%**	**13%**

The equivalence of the relativity of decision-makers is given because these have a proportionately equidistant level of importance to the context of management processes, and to the factors, the calculated judgment is willing equivalently for all companies, since the similar degree of importance exists between them. For criteria, it is especially the top-ranked: strategic planning, performance evaluation and people.

From the data obtained through the diagnosis applied to the proposed model for the KPIs, it was possible to obtain the result for each factor and finally the overall result regarding the performance in innovation management for each of the surveyed areas, as shown in Table 2.

Table 2
Results achieved.
Source: Authors

	Objective function	Goal
Southern Region	**91%**	**90%**
Southeast Region	**94%**	**90%**
Midwest Region	**87%**	**90%**
Northeast Region	**92%**	**90%**

From the results we can see that three regions achieved the target set at work. The Southeast Region had the best performance index in the management focused on innovation, mainly because expressed concern with the seven criteria under study, when performing actions to each of them, which guaranteed the permanence of their results above the target in three factors encountered in work. The Northeast Region and the Southern Region reached the target and obtained intermediate performance. Already the Midwest region showed low levels regarding the context of innovation as a priority in management. The poor performance in this case can be attributed to the fact that the company has not reached a satisfactory level of integrated management, with respect to decision-making, and is developing its actions focusing on the dimensions addressed in this research.

5 Final Consideration

The new economic context characterized by an attitude of customers is changing with the increasing competitiveness and, in this sense, innovation management becomes a global goal for organizations, making their decision makers take integrated decisions, in order to gain competitive advantage and even reduced costs and increased profits. You can also get an understanding of the dimensions studied, rather than being mutually exclusive, they can be mutually reinforcing and this perspective integrates the company's strategy.

In this sense, in order to have a comprehensive view of the sector or the companies surveyed, the use of the relativity of the factors and criteria listed by multi-criteria analysis made it possible by SMART and Swing Weighting models, to enabled a greater understanding of KPIs that have greater relevance before company managers of Magazine Luiza network. The application of performance measurement tool used, KPI, had an important contribution by allowing a more consistent evaluation of key performance indicators for managing innovation in retail.

By applying the proposed model at work, it was possible to say that it may be able to reflect the current situation of the researched environment, reference at the time assists in verifying the situation of this sector. Modeling can also facilitate the visualization, for managers, of which factors and criteria to take into consideration at the time of decision-making and strategic planning.

To better visualize the behavior of the variables that make up the proposed measurement systems, test and verification of results of the companies in the respective regions studied was important to draw a parallel between research and what is seen in the business reality of this business sector. It was emphasized that innovation management is in development and needs to improve in each of its dimensions in the context of this research. It was also observed the distinction between the importance given by companies in certain regions to the factors and criteria studied, even if dealing with the same performance and business network sector.

6 References

Almeida AT, Costa APCS (2003). Aplicações com métodos multicritério de apoio à decisão. Recife: Editora Universitária.

Clemen RT, ReillyT (2001). Making Hard Decisions With Decisions Tools. 2. ed. Pacific Grove: Duxbury.

Corrêa HL, Junior FH (2008). Sistemas de mensuração e avaliação de desempenho organizacional: Estudo de casos no setor químico no Brasil. Revista Contábil e Financeira, USP, São Paulo, v.19, n.48 – p. 50-64.

Edwards W (1971). Social utilities. Engineering Economist: v. 6, p. 119-129.

Ensslin L, Montibeller GN, Noronha SM (2001). Apoio à decisão – metodologia para estruturação de problemas e avaliação multicritério de alternativas. Florianópolis: Insular.

Fernandes B H R (2006). Competências e desempenho organizacional: o que há além do Balanced Scorecard. São Paulo: Saraiva.

Figueira J, Greco S, Ehrgott M (2005). Multiple criteria decision analysis: state of art surveys. New York: Springer.

Gomes CF, Gomes LFAM (2012). Tomada de decisão gerencial: Enfoque Multicritério. 4 ed. São Paulo: Atlas.

Gomes LFMA, Araya MCG, Carignano C (2004). Tomada de decisões em cenários complexos: introdução aos métodos discretos do apoio multicritério à decisão. São Paulo: Pioneira Thomson Learning.

Guitouni A, Martel JM (1998). Tentative guidelines to help choosing an appropriate MCD Amethod. European Journal of Operational Research, 109 (2), 501 – 521.

Kaplan RS, Norton DP (2008). A execução premium: a obtenção de vantagem competitiva através do vinculo da estratégia com as operações do negócio. Rio de Janeiro: Elsevier.

Parmenter D (2010). Key Performance Indicators (KPI): Developing, Implementing, and Using Winning KPIs. 2 ed. Wiley: Hoboken.

Porter M (2009). Competição. Rio de Janeiro: Elsevier, 2009.

Poyhonen M, Hamalainen RP (2001). On the convergence of multiattribute weighting methods. European Journal Operational Research, v. 129, p. 569-585.

Siluk JCM (2007). Modelo de gestão organizacional com base em um sistema de avaliação de desempenho. Tese de Doutorado em Engenharia de Produção - Programa de Pós-Graduação em Engenharia de Produção, UFSC. Florianópolis.

Silva ME, Sousa IG, Feitosa MJS, Balbino BP, Correia SEN (2010). O desempenho empresarial como reflexo de uma mudança organizacional: a análise de um grupo de empreendimentos no estado da Paraíba. REUNA, v. 15, n. 1, p. 33-45.

Tisott ST, Rizzo MR, Moura RGG, Veloso VL (2011). Desempenho e análise da utilização do Balanced Scorecard na companhia de transmissão de energia elétrica paulista – CTEEP, REUNA, v. 16, n. 2, p. 35-52.

Morris L (2012).The innovation master plan: the ceo's guide to innovation.Walnut Creek: Innovation Labs, 2011. Disponível em: http://www.innovationlabs.com. Jul 2012.

Predebon J, Zogbi E (2008). Inovação no varejo: o que faz o lojista criativo. São Paulo. Atlas.

Parente J (2010). Varejo no Brasil: Gestão e estratégia. 10 ed. São Paulo: Atlas.

Mattar F N (2011). Administração de Varejo. Rio de Janeiro: Elsevier.

Kotler P (2008). Administração de marketing: Análise, planejamento, implementação e controle. 5. ed. São Paulo: Atlas.

Scherer FO, Carlomagno MS (2009). Gestão da inovação na prática: Como aplicar conceitos e ferramentas para alavancar a inovação. São Paulo: Atlas.

Sebrae SP (2012): Serviço Brasileiro de Apoio às Micro e Pequenas Empresas de São Paulo. Pesquisa: Inovação e Competitividade nas MPEs Brasileiras. Disponível em: www.sebraesp.com.br. Maio 2012.

Cotec Portugal. Associação Empresarial para a inovação. Disponível em: www.cotecportugal.pt. Jan 2012.

Tidd J, Bessant J, Pavitt K (2008). Gestão da Inovação. 3. ed. Porto Alegre: Bookman.

Simulated Annealing applied to the problem of task assignment in a laboratory

Tavares F[1], **Massote A**[2]

Abstract: The task assignment becomes complex in companies that have the cross-training system, where multiple employees are trained for a particular job and each job can be executed by multiple employees. This paper proposes a methodology to the problem of task assignment in a lubricant analysis laboratory, consisting of a constructive heuristic designed to generate an initial solution followed by the application of the Simulated Annealing. This model was designed to be applied in small companies where computational capacity is limited, as well as the information available.

Keywords: Task assignment, Simulated Annealing, Cross-training.

1 Introduction

Norman et al. (2002) argue that a competitive advantage can be achieved by improving the importance of the human element in the manufacturing processes. Lean production and manufacturing cells require the use of cross training.

Despite the fact that cross-training brings benefits such as flexibility in the task assignment and an increase in the use of employees as Inman, Jordan and Blumenfeld (2004) argue, Pinker and Shumsky (2000) argue that its excessive use may also increase the company´s cost and reduce a product quality. In small companies where human resources are scarce, the use of cross training can be beneficial. Chemical laboratories have this particular cross training characteristic.

As many procedures are manual, each employee can have a different productivity and the company must have the highest productivity as possible. According to Zolfaghari, El-Bouri and Namiranian (2007), the allocation of staff is directly linked to a company's productivity.

Note that assigning tasks is an extremely difficult procedure to be performed manually. Apart from studying employee´s productivity it is also necessary to ensure that he or she is available at that particular time. In addition, the equipment´s order of importance must be verified. When the company has more equipment than available employees, it has to prioritize equipment restricted to their production capacity. Absenteeism is another problem that the supervisor has which can change a designation prepared the day before.

According to Bard and Wan (2006), the designation of an employee is an NP-complete problem. The company under study, as well as several small companies do not have enough data to make the task assignment with the model proposed by Zolfaghari, El-Bouri and Namiranian (2007).

To reduce the amount of required variables, the model was adapted from universities scheduling problems, but keeping certain characteristics of task assignment models. According to Even, Itai and Shamir (1976), the problem of university scheduling is also an NP-complete problem. Similar to the task assignment problem, the combinatorial nature of the problem prevents an investigation of the whole solution space.

For this model a skills and productivity scoring system was used for each employee and for each equipment. The laboratory supervisor is responsible to select the equipment in order of priority. The model was tested in six different scenarios in which both the quantity of employees and equipment that the company had varied.

1 **Fernando Perez Tavares** (fernandoperez21@gmail.com)
2 **Alexandre Augusto Massote** (massote@fei.edu.br)
Depto. de Engenharia de Produção.
Centro Universitário da FEI. São Paulo, Brazil.

2 Bibliographic review

2.1 Simulated Annealing

The Simulated Annealing (SA) is a meta-heuristic based on the annealing process of the materials. In practice, this process involves heating the material at a high temperature and cooling it slowly. The SA began with Nicholas Metropolis as we can see in his work Metropolis et al. (1953). Years later the work was computationally incremented by Kirkpatrick, Gelatt and Vecchi (1983) where they argue that there is a strong connection between the statistical mechanics and a multivariate or combinatorial optimization system. The SA has two probabilities, being *PA* random and *PN* natural that is calculated by the formula:

$$\mathrm{PN} = \frac{1}{e^{\frac{[\mathrm{Ep}-\mathrm{Ea}]}{\mathrm{T}}}} \tag{1}$$

Where *Ea* is the "energy" of the previous iteration, *Ep* is the "energy" of the later iteration and *T* the "temperature" of the iteration. At each iteration the "temperature" of the system is reduced according to the cooling rate used.

Its main characteristic is to start the process with a high "temperature" and cool slowly. In the beginning, the model can choose a new solution that is worse than the previous one, avoiding to be stuck in local solutions. While the temperature decreases, the probability of making this exchange decreases too.

2.2 Task assignment and scheduling

Zolfaghari, El-Bouri and Namiranian (2007) reported that after determining the demand, the next steps for the company to create work schedules are by scheduling work shifts, scheduling days off, the "tour scheduling" and the task assignment. This work aims at the task assignment. The shifts were already set by the company and were not aimed at modifying neither time not people in these shifts.

Another example that is widely studied is the allocation of teachers in classrooms (timetable). In this type of model, there are classes that should be given, available rooms and available time for teachers. Broder (1964) made an early work on universities timetabling where his goal was to minimize the total amount of conflicts at student's exams, using as a basis the Monte Carlo method.

Many studies used meta-heuristics for solving this kind of problem. Akjiratikarl, Yenradee and Drake (2007) and Souza Martins and Araujo (2002) are examples. Souza, Moretti and Podesta (2008) used the tabu search to solve the problem of timetabling in schools. They claim that the proposed procedure was successfully tested in Brazilian public schools.

Zhang et al. (2010) suggested a new neighboring structure for solving timetabling problems using the Simulated Annealing. In this search for a new solution, the algorithm changes the schedules between pair of rooms.

3 Methodology

A constructive heuristic was created to generate an initial solution to the problem. This solution is the starting point for the Simulated Annealing that start looking for better solutions. Another solution that was used for comparison was the laboratory supervisor who makes the manual assignment.

The results were compared in six different scenarios. The difference between each scenario is in the number of variables that each scenario has. The goal of creating scenarios is to check the laboratory super-visor's behavior and the methodology proposed with the variation in the number of variables in the system.

3.1 Problem description and modelling

Currently the laboratory supervisor, who has extensive experience in the area, does the task assignment manually. The company has the cross training feature. The supervisor should allocate the most appropriate employee for the equipment.

Since the model was developed with a focus on serving small businesses, care was taken to avoid increasing the amount of information needed to feed the model. The data of productivity for each employee in each piece of equipment will not be used. To replace the productivity data, a scoring system will be used.

An array with binary variables was chosen to model the problem. This array has three dimensions. The first is the time window, the second is the equipment and the third is the employee. If this cell has the value one, it means is allocated. Similarly, if the cell has the value of zero means that is not allocated.

The objective is to allocate the largest possible number of employees, respecting the restrictions, prioritizing the important equipment and allocating the most competent and productive employee for that equipment.

There are three constraints in the model. The first one prevents an employee from being at different pieces of equipment at the same time.

$$\sum_{p=1}^{P} {}^{h}H_{p}^{e} \leq 1 \qquad (2)$$

Where *p* is the employee index, *h* is the time index and *e* is the equipment index. This restriction should be tested at each time (h) of each equipment (e) in the allocation matrix *A*. If the constraint is false, even if only in one time window, the solution is considered as invalid.

The second restriction prevents two or more employees at the same equipment at the same time window.

$$\sum_{e=1}^{E} {}^{h}H_{p}^{e} \leq 1 \qquad (3)$$

This restriction should also be tested at each time (h) of each employee (p) in the allocation matrix A. If the constraint is false, even if it is in one place, the solution is considered as invalid. The third restriction is that the employee cannot be allocated on the time window that is not available. He becomes unavailable if already allocated to other piece of equipment or if in its availability schedule here is the value of zero for that time slot.

The objective function of the problem is the sum of all cells multiplied one by one by the weight of importance of the equipment and the weight of the employee for that equipment.

$$\text{MAX:} \ \sum_{h=1}^{H} \sum_{e=1}^{E} \sum_{p=1}^{P} \left({}^{h}H_{p}^{e} . n_{p}^{e} . k_{e} \right) \qquad (4)$$

Where n_p^e is a position of the fitness weight matrix, $\mathrm{k_e}$ is the position of the vector with the weight of importance of the equipment and ${}^{h}H_{p}^{e}$ is the position of the allocation matrix that can take the value of one if is allocated, or zero if it is not allocated. If the employee is not authorized to operate a piece of equipment, the fitness weight is equal to -1.

3.2 Constructive heuristic

The constructive heuristic of this problem was created based on the combination of fitness weights of the employee and the weight of the importance of the equipment for the company. First, the employee fitness weight is multiplied by the weight of importance of the equipment for each employee. With that is creates a two-dimensional array (equipment and employee). After this step, all the values for each piece of equipment are summed having a one dimension vector (equipment).

This array is sorted in a decreasing order, obtaining a new array with the equipment order. With this methodology, the goal is to make an importance order of the equipment that has a bigger number of employees with better scores in this equipment. The employee that has the major score for that equipment is then allocated.

3.3 Scenarios creation

The number of variables for each scenario can be found in table 1.

Table 1
Main characteristics associated to interoperability, cooperation and collaboration.

Scenario	Employee quantity	Equipment quantity	Time quantity	Total variables
1	6	4	24	576
2	11	8	24	2.112
3	20	16	24	7.680
4	30	24	24	17.280
5	40	32	24	30.720
6	50	40	24	48.000

Scenario 2 is the current situation of the company. Scenario 1 is a representation of the half of the company. The other scenarios were created with random simulations of weights, simulating a growth of the company.

4 Results

A maximum time was set for manual assignment of the tasks. This time was determined with the supervisor and it was established a value of 40 minutes. The results of the supervisor for each scenario are shown in Table 2 and Table 3. The supervisor failed to complete the task for the scenarios 4, 5 and 6.

For all tests the same computer was used. The results of the constructive heuristic can be seen in Table 2 and Table 3. The Simulated Annealing was executed with 500 blocks of temperature and 20,000 iterations in each block, totaling 10 million iterations in the model. The results are shown in Table 2 and Table 3.

Table 2
Time used for supervisor, constructive and Simulated Annealing.

Scenario	Time used (min)		
	Supervisor	Constructive	SA
1	8	1	1
2	13	6	5
3	26	30	21
4	*	33	52
5	*	39	97
6	*	44	159

Table 3
Objective function value for supervisor, constructive and Simulated Annealing.

Scenario	Objective function value		
	Supervisor	Constructive	SA
1	8,06 E+07	8,06 E+07	8,08 E+07
2	4,86 E+07	5,84 E+07	9,23 E+07
3	5,31 E+07	8,11 E+07	9,81 E+07
4	*	1,54 E+08	1,54 E+08
5	*	1,80 E+08	1,92 E+08
6	*	2,00 E+08	2,12 E+08

In scenario 1, the final value of the objective function has no significant gain. For scenarios 2 and 3 there are a significant gain when compared with the manual assignment, as can be seen in Table 4.

Table 4
Comparative of results in scenarios 1, 2 and 3 with supervisor results.

Scenario	Constructive heuristic	Simulated Annealing
1	0 %	0,15 %
2	20 %	90%
3	53 %	85 %

For scenario 3, the laboratory supervisor solved the problem in 26 min. Despite having initially been established 40 minutes as maximum, after about 20 minutes the supervisor was visibly tired of this activity and appeared to begin designing tasks with less discretion than at the beginning.

The constructive heuristics obtained an improvement of 53% compared to the result of the laboratory supervisor. The SA also scored 85% more than the supervisor and 21% better than the constructive heuristic. On the other hand, it took 21 minutes for the solution of the problem.

For scenario 4 the supervisor gave up the task after 28 minutes. As the scenarios 5 and 6 have more variables, it was decided that these tasks would also not be done. With this, the results were compared between constructive heuristic and the SA. In this scenario, the SA obtained approximately the same result as the constructive heuristic with a resolution time of 52.2 min. For the scenario 5, the results were better when compared to the previous scenario. The SA got a result 6.67% better than the constructive heuristic. One problem in this scenario was the resolution time that was 97.1 min.

For the scenario 6, the results were very similar to the scenario 5. The SA got a result 6.00% better than the constructive heuristic. The time was a problem since the algorithm took 158.8 minutes to show the results. In table 6 there are the results obtained by the SA compared with the results obtained by the constructive heuristic for scenarios 4, 5 and 6.

Table 5
Comparative of results in scenarios 4, 5 and 6 with constructive results.

Scenario	Simulated Annealing
4	0,0 %
5	6,67 %
6	6,00 %

5 Conclusion and future research

It can be concluded that for a scenario composed of few variables, the use of heuristics and meta-heuristics have not brought a major improvement in the results. For the current situation of the company it can be concluded that the use of constructive heuristic already brings significant gains for the allocation of staff. The results obtained using the SA were even better. Although taking about 5 minutes, it got a result 90% better than the supervisor and 58% better than the constructive heuristic.

The complexity of the scenarios 3, 4, 5 and 6 made the manual assignment impossible. This shows that with the growth of the company, the current company's process cannot fulfil this task successfully, requiring the computational aid.

Despite the high SA time, the task of assigning cannot be performed manually. In addition, the computer performs the task and liberates the supervisor to perform other tasks while waiting for the results. Note that the SA is a great option for the current company and its future.

The proposed model can be easily adapted to other types of analytical laboratories as the routine work is very similar. Future research may also apply other meta-heuristics that were not used in this paper. A new method for the exchange of the neighboring solutions could be created and compared with the current process. In addition, other tests with different parameters could be done like changing the number of iterations, taking into account the dimension of the solution. A stopping criteria could be used to stop the SA if the solution does not improve during a certain number of iterations.

6 References

Akjiratikarl C, Yenradee P, Drake PR (2007) PSO-based algorithm for home care worker scheduling in the UK. Computers & Industrial Engineering 53:559-583

Bard JF, Wan L (2006) The task assignment problem for unrestricted movement between workstation groups. Journal of Scheduling 9:315-341

Broder S (1964) Final Examination Scheduling. Communications of the ACM 7:494-498

Even S, Itai A, Shamir A (1976) On the complexity of timetable and multicommodity flow problems. SIAM Journal on Computing 5:691-703

Inman RR, Jordan WC, Blumenfeld DE (2004) Chained cross-training of assembly line workers. International Journal of Production Research 42:1899-1910

Kirkpatrick S, Gelatt CD, Vecchi MP (1983) Optimization by Simulated Annealing. Science 4598: 671-680

Metropolis N, et al (1953) Equation of State Calculations by Fast Computing Machines. The Journal of Chemical Physics 21:1087-1092

Norman BA, Tharmmaphornphilas W, Needy KL, Bidanda B, Warner RC (2002) Working assignment in cellular manufacturing considering technical and human skills. International Journal of Production Research 40:1479-1492

Pinker EJ, Shumsky RA (2000) The efficiency-quality trade-off of cross-trained workers. Manufacturing and Service Operations Management 2:32-48

Souza MJ, Martins AX, Araújo CR (2002) Experiências com Simulated Annealing e Busca Tabu na Resolução do Problema de Alocação de Salas. Simpósio Brasileiro de Pesquisa Operacional 34

Souza VN, Moretti AC, Podestá VA (2008) Programação da Grade de Horário em Escolas de Ensino Fundamental e Médio. Pesquisa Operacional 28:399-421

Zhang, D. et al. (2010) A Simulated Annealing With a New Neighborhood Structure Based Algorithm for High School Timetabling Problems. European Journal of Operational Research 203:550-558

Zolfaghari S, El-bouri A, Namiranian B (2007) Heuristics for Large Scale Labour Scheduling Problems in Retail Sector. INFOR 45:111-122

A procedure based on branch-and-bound for the Cyclic Hoist Scheduling Problem with n types of product

Mateo M[1], Manier M-A[2], Companys R[3]

Abstract: When various kinds of products must receive the same treatments in a production line of tanks and the size of batches is high, a cyclic manufacturing composed of a job from each batch can be scheduled. A hoist ensures the automated transfer of the jobs between tanks. The problem consists in the scheduling of repetitive hoist movements, which is known as CHSP (Cyclic Hoist Scheduling Problem). The objective is to find a sequence which minimizes the cycle time for jobs from different products. We consider the problem where *n* types of products must be treated and we search an n-cyclic schedule. The algorithm is based on the resolution of different sequences of products. For each one, a branch-and-bound is solved which considers only coherent subsequences. It enables to reduce the computational times most of the time for instances with 5 tanks and 4 product types.

Keywords: Scheduling, branch-and-bound, n-cycle, Hoist Scheduling Problem.

1 Introduction

In some manufacturing systems, transportation resources are the most critical ones and cannot be neglected in the related models. In surface treatment facilities, chemical processes are performed into tanks. A variety of jobs may be processed, and material handling can be ensured by hoists. This work can be included in the frame of the well-known Cyclic Hoist Scheduling Problem (CHSP).

A set of jobs in a limited number of products (j=1,…,n) is to be produced and receive one treatment in each one of a set of tanks (i=1,…,m). Each job j has its own processing time windows, a minimum value $a_{i,j}$ and a maximum value $b_{i,j}$, associated to operation i (in tank i). Jobs are moved along the production line by a hoist, which picks up a job from a tank at any feasible time and transfers it to the next one. This is done from a loading station (tank 0) to an unloading station (tank $m+1$), going through the m tanks. When the hoist arrives at the loading station, it can immediately load a job ($a_{0,j}=0$; $b_{0,j}=\infty$). At the unloading station, similarly the hoist only leaves a job and moves away ($a_{m+1,j}=0$; $b_{m+1,j}=\infty$). A hoist spends idle time above a tank if it arrives earlier than the scheduled instant for getting the job. It cannot pause while moving a job.

We consider the CHSP for lines with one hoist and tanks with capacity for only one job. The loading and unloading stations are considered dissociated; otherwise the model could be easily adapted. In the 1-cycle, the most studied case, one job is introduced into and removed from each tank during each cycle. So, each operation and each hoist move is performed exactly once (n times for an n-cycle). If n jobs are introduced into and n jobs are removed from the line during a cycle, we search for an n-cyclic schedule, where n is the cycle degree. An n-product problem means that n different products are alternatively

1 **Manuel Mateo** (manel.mateo@upc.edu)
Management Department. ETSEIB Engineering School.
Universitat Politècnica de Catalunya. Av. Diagonal 647, 7th, 08028 Barcelona.

2 **Marie-Ange Manier** (marie-ange.manier@utbm.fr)
OPERA - Université de Technologie de Belfort-Montbéliard.
Rue Thierry Mieg, 90010 Belfort cedex.

3 **Ramon Companys** (e-mail: ramon.companys@upc.edu)
Management Department. EPSEB-UPC.
Av. Doctor Marañón, 44-50, 3rd, 08028 Barcelona.

produced on the line. The purpose of our study is to offer a model for *n* kinds of products, particularly tested for n=4.

Section 2 describes the state of the art for the CHSP. Section 3 presents the n-product n-cyclic problem. Section 4 develops the procedure to solve the problem and Section 5 shows the computational results. Finally, the conclusions of the research are discussed in Section 6.

2 State of the art

The first model for the CHSP was developed by Phillips & Unger (1976). Manier & Bloch (2003) grouped the different works on HSP and classified them. According to their notation, the case dealt can be classified as: CHSP|m//diss|/n,m+2|C. It means there is a single hoist; *m* tanks; *diss* as the loading and unloading stations are dissociated; *n* kinds of products; *m+2* is the number of operations of the longest processing sequence; and *C* is the cycle time to be minimized. Generally, CHSP is NP-complete (Lei and Wang, 1989), even for the simplest variant.

The cyclic sequence is introduced to produce identical jobs (all the jobs of the same product), as Shapiro & Nuttle (1988) described. The hoist infinitely repeats cyclic movements to treat the input of jobs. The objective is to minimize the cycle time, i.e. the time consumed by the hoist to carry out a complete sequence of movements. Chen et al (1998), among others, have used graphs to solve it.

The simultaneous production of multiple products has been treated by means of several kinds of procedures. For non-cyclic scheduling, Lei and Liu (2001) presented a formal analysis of the HSP with two different products and developed a branch-and-bound procedure to find the optimal schedules. El Amraoui et al (2008) studied the 2-product 2-cyclic HSP and proposed a mixed integer linear program (MILP), which was extended in El Amraoui et al (2012). Three methods (exact and approach ones) are proposed to solve the n-cyclic (n≥2) HSP for heterogeneous jobs: in El Amraoui et al (2013a), the initial MILP is extended to n-cyclic problems. All the exact models are solved using commercial software CPLEX. El Amraoui et al (2011) proposed a heuristic, in which the cycle degree is a variable. And in El Amraoui et al (2013b), a genetic algorithm is used for the n-cyclic problem if n≤10. Nevertheless, those two approached methods cannot ensure to find the optimal solution.

This work develops an exact algorithm to solve the n-product n-cyclic problem, taking advantage of coherent constraints to evaluate only feasible sequences and reduce the node generation in a branch-and-bound.

3 The n-product n-cyclic problem and model

Considering *n* different products, the problem can be solved converting easily the usual *m* operations of a product (1-cyclic model) into *n·m* operations (n-cycle), as the tank virtual capacity is multiplied by *n*. First the concept of stage is defined. A stage in the model is each one of the treatments received by any product in any tank of the line (Mateo and Companys, 2006). Only one of the stages associated to a given tank can be carried out simultaneously. In an n-product n-cyclic schedule, each stage is performed exactly once during a period. In the model, the sequence for product 1 is formed by stages 0, n, 2·n…; for product 2 formed by stages 1, n+1, 2·n+1… and so on, up to product *n* (stages n-1, 2·n-1,…). Equation (1.1) expresses the index k of any stage according to the corresponding couples of indices (i, j) (tank i and product j):

$$k = i\cdot n + (j-1) \quad k=0,\ldots,n\cdot(m+1)+(n-1) \quad \text{for } i=0,..,m+1;\ j=1,...,n \qquad (1.1)$$

For instance, for n=2, the third operation of product 1 corresponds to stage k=6. Then using this expression, the model of the problem, in particular the constraints of time windows and hoist movements, can be expressed according to the defined stages k rather than to product j *and tank* i*, whatever a number* n *of products (see (1.2) to 1.7)). For this goal, we introduce the following notations:*

k index for stages ($k=0,...,n\cdot(m+1)+(n-1)$)

a_k, b_k minimal and maximum values for the time window at stage k ($0\leq k\leq n\cdot(m+1)+(n-1)$); $a_k=0$ and $b_k=0$ ($k\geq n\cdot(m+1)$)

f_k transportation time between stages k and $k+n$ ($k=0,.., n\cdot(m+1)-1$)

$e_{k,k'}$ empty hoist time from stage k to stage k' ($k,k'=0,..., n\cdot(m+1)+(n-1)$)

c_k 1, if a job arrives and leaves the stage k in different cycles ($0\leq k\leq n\cdot(m+1)+(n-1)$); 0, otherwise.

Let **H**=($h_{[0]}, h_{[1]}, ..., h_{[n.(m+1)-1]}$) be a circular permutation of the full-hoist movements, which indicates the origin stage. Vector **T**=($t_{[0]}, ..., t_{[n.(m+1)-1]}$) contains the starting times associated to vector **H**. Without loss of generality, $h_{[0]}=h_0$ and $t_{[0]}=0$ and $t_{[0]}<t_{[1]}<...< t_{[n.(m+1)-1]}$. A cyclic sequence (**H**, **T**) will be feasible if and only if there is a job in the tank to be taken, the destination tank for the job is empty and the processing times fall within the limits of the time windows. C is the time to complete the $n\cdot(m+1)$ movements. A set of $n\cdot(m+1)-1$ variables come from the vector T, because t_0 is supposed to be fixed, and an additional variable is the cycle time C. Therefore, the variables are:

h_k transportation move of a job from stage k (k=0,.., $n\cdot(m+1)-1$)
t_k ending time of stage k or starting time of movement of a job to next stage ($0\leq k\leq n\cdot(m+1)+(n-1)$)
C cycle time to be minimized

And the model is:

$$[\text{MIN}]\ C \qquad (1.2)$$

subject to

$$t_k - t_{k-n} \geq a_k + f_{k-n} - c_k \cdot C \qquad k=n, ..., n\cdot m+(n-1) \qquad (1.3)$$
$$t_{k-n} - t_k \geq -b_k - f_{k-n} + c_k \cdot C \qquad k=n, ..., n\cdot m+(n-1) \qquad (1.4)$$
$$t_{[k+1]} - t_{[k]} \geq f_{[k]} + e_{[k]+n,[k+1]} \qquad k=0,1, ..., n\cdot m+(n-2) \qquad (1.5)$$
$$t_0 - t_{[n\cdot m+(n-1)]} \geq f_{[n\cdot m+(n-1)]} + e_{[n\cdot m+(n-1)]+n,0} - C \qquad (1.6)$$
$$C \geq 0;\ t_k \geq 0 \qquad k=0, ..., n\cdot(m+1)-1 \qquad (1.7)$$

The length of the cycle C is to be minimized in (1.2). Constraints (1.3) and (1.4) ensure that the minimal and maximal processing times are respected at each stage k. Constraints (1.5) and (1.6) impose that the hoist movement time. Constraint (1.7) indicates that variables are non-negative. We use a graph approach of Chen et al (1998) to represent the values of the variables from vector T in vertices and arcs for the constraints. For each constraint (1.3 to 1.6), an arc is defined between two of the $(m+1)\cdot n$ vertices, the initial stage and final stage, with has a positive or negative value and sometimes adding or subtracting the variable C.

4 The procedure to solve the n-product n-cyclic problem

4.1 Branch-and-bound procedure given a sequence of products

For the cyclic problem, a branch and bound procedure inspired by Shapiro & Nuttle (1988) is developed. The solutions in the research tree are constructed by adding a new tank i at each level and the associated stages in vector **H**.

Nodes. The number of levels in the tree is equal to the number of tanks m. The sequence in the root node is automatically determined. A node v at a level r ($2\leq r\leq m$) is characterized by a permutation of movements assigned to the first $n\cdot(r+1)$ stages. $\mathbf{H}_{r,[v]}$ =($h_{[0]},...,h_{[n\cdot(r+1)-1]}$) corresponds to a permutation such that $h_{[0]}=h_0$ and any $h_w \in \mathbf{H}_{r,[v]}$ must respect the constraints on coherent subsequences. If we consider two consecutive tanks (i and $i+1$) and the hoist movements associated to the stages (from k to $k+m\cdot n-1$), the order of movements is prefixed due to the general hypothesis of the model. Given a tank i in which stages k and $k+1$ are performed, and the new tank $i+1$ associated with stages $k+n$ and $k+n+1$, they follow the circular permutation (k, k+n, k+1, k+n+1). The relation of hoist movements between these four stages, and the constraint satisfaction on the associated variables, depend on the occupation of tank i by jobs at the beginning of the cycle (Mateo and Amorós, 2002). This can be applied on two consecutive products. This is a condition that ensures the feasibility of the sequence (Lei and Liu, 2001).

For the sub-problem at each node, a graph is developed and solved with a shortest path algorithm. If the node is a leaf and C($\boldsymbol{H}_{r,[v]}$) is lower than the cycle time of the best known solution, $\boldsymbol{H}_{r,[v]}$ and its cycle time will be the new best one.

Branching. If v is a non-leaf node of level r-1, the vectors in descendant vertices at level r are obtained by adding n new stages, which correspond to the next tank r. For any value n, n groups of four stages are considered to satisfy the coherent conditions and the new potential descendant vertices are accepted or rejected.

Bounding. Let v be a node at level r (with r tanks) defined by $\boldsymbol{H}_{r,[v]}$. A lower bound for C, trying to use the idle time for the hoist, can be determined considering the moves included in vector $\boldsymbol{H}_{r,[v]}$ and, if necessary, an additional time for not assigned moves ($h_l \in \mathbf{U}$). Given $C(\boldsymbol{H}_{r,[v]})$, the cycle time for $\boldsymbol{H}_{r,[v]}$; $\mathbf{U}$, the set of unassigned loaded moves in $\boldsymbol{H}_{r,[v]}$ and w_k, the waiting time for hoist above the stage k, besides more lower bounds obtained from the graph (Chen et al, 1998):

$$LB(\mathbf{H}_{r,[v]}) = C(\mathbf{H}_{r,[v]}) + \max\left\{\left[\sum_{h_l \in U}(f_l + e_{l,l+1}) - \sum_{h_k \in \mathbf{H}}(w_k)\right], 0\right\} \tag{1.9}$$

4.2 General algorithm

If a 1-product n-cyclic sequence is going to be determined, one option is the addition of n 1-cyclic sequences. Also, if a sequence is searched for an n-product n-cyclic sequence, the initial solution may be obtained solving the 1-product 1-cycle, for a fictitious product with the most restricted time windows at each tank.

For n>2, the first decision is the evaluation of each possible sequence of products $\mathbf{J}_{sp}$ entering the line. Let sp an index for the *(n-1)!* different sequences in a cycle. For example, 4 products (A,B,C,D) must be produced simultaneously through the line. The first level consists in determining each possible sequence $\mathbf{J}_{sp}$ (ABCD, ABDC, ACBD, ACDB, ADBC, ADCB) and for each of the six sequences, the corresponding branch-and-bound procedure is developed. Moreover, the optimum cycle time for the second sequence could be computed with an upper bound, the optimal cycle time for the first one, and so on for the other sequences.

Algorithm

Step 1. Obtain data (n; time windows: a_k, b_k; hoist times: f_k, $e_{k,k'}$)
Step 2. 2.1. Define a single virtual product *vp* with time windows:
$[a_i,b_i] = [\max_j \{a_{i,j}\}, \min_j \{b_{i,j}\}]$:
2.2. Solve a branch-and-bound for the this single virtual product
→ Optimal sequence H^*_0 and optimal cycle time C^*_0
Step 3. 3.1. sp=1; J_1=(1, 2,..., n)
3.2. Given $UB_1=C^*_0$, solve a branch-and-bound for the sequence of products J_1
→ Optimal sequence H^*_1 and optimal cycle time C^*_1
3.3. $H^* = H^*_1$; $C^*=C^*_1$
Step 4. While not all the product permutations are evaluated
4.1. sp=sp+1; J_{sp}=(1, [2],...,[n])
4.2. Given $UB_{sp}= C^*$, solve a branch-and-bound for another sequence J_{sp}
→ Optimal sequence H^*_{sp} and optimal cycle time C^*_{sp}
4.3. If $C^*_{sp} < C^*$
$H^* = H^*_{sp}$; $C^*=C^*_{sp}$

5 Computational results

The computational experiments are based on a set of 30 instances corresponding to 4 products and 5 tanks (Mateo and Companys, 2012) and various ranges in the width of time windows and the hoist speed, or the relation between loaded and empty hoist moves. We focused here both on the cycle time and the computing time. The algorithm is written in Visual C++ and run in a Pentium Core2 Quad 2.40 Ghz, 2 Gb RAM. The results on the instances are given in Table 1. Each line provides: the reference number for the instance, the computational time (in seconds) and the optimal value found in El-Amraoui et al (2013a), called as EA13, and then the computational time and optimal cycle time we obtained.

For an instance (209080305), we reach a different solution (ours is 718) as there is a mistake in El-Amraoui et al (2013a); indeed for their announced results, the time windows are violated. We discovered they really solved a mix of two instances (time windows were from instance 207080605). We obtain the optimum (679) of that "mixed" instance in 32 seconds. For the remaining instances, we almost always reduce the computing time and always obtain the optimum. For the four instances with computational time equal to 24 hours, we can guarantee that the best results obtained are optimal ones, in a mean time of 8.4 seconds. Moreover, the mean reduction in time is 291 seconds (nearly 5 minutes).

Table 1
Results (for n=4 and m=5) obtained with our algorithm compared with El-Amraoui et al (2013).

Instance	Time(s) EA13	Opt EA13	Time(s)	Opt	Instance	Time(s) EA13	Opt EA13	Time(s)	Opt
104040705	690	736	105	736	201080405	29	988	1	988
105040905	785	622	9	622	207080605	279	768	32	768
109040505	235	978	2	978	209080305	371	678	283	718
102040605	59	637	4	637	205080205	341	826	181	826
103040805	178	810	7	810	204080905	624	646	35	646
107070405	440	708	618	708	308060205	821	784	77	784
109070605	271	904	9	904	301060405	86400	1188	7	1188
102070205	98	642	60	642	304060405	86400	1152	2	1152
102070705	140	645	15	645	303060905	990	646	22	646
101070405	154	718	55	718	309060805	86400	1092	4	1092
205050605	171	842	58	842	309090705	86400	1024	79	1024
203050905	29	520	4	520	308090205	977	772	183	772
208050705	55	700	2	700	303090905	192	650	54	650
209050705	100	721	47	721	302090205	309	756	160	756
204050805	91	638	15	638	304090405	86400	1116	2	1116

6 Conclusions

The proposed model relies on the stage definition, the operation performed in any given tank according to the part type. Consequently, multiple stages are assigned to each tank. This model opens new paths to study more complex cyclic sequences, with multi-part types, reduced to procedures considered for single part jobs. The conditions for coherent subsequences limit in a smart way the node generation in the described branch-and-bound. Finally, the study on the n-product n-cycle, with n=4, shows the advantage of the use of bounds. As future research lines, the algorithm should be extended to n>4 and m>5 and evaluate if it can be used to confirm and obtain optimal values for greater size instances.

7 References

Chen H, Chu C, Proth JM (1998) Cyclic Scheduling of a Hoist with Time Window Constraints. IEEE Transactions on Robotics and Automation. 14: 144-152

El Amraoui A, Manier MA, El Moudni A, Benrejeb M (2008) A mixed linear program for a multi-part cyclic hoist scheduling problem. International Journal of Sciences and Techniques of Automatic control and computer engineering, 2: 612-623

El Amraoui A, Manier MA, El Moudni A, Benrejeb M (2011) Heuristics for the resolution of the cyclic hoist scheduling problem with multi-items. 18th IFAC World Congress, Milano: 8195-8200

El Amraoui A, Manier MA, El Moudni A, Benrejeb M (2012) Resolution of the Two-Part Cyclic Hoist Scheduling Problem with bounded Processing Times in Complex Lines' Configuration, European Journal of Industrial Engineering, 6: 454-473

El Amraoui A, Manier MA, El Moudni A, Benrejeb M (2013a) A linear optimization approach to the heterogeneous r-cyclic hoist scheduling problem. Computers & Industrial Engineering, 65: 360-369

El Amraoui A, Manier MA, El Moudni A, Benrejeb M (2013b) A genetic algorithm approach for a single hoist scheduling problem with time window constraints. Engineering Applications of Artificial Intelligence, 26: 1761-1771

Lei L, Liu Q (2001) Optimal cyclic scheduling of a robotic processing line with two-product and time-window constraints, INFOR, 39: 185-199

Lei L, Wang TJ (1989) A proof: the cyclic hoist scheduling problem is NP-complete. Working paper #89-0016, Rutgers University.

Manier MA, Bloch C (2003) A classification for Hoist Scheduling Problems. International Journal of Flexible Manufacturing Systems. 15: 37-55

Mateo M, Amorós A (2002) Estudio del caso 2-cíclico para el Hoist Scheduling Problem. Document Intern de Treball 2002/14. Dep. Organització d'Empreses. UPC, Barcelona, Spain

Mateo M, Companys R (2006) Hoist scheduling in a chemical line to produce batches with identical sizes of different products. 6ème Conférence Francophone MOSIM, Rabat: 677-684

Mateo M, Companys R (2012) n-Cyclic Hoist Scheduling Problem to manufacture more than 2 products. Research Report. http://hdl.handle.net/2117/16384

Phillips LW, Unger PS (1976) Mathematical Programming Solution of a Hoist Scheduling Program. AIIE Transactions. 8: 219-225

Shapiro GW, Nuttle HW (1988) Hoist Scheduling For A PCB Electroplating Facility. IEE Transactions. 20: 157-167

Analysis of Relevant Factors in Competitive Intelligence System Implementation

Junior R R S[1], Neuman Garechana G[2], Fernández S[3], Azkarate A[4], Río-Belver R[5]

Abstract: This study analyses the effect of a set of factors in the implementation of competitive intelligence (CI) systems in order to determine if they act as drivers or barriers. A survey was passed to key people in six implementations that took place in significantly different firms and a consensus was found about the positive influence of most of the factors, the lowest ratings falling in indifference rather than being clearly perceived as negative. In spite of this, data show that CI tools have a remarkably strong positive effect, specially regarding the power of the CI tool used, and that people, and particularly the prejudices coming from previous experiences in CI implementation, can have an influence that goes from neutral to negative in CI projects.

Keywords: Competitive Intelligence; Implementation; Project; Driver; Barrier.

1 Introduction

A widely accepted definition of competitive intelligence (CI) can be the following:

> "Systematic and ethical process for gathering, analysing, and managing information that can impact an organization's operations and plans. Competitive intelligence is a necessary, ethical business discipline for decision-making based on understanding the competitive environment" (McGonagle 2007)

This study analyses the effect of a set of factors in the implementation of CI systems in order to determine if they act as drivers or barriers.

Previous works have been conducted addressing this same area, some focused in firms corresponding to a particular sector such as information technology or metal sector (Akhavan & Salehi 2013; Pérez-González & Placer-Maruri 2011), but an overall consensus can be found about the relevance of the following dimensions in the implementation of CI (Goitia et al. 2008; Saayman et al. 2008; Self 2003; Watson & Wixom 2007):

- Information overload, caused by an excessive focus in information collection and dissemination stages of CI, to the detriment of the proper identification of user real information needs and a correct filtering of information.
- The lack of CI-trained workforce in the firm.
- The manager's distrust regarding CI, either due to the difficulties to measure the economic return of these activities or to previous failures.

1 **Roberto Rosa da Silveira Junior** (robertojr@cespe.unb.br)
Dpto de Ciência da Computação.
2 **Gaizka Garechana** (gaizka.garechana@ehu.es)
Dept. of Industrial Engineering. Escuela Universitaria de Estudios Empresariales de Bilbao.
University of the Basque Country (UPV/EHU). C/Elcano 21, 48008 Bilbao (Spain).
3 **Santi Fernández** (sfernandez@ideko.es)
IK4-IDEKO Technology Centre. Arriaga industrialdea 2, E-20870. 20870 Elgoibar (Spain).
4 **Ander Azkarate** (aazcarate@ideko.es)
IK4-IDEKO Technology Centre. Arriaga industrialdea 2, E-20870. 20870 Elgoibar (Spain).
5 **Rosa Río-Belver** (rosamaria.rio@ehu.es)
Dept. of Industrial Engineering. Escuela Universitaria de Ingeniería de Vitoria-Gasteiz.
University of the Basque Country (UPV/EHU). C/ Nieves Cano 12, 01006 Vitoria (Spain).

- Related to the previous point, the inconsistencies between company's strategic lines and the strategic planning of CI unit.

Other authors emphasize the relevance of collaboration in CI, given that a willing collaboration is the basis for the flow of knowledge, and a dense collaboration network can be vital to provide key information to decision makers in the very moment it is needed. It must also be noted that the undervaluing of CI systems by many managers is often due to a misconception in the design and building of CI systems: they are sometimes thought of as a bare information supply system instead of a knowledge management tool that captures, codifies, stores and delivers "activable knowledge" to the system's user.

2 CI Implementation cases and factors

IK4-IDEKO has developed a self-guided, simple and relatively quick system for implementing CI systems in firms, the COMPETE ® methodology. The thorough study of six implementations in which COMPETE ® was used led to the determination of the following 21 factors that correspond to three distinct factor groups:

1. Organization group.

F1. Goal setting: Goals defined for CI system are realistic and feasible, and each of them is linked to a performance indicator for evaluating the advances being made.
F2. Responsibilities definition: The responsibility corresponding to each participant in the implement-tation is defined and key people in the project have authority and leadership in the firm.
F3. Strategic planning of the company: CI activities are deemed to be important and are included in company's strategic planning.
F4. CI planning: CI activities are planned from both a strategical and tactical point of view and the planning is periodically checked.
F5. Player network design: Key people in project shows leadership skills and authority, and analysts have enough technological skills.
F6. Key Intelligence Topics (KIT) definition: KITs are defined accordingly with the resources available and the firm's real situation.
F7. Information organization: A clear and concise information structure is designed, and KITs are aligned with this structure.
F8. Project dimensioning: Resources needed for the project are well defined, and pilot projects are started in case there are not resources available for a full-scale project.
F9. People and resources available: There are enough resources allotted to the project, including time and technical resources.
F10. Results diffusion: CI system results are used in decision making in several levels across the company.
F11. External support: External consulting services are available all over the project's duration.

2. CI tools group.

F12. User friendliness of tools: CI tools are easy to use and can be easily customized by key people in the project
F13. CI tools power: Accessibility, connectivity, functionality and flexibility of the CI tool. Information is easily accessed and spread.
F14. Customization possibilities: The tool can be easily adapted to user needs.
F15. Easy access to information: Easy access to both the information already present in the company and to the new information being generated.

3. People group.

F16. IT skills: People working on CI has enough IT skills.
F17. CI awareness: People working in CI project understand what the CI system is for and believe on its potential for improving decision making.
F18. Corporate culture: The firm has an open culture, workers do often interact with each other and frequently do share information.
F19. Key people involvement: Key people in project are strongly involved in it.
F20. Previous experiences: Amount to which people in the organization has previous experiences that determine their attitude towards CI.

F21. Top management involvement: Top management is involved in CI implementation and lead by example.

The set of implementations analysed in this work is formed by firms of all types that in some cases show very different features. Table 1 contains a brief description of each case.

Table 1
Some relevant features of the firms where implementations took place.

	CASE A	CASE B	CASE C	CASE D	CASE E	CASE F
SECTOR	**INDUSTRIAL**	**INDUSTRIAL**	**IND / SERV**	**INDUSTRIAL**	**INDUSTRIAL**	**RESEARCH**
GEOGRAPHIC MARKET	**INTERNAT.**	**INTERNAT.**	**INTERNAT.**	**INTERNAT.**	**INTERNAT.**	**INTERNAT**
TECHNOLOGY LEVEL	**HIGH**	**MEDIUM**	**MEDIUM**	**VERY HIGH**	**HIGH**	**VERY HIGH**
FIRM TYPE	**SME**	**BUSINESS GROUP**	**BUSINESS GROUP**	**BUSINESS GROUP**	**BIG FIRM**	**SME**
IMPLEMENTATION TYPE	**PILOT**	**MULTILOCATED CI UNIT**	**EXTERNAL CI UNIT**	**EXTERNAL CI UNIT**	**CI UNIT**	**CI UNIT**

A survey was made containing the 21 factors explained before, and key people from each of the six implementations was asked for quantifying from 0 (totally negative) to 10 (absolutely positive) the influence each of these factors had on the development of the project. The total number of answers collected was 19, obtaining at least 3 answers from each project.

3 RESULTS AND DISCUSSION

A first descriptive analysis was conducted in order to study the perception about the factor groups, with the results shown in figure 1:

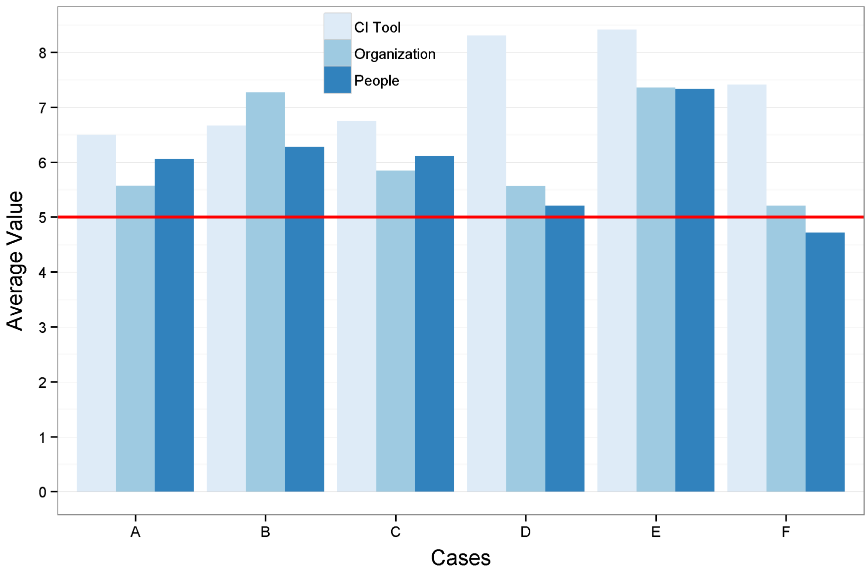

Fig.1
Bar plot corresponding to the average evaluation of each factor group, itemized by cases.

The mean values obtained by each factor group in each case, together with standard deviation data, are given in table 2:

Table 2
Mean and standard deviation of factor groups, itemized by case.

	CASE							
FACTOR GROUPS	A	B	C	D	E	F	**Factor group mean**	**Factor group standard deviation**
CI Tool	**6.50**	**6.67**	**6.75**	**8.31**	**8.42**	**7.42**	**7.34**	**2.10**
Organization	**5.58**	**7.27**	**5.85**	**5.57**	**7.36**	**5.21**	**6.14**	**1.58**
People	**6.06**	**6.28**	**6.11**	**5.21**	**7.33**	**4.72**	**5.95**	**1.85**
Case mean	**6.04**	**6.74**	**6.24**	**6.36**	**7.70**	**5.78**		

The first results show that every factor group was perceived to have a positive influence in the implementations, particularly those related with CI tool. Organization group is also found to be positive with some cases showing values near to indifference, but in any case, this factor shows a certain degree of agreement between respondents, as shown by the standard deviation data. People factor group grades the lowest, till the point of being perceived as a barrier in the implementation F, even though near the indifference.

Analysing cases, E case has the highest mean value, while F has the lowest, this being of interest because F is the only firm in the dataset which operates in the national market while E is the only big firm in the sample. It is also noticeable that the highest grade of CI tool is achieved in firms with high or very high technology level, regardless of firm size.

Figure 2 shows the standard deviation and mean of the responses corresponding to each of the factors.

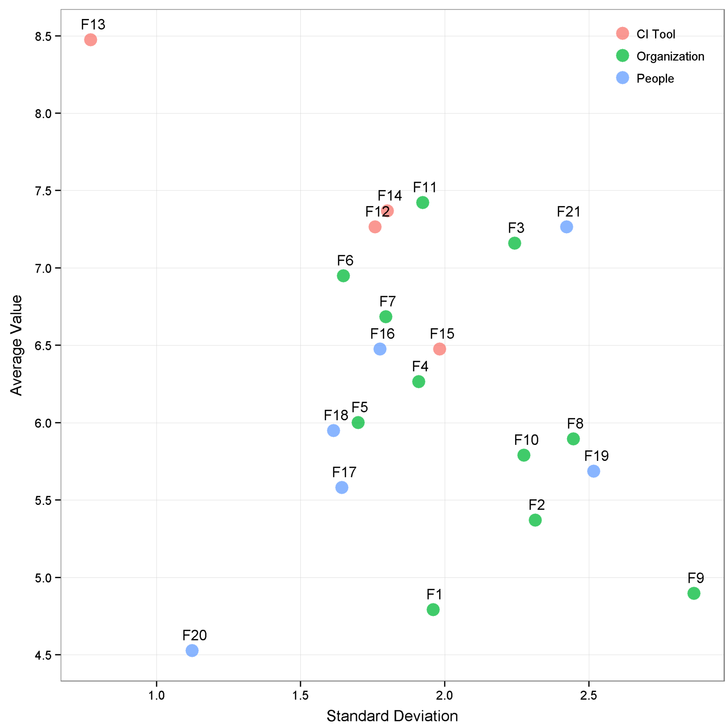

Fig.2
Mean value of each factor *vs* standard deviation.

Figure 2 shows that CI tools - related factors are on the top, with the remarkable position of F13 (CI tools power). A cloud formed by many factors stands between values of 5.5 and 7.5 in mean value and 1.5 - 2.5 in standard deviation, being difficult to extract further conclusions. Factor F9 (People and resources available) shows a high standard deviation, probably pointing at the very different situations each implementation had to face regarding resource allocation. This factor, together with factors F1 (goal setting) and F20 (previous experiences) are the only ones that are perceived as barriers for implementations, and there is a certain consensus in that. It must be noted, however, that mean values are near indifference.

In order to delve deeper into the data, correlation between factors has been calculated. Table 4 shows the factors correlated higher than 0.6. It must be noted that all significant correlations are positive, except that between F21 (top management involvement) and F15 (easy access to information), correlated at -0.62. The lion's share of positive correlations takes place among organizative factors and between organizative factors and two factors from people group (F21 and F19). These data point at a significant and positive relationship between managers' involvement and many organizational factors favorable to CI system implementations.

Table 3
Factor pairs showing significant (>0.6) correlation.

FACTORS		CORRELATION
F4	F3	0.66
F11	F3	0.64
F21	F3	0.61
F11	F4	0.63
F21	F4	0.73
F8	F5	0.64
F15	F7	0.67
F19	F8	0.72
F14	F9	0.63
F19	F10	0.66
F16	F14	0.64
F21	F15	-0.62

The negative correlation between F21 and F15 is difficult to explain, and any interpretation about it may be just idle speculation, particularly considering the small sample size of this study. Being conscious of this fact, the authors agree that managers often show a particular awareness of the importance of information availability for proper decision-making in all levels of the company. When an information-poor situation is perceived by managers, this could led them to adopt a positive mindset towards initiatives aimed at improving this situation, CI systems being a tool for achieving this purpose.

4 Conclusions

This study has conducted a descriptive study of the perception of 21 factors relevant for CI systems implementation, grouped in three factor groups corresponding to organizational features, the CI tools and people. Results show that most of the factors are perceived as positive for the implementation, but the following features are observable:

- Factors related with "CI Tool" group rate the highest, and factor F13 (CI tools power) is clearly valued as highly positive. In addition to this, the low standard deviation of answers points out the consensus of respondents regarding factor F13, this has relevant implications for future CI implementations.

- The factors related with "Organization" group have had a positive effect, with some of the factors being rather indifferent. The dispersion of data in factor F9 points out that resource allocation has been quite different from one case to another.
- "People" gets the lowest rating among the factor groups, but it cannot be asserted that this factor is a barrier for implementations, even though the only negative (4,72) average perception of the dataset corresponds to group "People" in implementation F. Factor F20, measuring the effect of previous experiences in CI projects, shows the lowest value among all factors, with fairly low standard deviation, remarking the importance of promoting the CI virtues in firms that did not obtain clear results in previous implementation attempts.
- An interesting hypothesis has been formulated regarding the negative correlation between managers involvement in CI implementations and the perception that there is not enough information available in the firm for proper decision making: The sensitivity of managers to the lack of information could lead them to involve more actively in CI implementations. This is a hypothesis filled with practical implications for CI project management, and can be object of future studies.

The conclusions extracted from this study can give valuable insight about the main factors conditioning the success of CI projects, and help managers to improve their strategy and increase the chance of success of the project. The main limitation of this work lies on its small sample (19), making it imprudent to extend these conclusions to firms other than those here studied. Further studies regarding the influence of these factors will be conducted in the light of more data.

5 References

Akhavan P, Salehi S (2013) Critical Factors of Business Intelligence: Case of an It-Based Company. World Applied Sciences Journal 1344–1351. Available via: http://www.idosi.org/wasj/wasj22(9)13/17.pdf. Cited 7 Jan 2015, doi: 10.5829/idosi.wasj.2013.22.09.364

Goitia S, Sáenz-de-Lacuesta S et al (2008) Implantación de sistemas de información empresarial. El profesional de la información 540 – 545, doi: 10.3145/epi.2008.sep.08

McGonagle J (2007) An examination of the ′Classic′ CI model. Journal of Competitive Intelligence and Management 71–86

Pérez-González D, Placer-Maruri E (2011) Vigilancia tecnológica en pymes industriales del metal: conocimiento, aplicación y medición de sus beneficios. El profesional de la información doi: 10.3145/epi.2011.sep.02

Saayman A, Pienaar J et al (2008) Competitive intelligence: construct exploration, validation and equivalence. Aslib Journal of Information Management 383–411, doi: 10.1108/00012530810888006

Self K (2003) Why do so many firms fail at Competitive Intelligence? In: Controversies in Competitive Intelligence: The Enduring Issues. ISBN: 156 7205607

Watson HJ, Wixom BH (2007) The Current State of Business Intelligence. Computer 96–99. Available via http://ieeexplore.ieee.org/articleDetails.jsp?arnumber=4302625. Cited 2 Dec 2014, doi: 10.1109/MC.2007.331

Utilization of Fuzzy constraints to build applications to support a Concurrent Engineering Environment in the process of Design and Manufacturing

Walker R[1], Fandino S[2], Paixão A[3], Bezerra M[4]

Abstract: In this article presents a proposed an application in the concept Design evaluation stage through manufacturing features. In a Concurrent Engineering environment, using logic it need to set the imprecision. The Fuzzy logic is one path for evaluate the data inconsistency to evaluate industrial pumps conceptual design. Helping in integrate Design, Process and Manufacturing stages.

Keywords: Design, Manufacturing, Fuzzy.

1 Introduction

Since the 80's Concurrent Engineering is a technique that has been used to reduce the time-to market for a new product. Concurrent Engineering differs from.classical approaches in that it moves the sequential flow of product develops to a parallel process development. This paper describes a computer application using fuzzy logic constraint to predict values of design in a Concurrent Engineering view.

2 Concurrent Engineering

There are two approaches for the Concurrent Engineering inside the enterprise (Naveiro and O'Gray, 1995), 'human': make cross functions times, benchmarking; and 'computer': Design for Manufacturing & Assembly Quality Function Deployment, Robust Design, integrated CAD, Simulation, Product Data Management, etc.

The human approach is based in collaborative groups to develop a project. This means in create cross functions teams using at least one person of each stage of the design, process planning, manufacturing, and others like logistic and sales. The cross function time has the responsibility to link the ideas of the product development through the capability of the factory to over lap the functions in the different stage of the new project. Some studies of this model give a limitation for the capability of develop the project with a complete integration. This means that the higher complexity of the product and the manufacturing the more time you spend to communication among the times. To simplify the model some subdivision

1 **Rubens Aguiar Walker** (rwalker@cetiqt.senai.br)
SENAI CETIQT - Industry Technology Center of Chemical and Textile.
Rio de Janeiro, RJ, CEP: 20961-020.BRASIL.

2 **Sérgio Baltar Fandiño** (sergiofandino@uezo.rj.gov.br)
Dept of Industrial Engineering. UEZO/State University of west.
Rio de Janeiro, RJ, CEP: 23070-200, BRASIL.

3 **Alexandre Camacho da Paixão** (apaixao@cetiqt.senai.br)
SENAI CETIQT - Industry Technology Center of Chemical and Textile.
Rio de Janeiro, RJ, CEP: 20961-020.BRASIL.

4 **Marlene Jesus Soares Bezerra** (marlenebezerra@uezo.rj.gov.br)
Dept of Industrial Engineering. UEZO/State University of west.
Rio de Janeiro, RJ, CEP: 23070-200, BRASIL.

can be made to a modular interfaces of the product and/or improve the information technology (Hoedemaker, 1999).

The computer approach is based on CAD systems that interact through the design stages. Many CAD's systems can be manager for the final result of the project as 3D CAD model, used to develop the preliminary stage of the design, and 2D CAD documentation, used to develop the detail stage of the design. The data usually are manager with a product data management (PDM). Usually a UNIX platform is used to 3D CAD model and widows platform to 2D CAD documentation. For a final manufacturing documentation usually make by a CAPP system for the manufacturing path of short-term and the-long term. The short-term is recognized by the reduce of the time-to-market and the higher quality of the product in the beginning of the implementation of CE. The higher quality of the product in the beginning of the implementation of the CE. The transition of the skills for other project take some time to adjust the method to the requirements of the organization. In this long term the product develop team may have some problem in identify lower priority items and lose a bunch of time in the process of make a decision (Componation, 1999).

The supply change can be considering a third approach. In this case the integration between the enterprises is critical for the knowledge of each enterprise limits. A supply change must be consider a partner and develop the new products together. The communication is very important to set the design development. In this case the transparence of the manufacturing and its limits is very important to make the decisions for develop a new product (Hoedemaker, 1999).

Toyota make a successful in CE in develop many small prototypes, a strong organizations of the activities without the necessity of a multifunctional team to make small decisions, and just do the final choice at the end. In this case they avoid in given up of some good solutions on the process of develop the new project (Sobek, 1999).

The CE brings many changes in the way of see the flow of the product development and a become a routine practice (Componation, 1999), but must of the time the enterprises do not need all the changes or can make its gradually.

Most of the bibliography speck about the integration of the product, but a critical factor is predict values to make a decision during the process of develop the design. This paper describe how we can use fuzzy constrains to predict manufacturing values on the earlier stage of the design.

3 Design and manufacturing environment

Not many products are new or innovative that actually belong to the manufacturing platform of the enterprise. Most of the information can be explained through knowledge and linkages between different design stages. The design is represented by six stages — the conceptual, the embodiment, preliminary, detail, process planning, and manufacturing. The conceptual stage is responsible for the ideas and functions of the product design. The embodiment stage represents the details of the geometric features and manufacturing. The detail design stage is the documentation of the project. The process planning stage is developing the product fabrication and assembly. The manufacturing stage is the final stage that aggregates the all information of the design to make a product.

The planning and design process is divided into the following phases: product planning and clarifying the task, conceptual design, embodiment design, and detail design. The working steps proposed for each of the main phases must be considered the main working steps. The results of these main working steps provide the basis for the subsequent working steps. Some results in many lower levels working steps are required such as collecting information, searching for solutions, calculating, drawing and evaluating. Each of these working steps is accompanied by indirect activities such as discussing, classifying and preparing.

Before a commercial product can be designed there has to be a product idea, that promised to lead to a technically and economically viable product. In many companies the product planning department is expect to follow the development of product idea through the design and manufacturing departments, and then to watch over this market behavior. This includes monitoring the financial position and market success of the product and, if is necessary, taking appropriate corrective measures. Companies deal with product planning in different ways, in many cases is a good sense of a director or an individual employee. However, systematic procedures are frequently used to find new ideas, there are much easier to measure the time and the cost of product planning and development. The basis and beginning point is marketing, that provides an interface between customer and product planning. The internal and external stimuli for product plan come from marketing, the company, and others sources. Those give us five main working steps: Analyzing the Situation, Formulating Search Strategies, Finding Products Ideas, Selecting Products Ideas, and Defining Products.

The Conceptual Design consist in identify the essential problem through abstraction, by establishment of function structures and by the search for appropriate working principles and their combination, the basic solution path is down through the elaboration of a solution principles.

The Embodiment Design must determinate the overall design (general arrangements and spatial compatibility), the preliminary from design (components shapes and materials) and the production process, and provide solutions for any auxiliary functions.

The Detail Design completes the embodiment of technical products with final instructions about the layout, forms, dimensions, and surface proprieties of all individual components, the definitive selection of material and a final scrutiny of the production methods, operating procedures and cost. In this phase is responsible to elaborate the production documents, especially of detailed components and assembly design and of appropriate parts list.

The Process Planning is a role in detailed procedures by which work pieces or parts are convert from the initial stage (raw material form) to finished stage (desire form). Product design data such as geometrical features, dimensional sizes, tolerances, material, and finishes are analyzed and evaluated to determine the appropriate workstation available within the manufacturing systems concerned. Those detail methods are then documented into process plane or processes sheets, which server as technical instructions on the shop floor, and assure the desired characteristics of the final product.

The Manufacturing is understood as a series of activities including customer need recognition, design, material selection, planning, material transformation process, quality assurance, and logistic management. Basic means the material transformation processes through machines, tolls, and any device to get the design model. Manufacturing is responsible to do or build the product, including fabrication of part number and assembly. Some critical conditions are dealt with tolerance a finishing for transformation the material through the available machines.

The environment of computer applications that aid concurrent engineering are CAD 3D CAD 2D, CAP P, CAM, expert systems, etc. In this case, we link the product features between different stages of development. So in each stage we can have more detail of the design and can represent its limits and anticipate some design values for the project development. At the same time, we do not need to detail all the features of the project for documentation. In this case the results of this information can be used to start the documentation of the design in a CAD system and the process planning in a CAPP system. (Pahl and Beitz, 1997).

4 AI and fuzzy logic

The Artificial Intelligence (AI) look like a computer ability to think (BENCH-CAPON, 1990). Inside of this point of view the AI represents tree of decision that you can validate restrictions through dates. The domain, constrain and restrictions represent a declarative environment to relate the knowledge (TAYLOR, 1988).

The fuzzy logic theory is a simplification of the classical logic theory approach. The classic approach consider only crisp values, for example 0 or 1, or true or false. The fuzzy theory is a set of values between 0 and 1 according with the truth-value that you set. One example of truth-value is if you set as 0.5 and your values are minimum 1, mode 3, and the maximum 7, the range of values that you can have are between [2,5]. Throughout the enterprise environment there is inherent imprecision and soft specifications represented by cost, quality and dimensionality. Soft specifications are more prevalent in the early stages of the design and within manufacturing in its use of tolerances, imprecision is more prevalent. We use fuzzy data to model the inconsistency and imprecision. This helps the designer to develop the idea of the design project without the necessity of precise specifications and values. Later, some information can be more precise in other design stages while other information must still deal with imprecision in the parameters in the fabrication and assembly environment. This is the imprecision of manufacturing tolerances and can be better described using a fuzzy numbers.

The description matches the distributed processing environment in a fuzzy constraint system. The applications are built in the FUZCON (Fuzzy Constraint Processing System), MS-Access database, and using Delphi to build the user interface. It is divided into four modules: conceptual design, embodiment design, processes planning, and manufacturing. All these modules exchange information among them selves and with different databases. All the data are used for manufacturing components of a hydraulic pump.

4 Problem

The enterprise is a subsidiary in Brazil, and consists in sales hydraulic pumps by order and standard. In spied of be by order the parts number are standard to the customer. The factory does not need to develop a conceptual design of a new product just make some alterations to attendance of specifications or material changes of marketing. This made constant consult to preliminary evaluation of the viability design cost.

It does not exist multifunctional times. Usually the employee change is because some one gets out of the enterprise. Chefs trust in the individual experience of each employee to develop embodiment and detail design. The knowledge pass is not formal trough the enterprise or the employee. This area is extremely pressed that make difficult to interchange design and manufacturing functions.

The enterprise has a good computer automation degree in the embodiment and detail design phases. These represented by 3D CAD to model and 2D CAD to documentation and a CAPP system to integrate to the manufacturing. It does not have any expert system to integrate and validate functions. The information stream is aided by a Work Group system that can used to pass Email and mandatory actions.

There are many numerical control (NC) machines associated to a machine center. There is also an effort to standardization the information part number in families that is represented by the Group Technology.

The only pointer of performance is the manufacturing quality measure. There is no point performance to the design or any decisions make.

The Research & Development sector is located in USA. The research is represented by under graduation final project developed by trainees.

4.1 What are the problems?

In the description of the industry engineer, you can find some problems, it is not so difficult to compare with the necessity in integrate function to get in the Concurrent Engineering environment, there are:
No multifunction times;
No integration between design phases and manufacturing process;
No integration between the systems CAD 3D, CAD 2D, CAPP, CN program;
No system to analyze cost with changes in the design or manufacturing phases;
No formal documentation of the knowledge;
No complete standardization of the information to use Group Technology.

4.2 What are the goals?

There are four goals that was discuss between professors and industrial professional:
Integration of information between embodiment design, detail design, process planning, and manufacturing phases trough a system;

A system that helps in costs analysis in changes of design, process planning and manufacturing;
Data standardizing;

The researched enterprise environment has presented some problems and difficulties in engineering. This can be identified as necessities of integration that are present in Concurrent Engineering. For example: a company does not have any multifunctional teams, any integration between the design and manufacturing stages, does not have any system to analyze cost and viability in changes design parameters, etc. To help address these problems we model an application which is explained later in this article.

5 System

The emphasis of this paper is describing a computer application developed to predict values. The example is made on the development of parts of a hydraulic pump. The development stages of the design are conceptual, embodiment, process planning, and manufacturing. In the conceptual stage the designer just have an idea new product, the quality, and the dimensions, some information about the cost Will be very helpful to make decisions in this early stage. In the embodiment stage of the design the designer define the geometric features, the material, and some specifications. The process planning stage document the manufacturing process and optimize the manufactory process cost. The manufacturing stage of the product is the machines and tools of job shop, represented through its features in a database.

It was made a computer application divide in four modules as: Conceptual Design, Embodiment Design, Process Planning, and Manufacturing.

6 Example

The designer is checking the possibility of made a pump house. To solve it the designer must give for this component a proportional dimension (ex. Big), quality (high),and the system generate a high cost solution for this specific case. In others cases that you have more then one solution you must set the value to see if is possible or not. The next stage is representing the dimensions and quality values for geometry and -manufacturing features in the embodiment design that is automatic restrict the domain by conceptual when choose, 'enormous', 'big', 'medium', 'small', or 'standard'. When the embodiment designer chooses the manufacturing features as: through hole, assembly guides hole, surface glides, etc., it propagates the relation and defines the process planning and the possible machines with its set of tools. The cost, the tolerance, and the finish, as the dimension restrict set of machines. The sum of process time plus cost/hour of each machine calculate the cost.

When the tolerance is higher the application can accept the solution if the respective truth-value is significant in the range of fuzzy numbers. In this case some solutions that are usually ignore, can be significant in the process optimize cost or give some alternatives for the manufacturing.

7 Results

The expected results of the computer application involve three goals. The first, demonstrate integration of information between conceptual design, embodiment design, detail design, process planning, and manufacturing stage through a prototype system. The second, a system that helps in cost analysis when changes are made in design, process planning and manufacturing. The third, use fuzzy constraints to model data inconsistency. The data at each design stage is used to determine the viability of the project and its cost.

8 Conclusion

This research expects to develop a computer application that helps in the making decision of a designer, process planner or manufacturing engineer. In each stage we validate the information and anticipate others such as cost or quality. The expected results and the industry summarize the interests of each author in building applications to aid the design and manufacturing using fuzzy constraint. In this approach the link and the anticipation of the data values helps the Concurrent Engineering environment to deal with different possibilities for the design and manufacturing.

9 References

Bench-Capon, T.J.M (1990) Knowledge Representation, an Approach to Artificial Intelligence. Ed Acadeic Press, London, 220p.

Componation PJ (1999) Using a modified readiness assessment for concurrent engineering. Engineering Management Journal, Rolla;; Vol. 11, ISS. l, pg. 21, 8 pgs.

Hoedemaker GM (1999) Limits to currency. Decision Sciences, Atlanta; Winter; vol. 30, ISS. 1; pg. 1, 18 pgs.

Naveiro RM, O'Gray P (1995) A Concurrent Engineering Approach for Design Assistance of Casting Parts, ICED 95, Praha, August 22-24.

Pahl, G and Beitz, W (1997) Engineering Desgn; London, Ed. Springer, 543 p.

Sobek DK (1999) Toyota's principles of set-based concurrent engineering; Sloan Management Review, Cambridge; Winter; Vol. 40, ISS. 2; pg. 67, 17 pgs.

Taylor W A (2010) What Every Engineer Shoul Know About Artificial Inteliigence, The MIT Press, Cambridge, USA, 330p.

Proposal for an aggregate planning model of production in a sugar and alcohol plant linked to the fluctuation of prices in cash markets and the future markets

Carvalho M[1], Pratti F

Abstract: The objective of this paper is to show a model of aggregate production planning to support decisions of management and board level of sugar and alcohol plants, maximizing its margin of contribution. We conducted a case study in a sugar mill and alcohol in southeastern Brazil to validate the proposed model. The results are consistent, making this model a very useful and rentable tool for sugar and alcohol mill management.

Keywords: Plants of sugar and alcohol, aggregated production planning, mixed integer linear programming, quadratic programming, Markowitz portfolio models.

1 Introduction

Brazil has become a reference in the field of sugarcane industry. According to Unica (Union of cane sugar industry, a business association of mills in Brazil), sugarcane production in Brazil is expected to reach 1 billion tons in 2020. Due to the international pressure, Brazil is constantly innovating and seeking to improve their technologies in this area to maintain his position of dominance in this sector. At the same time, entrepreneurs are increasingly seeking effective solutions to manage their business.

This paper is structured according to Bertrand and Fransoo in their article "Operations management research methodologies using quantitative modeling", thereby dividing as follows. In the session 2 we have the explanation of some key concepts concerning the sugarcane industry sector, structuring the problem. In the session 3 some ideas are explored from previous works. In the session 4 we have the presentation of the research method. In the session 5 it is shown the mathematical model used to get the results. In the session 6 the results are presented. In the session 7 we have the conclusion and perspectives for future studies.

1 **Marcelo Dias Carvalho** (marcelod@eseg.edu.br)
Dpto. de Estatística e Pesquisa Operacional,
Eseg, Escola Superior de Engenharia e Gestão, São Paulo, Brasil.

2 Operational dynamic of the sugar and alcohol sector in Brazil

According Brunstein (2005), the economic model of the sugarcane system can be structured as follow in the figure 1.

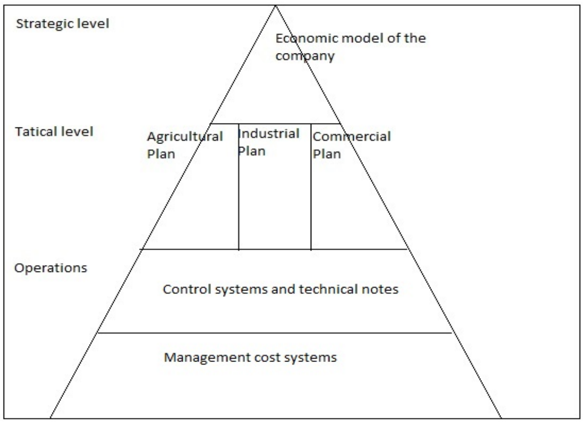

Fig.1
Levels of planning and integration in the production and sale of sugar and alcohol.

In the figure 2 it is possible to see a brief overview of the whole scenario concerning the tactical level.

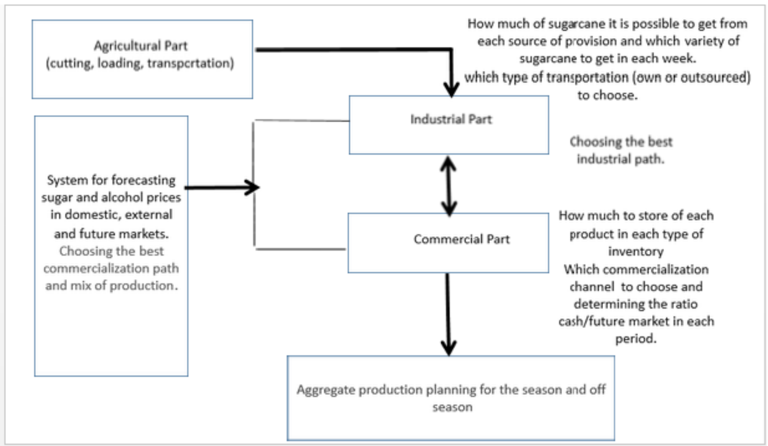

Fig.1
Main issues discussed in this paper.

Through the use of the proposed model objective is to give a solution to this problem of relationship between sectors, maximizing the profits of a sugarcane mill.

3 Previous works

The main concern of this paper is to show an aggregated planning model for sugarcane mills that could help them increasing their taxes of profitability. While others studies have investigated some parts of the tactical planning, this one has proposed a model integrating this whole section. Speranza et al. (2000) developed a work in which he determined the best mix for a stock lot, maximizing its profitability and minimizing the shifts under the mean. It was a great signal of application in the sugarcane sector. Burnquist et al. (2002) showed an analyze of the sugar and alcohol prices oscillations aiming to establish the best period to get the best profitability taxes to each product. The studies of Higgins (2004, 2006) showed good results in improving efficiencies at the harvesting and transport of cane. However, only by themselves they are very limited due to the current level of competition and changes in the sugarcane industry scenario. In a study conducted by Paiva (2009), there were an integration of the process involving the agricultural and industrial parts. However, they did not consider the commercial part in their work. Another study by Torres et al. (2007) shows the whole integration but in a very limited way. He fixed many costs of production and prices of sugar and alcohol not allowing the best results in terms of price forecast and overall profits maximization. Carvalho (2009) discusses the integration between agricultural, industrial and commercial parts. Take into account the variations sugar, ethanol prices, and tradability of products in domestic and foreign market and uses the Markowitz models (Markowitz et al, 1959, 1992) to minimize the risks in choosing production mix of the products of the sugar cane plants.

4 Research method

The techniques used in this work: literature review, experimental research and interviews made with the managers of mills in order to validate the model. It is thus based on a case study.

5 The Proposed Model

This model gives us the profits maximization. The model formulation is divided into commercial and industrial stage. The commercial stage feeds industrial with production mix information linked to sugar price fluctuations and alcohol and agricultural stage supplies data with sugarcane varieties.

5.1 Semi- variance model of Markowitz analysis scenarios - The commercial hedge stage

Hedging is defined as a financial transaction to protect certain assets of a business against unexpected changes in prices. In this work, it is used a model of choice of product mix for Hedge linked to profitability and minimizing risk. This is a quadratic programming in the objective function and the model idea is to maximize the return on investment of each product in hedge funds: sugar, anhydrous alcohol and hydrated alcohol, as follows.

Sets and indices

PRB_s : probability associated with scenario s; T: profitability target desired by plant managers; p : index for

products that will make up the hedge, namely VHP sugar, AEAC alcohol and AEHC alcohol; $VE_{p,s}$: expected value of product p to compose the mix under scenario s; X_p : percentage of product p to make up the hedge; PM_p : minimum holding (%) of product p in hedge; DVU_s : deviation of returns above average

under scenario s; DVL_s : deviation of returns bellow average under scenario s; R_s : probability associated with all products p under scenario s; μ: average of all returns associated with the respective probabilities of the scenarios.

Objetive Function

$$\text{Min} \quad Z = \sum_{s=1}^{5} PRB_s (DVL_s)^2 \qquad (1)$$

Constraints

$$R_s = \sum_{p=1}^{3} X_p . VE_{p,s} \quad , \quad s = 1,...,5 \qquad (2)$$

$$DVU_s - DVL_s = R_s - \mu \quad , \quad s = 1,...,5 \qquad (3)$$

$$\sum_{p=1}^{3} X_p = 1 \tag{4}$$

$$X_p \geq PM_p \quad , \quad p = 1,2,3 \tag{5}$$

$$\mu = \sum_{s=1}^{5} PRB_s . R_s \tag{6}$$

$$\mu > T \tag{7}$$

$$X_p \geq 0 \quad , \quad p = 1,...,3 \tag{8}$$

Model explanation

The objective function in (1) minimizes the deviation of return below the target profitability. In (2) has the profitability associated with all s scenarios and p products. In constraint (3), it is observed that the deviation below the mean (DVLs) for each setting is made so that the subtrahend can be minimized in the objective function. In (4), the sum of the percentages of each product in the hedge valley 100%. In constraint (5) there is a lower limit preventing each product has its participation in the lower hedge PM (%) a minimum interest. In constraint (6), the mean μ is equal to the sum of the probabilities of each scenario with their returns. In (7), the average is imposed greater than or equal to T. target profitability Constraint (8) ensures no negative share of products in the hedge. Restriction necessary if the modeler want to delete the constraint (5).

5.2 The industrial stage

Sets and indices

v: varieties of cane (out of 15 possible varieties); *p:* commercialized products: sugar VHP, alcohol AEHC, alcohol AEAC and molasses; *t:* week; ss: source of supply; *oss:* outsourced source of supply; *tt:* type of transport; *ot:* own transport; *k:* industrial/commercial processes of sugar, alcohol and molasses; *e*: types of inventory.

Inputs of the industrial model

$ValuePISpot_{p,t}$:Value at the internal spot market of the product p in the week t; $ValuePESpot_{p,t}$: Value at the external spot market of the product p in the week t; $ValuePHedge_{p,t}$: Value at the future market of the product p in the week t; $MinMilling$: minimum milling; $MaxMilling$: maximum milling; WC_t : Working Capital necessary for week in order to deal with financial issues at the mill; $SC_{p,t,e}$: Inventory capacity of the product p in the week t at the inventory type e; PWT_t : Percentage of mill's working time during the weeks of analyze t; $DemHedge_{p,t}$: demand for the product p in each week t due to the hedge of product p; $DemSpot_{p,t}$: Spot internal demand for the product p in each week t; $AGY_{p,v,k,t}$: Agro industrial yields of each product p generated from the cane variety v, due to the process k and in the week t; IS_p : Initial Inventory quantity of the product p; $PlanSeason_{v,ss}$: Availability of each cane variety v according to the supply source ss in the week zero; $AgriculturalCosts\,\mathrm{var}_{v,ss,t}$: agricultural costs of the cane variety v; $CostIC\,\mathrm{Pr}oc_{k,t}$: Cost of each industrial/commercial process k in each week t; $IndComYield_{p,k,t}$: Industrial/commercial yield of each product p in each process k and in each week t; $TCO_{p,z,t}$: taxes of commercialization of the product p by the commercial process z in the week t; $InventoryC_{e,t}$: cost of the product inventory; α : Percentage of permissible cane coming from outsourced; $TranspCap$: Mill's transports capacity; $TranspCost_{tt,t}$: cost of transporting of each ton of cane in each week t;

$CommercialHedge_{p,k,t}$:Commercial revenues coming from all hedges sellings of the products p from each process k and in each week t; $CommercialRISpot_{k,t}$: Commercial revenues coming from all sellings at the Spot internal market and from each process k and in each week t; $CommercialRESpot_{k,t}$: Commercial revenues coming from all sellings at the Spot external market and from each process k and in each week t; PCQ_t : decision variable of the processed cane quantity according to the industrial process k in the week t; $VCQ_{v,ss,t}$: decision variable of cane quantity of the variety v in each week t; $TCQ_{tt,,t}$: decision variable of how much to transport of cane in each week t; $ProInv$: decision variable of how much to store of each product p in the end of week t; X_t : binary variable for choosing the industrial/ commercial process; $AvailCAne_{v,ss,t}$:availability of each cane variety at harvest in the beginning of each week t related to each source of supply ss (own or outsourced); $PCQHedge_{k,t}$: Quantity of processed cane by the industrial process k in order to satisfy the hedge's quantities the in each week t; $PCQSpotI_{k,t}$: Quantity of processed cane by the industrial process k in order to satisfy the Internal Spot market in each week t; $PCQSpotE_{k,t}$: Quantity of processed cane by the industrial process k in order to satisfy the external Spot market in each week t; CM_t : Contribution margin of the mill in each week t.

Objetive Function

$$\begin{aligned}
&\text{Max } Z = \sum_p \sum_k \sum_t \text{CommercialRHedge}_{p,k,t}.\text{PCQ}_{k,t} + \\
&\sum_p \sum_t \text{ValuePISpot}_{p,t}.\text{ISellings}_{p,t} + \sum_p \sum_t \text{ValuePESpot}_{p,t}.\text{ESellings}_{p,t} - \\
&\sum_{ff} \sum_t \text{AgriculturalCostsvar}_{ss,t}.\text{VCQ}_{ss,t} - \\
&\sum_{tt} \sum_t \text{TransportCost}_{tt,t}.\text{TCQ}_{tt,t} - \sum_k \sum_t \text{CostIProc}_{k,t}.\text{PCQ}_{k,t} \\
&- \sum_p \sum_e \sum_t \text{InventoryC}_{p,e,t}.\text{ProInv}_{p,e,t} - \\
&\sum_p \sum_t \text{Demhedge}_{p,t}.\text{ValuePHedge}_{p,t}.\text{TCOHedge}_{p,t} - \\
&\sum_p \sum_t \text{ISellings}_{p,t}.\text{ValuePISpot}_{p,t}.\text{TCOISpot}_{p,t} - \\
&\sum_p \sum_t \text{ESellings}_{p,t}.\text{ValuePESpot}_{p,t}.\text{TCOESpot}_{p,t}
\end{aligned} \qquad (1)$$

Constraints

$$X \in \{0,1\} \qquad (2)$$

$$Y \in \{0,1\} \qquad (3)$$

$$PCQ_{k,t} = PCQhedge_{k,t} + PCQSpotI_{k,t} + PCQSpotE_{k,t}$$
$$k = 1,...,384, \quad t = 1,...,36 \qquad (4)$$

$$\begin{aligned}&\sum_p\sum_k\sum_t CommercialRHedge_{p,k,t}.PCQ_{k,t} + \sum_p\sum_t ValuePISpot_{p,t}.ISellings_{p,t} + \\ &\sum_p\sum_t ValuePESpot_{p,t}.ESellings_{p,t} \geq \sum_{ff}\sum_t AgriculturalCostsvar_{ss,t}.VCQ_{ss,t} + \\ &\sum_{tt}\sum_t TransportCost_{tt,t}.TCQ_{tt,t} + \sum_k\sum_t CostIProc_{k,t}.PCQ_{k,t} \\ &+ \sum_p\sum_e\sum_t InventoryC_{p,e,t}.ProInv_{p,e,t} + \\ &\sum_p\sum_t Demhedge_{p,t}.ValuePHedge_{p,t}.TCOHedge_{p,t} + \\ &\sum_p\sum_t ISellings_{p,t}.ValuePISpot_{p,t}.TCOISpot_{p,t} + \\ &\sum_p\sum_t ESellings_{p,t}.ValuePESpot_{p,t}.TCOESpot_{p,t}\end{aligned} \tag{5}$$

$$\begin{aligned}&\sum_p\sum_e\sum_t ProInv_{p,e,t} = \sum_p\sum_e\sum_t ProInv_{p,e,t-1} + \\ &\sum_p\sum_k\sum_t IndComISpotYield_{p,k,t}.PCQISpot_{k,t} + \\ &+ \sum_p\sum_k\sum_t IndComESpotYield_{p,k,t}.PCQESpot_{k,t} \\ &- DemHedge_{p,t} - ISellings_{p,t} - ESellings_{p,t} \qquad t = 1,\ldots,36\end{aligned} \tag{6}$$

$$\begin{aligned}&\sum_t\sum_k (IndComISpotYield_{VHP,k,t} + \\ &IndComESpotYield_{VHP,k,t}).PCQHedgeVHP_{k,t} \\ &= DemHedge_{VHP,t}\end{aligned} \tag{7}$$

$$\begin{aligned}&\sum_t\sum_k (IndComISpotYield_{AEAC,k,t} + \\ &IndComESpotYield_{AEAC,k,t}).PCQHedgeAEAC_{k,t} \\ &= DemHedge_{AEAC,t}\end{aligned} \tag{8}$$

$$\begin{aligned}&\sum_t\sum_k (IndComISpotYield_{AEHC,k,t} + \\ &IndComESpotYield_{AEHC,k,t}).PCQHedgeAEHC_{k,t} \\ &= DemHedge_{AEHC,t}\end{aligned} \tag{9}$$

$$\begin{aligned}&PCQHedge = PCQHedgeVHP + PCQHedgeAEAC + \\ &PCQHedgeAEHC\end{aligned} \tag{10}$$

$$ISellings_{p,t} \geq DemISpot_{p,t} \tag{11}$$

$$ESellings_{p,t} \geq DemESpot_{p,t} \tag{12}$$

$$\begin{aligned}&\sum_e SC_{p,e,t-1} + \sum_p\sum_k\sum_t IndComISpotYield_{p,k,t}.PCQSpotI_{k,t} - \\ &DemHedge_{p,t} \geq ISellings_{p,t}\end{aligned} \tag{13}$$

$$\begin{aligned}&\sum_e SC_{p,e,t-1} + \sum_p\sum_k\sum_t IndComESpotYield_{p,k,t}.PCQSpotE_{k,t} - \\ &DemHedge_{p,t} \geq ESellings_{p,t}\end{aligned} \tag{14}$$

$$AvailCane_{ss,1} \leq PlanSeason_{ss} \tag{15}$$

$$AvailCane_{v,ss,1} \leq AvailCane_{v,ss,t-1} - VCQ_{v,ss,t-1} \tag{16}$$

$$VCQ_{v,ss,t} \leq AvailCane_{v,ss,t} \tag{17}$$

$$\sum_{ss}\sum_t VCQ_{v,ss,t} = \sum_{ss}\sum_t TCQ_{v,ss,t} \tag{18}$$

$$\sum_{ss}\sum_t TCQ_{v,ss,t} = \sum_k\sum_t PCQ_{v,ss,t} \tag{19}$$

$$\sum_{k}\sum_{t} PCQ_{k,t} \geq MinMilling_t - M.y \tag{20}$$

$$PWT_t \leq M.(1-y) \tag{21}$$

$$PCQ_{k,t} \geq MaxMilling_t - PWT_t \tag{22}$$

$$\sum_{oss}\sum_{t} VCQ_{oss,t} \leq \frac{\alpha}{100}.\sum_{k}\sum_{t} PCQ_{k,t} \tag{23}$$

$$\sum_{ot}\sum_{t} TCQ_{ot,t} \leq TranspCap \tag{24}$$

$$PCQ_{k,t} \leq MaxMilling_t.PWT_t.X_{k,t} \tag{25}$$

$$\sum_{k}\sum_{t} X_{k,t} = 1 \tag{26}$$

$$\mathrm{Pr}ovInv_{p,e,t} \leq SC_{p,e} \tag{27}$$

$$\sum_{k}\sum_{t} PCQ_{k,t} \leq \sum_{ss} Planseason \tag{28}$$

$$PCQ_{k,t} \geq 0,\ VCQ_{v,ss,t} \geq 0,\ TCQ_{tt,t} \geq 0,\ \mathrm{Pr}oInv_{p,t} \geq 0,\ AvailCane_{v,ss,t} \geq 0,\ PCQHedge_{k,t} \geq 0$$

$$,\ PCQSpotI_{k,t} \geq 0,\ PCQSpotE_{k,t} \geq 0,\ CM_t \geq 0 \tag{29}$$

6 Case study and results

This study was undertaken in Junqueirópolis, state of São Paulo, Brazil. In order to verify the perfomance of the proposed model, it was made a comparison between the real results of the mill during one season and the computational ones (the computational model is named SOVTICE) for the same period. VHP refers to the sugar, AEH and AEAC are two types of alcohol and molasses is the sub product. These products can be commercialized to the internal, external or future ("hedge of the product") markets.

In the table 1 are shown the results.

Table 1
Comparison of economic results.

Indicators	Results of Usapa (RU)	Results of SOVTICE (RS)	(RS-RU) / RU
Agricultural costs	335,6 currencies	321,4 currencies	-4,2%
Selling of VHP sugar to the internal Market	231.435 sacks of 50 Kg	62.345 sacks of 50 Kg	-73,1%
Selling of AEHC to the internal Market	33.789.232 m³	28.345.323	-16,1%
Selling of AEAC to the internal market	13.789.232 m³	8.345.323	-39,5%
Selling of molasses	0	0	0%
Selling of VHP sugar to the external market	986.544 sacks of 50 Kg	1.234.346 sacks of 50 Kg	+25,1%
Selling of AEHC to the external Market	3.234.224 m³	2.345.784 m³	-27,5%
Selling of AEAC to the external Market	10.349.247 m³	18.332.245 m³	+77,1%
Hedge of VHP	23,4 currencies	123,5 currencies	4,3
Hedge of AEHC	0 currencies	45,6 currencies	-
Hedge of AEAC	25,6 currencies	98,5 currencies	2,8
Contribution Margin	1105 currencies	1181,1 currencies	+6,9%

Analyzing the results, it is possible to note significant differences between the products destination for internal and external markets between the decisions of the company Usalpa and the Sovtice model. The selling of AEAC to the internal market was 39,5% lower and to the external +77,1% higher with the model application. Besides that, this model helped to save money in the agricultural part (-4,2%) and the contribution margin has increased (+6,9%). It suggests that the model has a great accuracy when it comes to choose the best path of commercialization and the best mix of production.

It is worth mentioning that it was not possible to show the financial values due to the ask of the managers for keeping it in secret. It was ended up divided by a constant but the results still interesting, reinforcing the ideia that this model is a very useful tool when it comes to profits maximization.
Finally, in the work of Higgins (2006), his model application to five large Australian mill regions through strong industry participation resulted in up to a 7 per cent increase in net revenue, a similar result.

7 Conclusion

The problem of maximizing the contribution margin is indeed complex and it has been analyzed for many years in some sugarcane producers countries (Australia, India, Brazil) and there is much yet to discover and develop about this theme.

In this work it is given a significant contribution. It is shown a new model able to integrate the three areas of the tactical planning (agricultural, industrial and commercial parts) which could help many producers to enhance their profits. The results are interesting, being possible also to make some changes/adaptations in this model according to the reality of each mill in order to reach even better results.

Finally, there are several paths for future research to be conducted in the sector taking this work as basis. It is possible to integrate this model to logistics studies. In the agricultural part it is possible to add up choices (inputs, fertilizers) to the model which could improve the productivity of the canes varieties and in the methodological part developing a work in pool plants in order to verify the adequability of the model.

References

Bertrand JW, Fransoo JC (2002). Operations management research methodologies using quantitative modelling. Department of Technology Management, Technische Universiteit Eindhoven. International Journal of Operations & Production Management, Vol 22, No 2, pp. 241-264.

Brunstein I; Tomyia EH (1995). Modelo econômico de empresa sucroalcooleira. Gestão & Produção, v. 2, n. 3, p. 264-280.

Burniquist HL, Bacchi MRP, Marjotta MC (2002). Análise da comercialização dos produtos do setor sucroalcooleiro brasileiro: Evolução, contexto institucional e desempenho. Agroindústria canavieira no Brasil: evolução, desenvolvimento e desafios. São Paulo, Atlas.

Carvalho MD (2009), Proposta de um modelo de planejamento agregado da produção numa usina de açúcar e álcool vinculado à flutuação de preços em mercados à vista e no mercado futuro. Dissertação (Mestrado em Engenharia de Produção) - Universidade Federal de São Paulo, São Paulo.

Higgins AJ et al (2004). A framework for integrating a complex harvesting and transport system for sugar production. Agricultural Systems, v. 82, n. 2, p. 99-115.

Higgins AJ (2006). Scheduling of road vehicles in sugar transport: A case study at an Australian sugar mill. European Journal of Operational Research, v. 170, n. 3, p. 987-1000.

Markowitz HM (1959), Portfolio Selection: Efficient Diversification of Investments. Wiley, New York.

Markowitz HM, Todd P, Xu GE, Yamane Y (1992). "Fast Computation of Mean-Variance Efficient Sets Using Historical Covariances." Journal of Financial Engineering, 1, 117-132.

Paiva, POR (2009). Modelagem do planejamento agregado da produção em usinas cooperadas do setor sucroenergético utilizando programação matemática e otimização robusta. 2009. Tese (Doutorado em Engenharia de Produção)-Universidade Federal de São Carlos, São Carlos.

Speranza MG, Kellerer H, Mansini R (2000), Selecting portfolios with fixed costs and minimum transaction lots, Annals of Operations Research 99, 287304.

Torres A, Diaz P (2007) Planejamento da produção numa usina de açúcar e álcool, anais de congressos do ICIDCA (Instituto cubano de pesquisa e derivados cana-de açúcar).

Union of the Sugar Cane Agroindustry of São Paulo (UNICA), 2011. Portal UNICA. Available at <http:// www.unica.com.br> Accessed on 02/11/2015

Comparative Study between Financial Performance of Companies that Compose Corporate Sustainability Index and BOVESPA Index

Santis P[1], Albuquerque A[2], Lizarelli F[3]

Abstract: Stock Exchanges around the world have created indexes to offer its investors the option to prioritize sustainable companies. In Brazil, the initiative came from the São Paulo Stock Exchange to launch the Corporate Sustainability Index (ISE). In search of greater knowledge on the subject, we analysed the financial performance of companies from two different indexes. The first is the ISE and the second, the Bovespa Index (Ibovespa), which is the indicator of the most traded and representative assets of the Brazilian stock market. We aimed to compare the differences in economic and financial performance of the companies included in these indexes. For this, profitability and liquidity indicators were calculated and multivariate statistical tests were applied. From the analysis, it was observed that there is no evidence of differences in economic and financial performance of the companies belonging to the studied indexes.

Keywords: Corporate Sustainability Index; Performance Analysis; Economic and financial performance.

1 Introduction

In the business world, sustainable development means adopting strategies and ac-tivities that meet the needs of the business and its shareholders today while pro-tecting, supporting and enhancing natural and social resources that will be needed in the future. This concept also suggested by the World Commission on environment and Development (BUSINESS…, 1992).

At the beginning sustainable development discussions, sustainability was seen as an obstacle to business growth. However, it is assumed today that the continuity of organizations is based on economic, social and environmental pillars, having the necessity of creation of alternative ways of production (SOUZA et al., 2001).

In the financial market, the main stock exchanges, started to offer their investors the option to prioritize companies that carry the principle of sustainability that would form the sustainability indexes (SOUZA et al., 2001). Indexes exist to demonstrate the performance of capital markets and are an indicator, which represents the behaviour of stock prices of a particular market at a given time period, still measuring overall economic trends (MALACRIDA; YAMAMOTO, 2006).

The first sustainability index established, in 1999, was the Dow Jones Sustainability Index (DJSI), an initiative of the New York Stock Exchange to track the performance of the shares from most important companies in the world regarding to economic, environmental and social criteria (DOW JONES SUSTAINA-BILITY INDEX, 2014).

Two years later, in 2001, the London Stock Exchange created its sustainability index, FTSE4Good (FTSE INDEX SERIES, 2014). In 2004, it was the Johannesburg Stock Exchange turn to launch the first sustainability index in developing countries (CUNHA; SAMANEZ, 2013), starting the JSE SRI index (Johannesburg Stock Exchange Socially Responsible Investment Index), which evaluates a set of aspect

1 **Paula de Santis** (paula_santis2@hotmail.com)
2 **Andrei Aparecido de Albuquerque** (andrei@dep.ufscar.br)
3 **Fabiane Letícia Lizarelli** (fabiane@dep.ufscar.br)
Production Engineering Department, University of São Carlos.
Rod. Washington Luís – SP-310, Km. 235 CEP 13565-905, São Carlos – S.P., Brasil.

related to social, governance, and environmental issues, sustainability, and climate change (JOHANNES-BURG STOCK EXCHANGE, 2013).

In Brazil, the initiative came in 2005 from the São Paulo Stock Exchange (BM&FBOVESPA), by launching the Corporate Sustainability Index (ISE). Basically, what ISE measures is the average return on a theoretical portfolio of shares of publicly traded companies listed on BM&FBOVESPA with the best sustainability practices (BM&FBOVESPA, 2014). Several studies focused on ISE were made, contributing to discussions on the topic. Machado et al. (2012) consider whether the investment made by companies have a relationship with the inclusion of those companies in the ISE portfolio. Nobre and Ribeiro (2013) made a re-search addressing the relationship between the participation of a company on ISE and the required degree of cognitive complexity, concluding that a higher degree of cognitive complexity is necessary for organizations that seek sustainability.

Nevertheless, a very relevant issue on the subject is whether the investments necessary for the consolidation of an organization that fits in corporate sustainability standards are economically and financially justified. Studies on the ISE with an emphasis on financial results are given mainly to analyse the relationship between adherence of companies to the ISE and the company's value (ANDRADE et al, 2013) and to assess how has behaved the average profitability of the ISE portfolio compared to other portfolios provided by BM&FBOVESPA (MACHADO; MACHADO; CORRAR, 2009).

Some researches about the financial returns compare the ISE, the Ibovespa and the Brazil Index (IBrX). Analysing data of the ISE, Cavalcanti, Bruni and Costa (2009) were able to conclude that the return of ISE companies is similar to the companies in other indexes. Rezende, Nunes and Portela (2009), studying data from December 2005 to March 2007, were able to conclude that the ISE companies has no better return than others in different indexes studied.

Following the direction of the analysis previously discussed, this study aims to investigate, in the Brazilian stock market, the return of the companies in the ISE portfolio in comparison with the return of companies that are part of other index from the stock exchange, ie, if the efforts demanded from the companies to meet requirements stipulated by BM&FBOVESPA to be recognized as a sustainable enterprise, and to be part of ISE, are economically justifiable. For this research, the index used as a comparative standard to ISE was the Bovespa index (Ibovespa). The Ibovespa index is an average performance indicator of the prices of most traded assets and representative of the Brazilian stock market (BM&FBOVESPA, 2014).

The research goal is to compare three different groups of companies: companies that are included only in the ISE, the companies that are included only in the Ibovespa and the companies that are part of both indexes. The evaluation is done by comparing the economic and financial performance among the three groups.

2 Methodological Procedures

To achieve the proposed objective, the identification of companies that were part only of the ISE investment portfolio, companies were only part of the investment portfolio of the Ibovespa and companies that were part of both portfolios, from 2009 to 2013, was made. For these companies, economic and financial ratios were calculated, specifically the profitability ratios ROA (Return on Assets), ROI (Return on Investment) and ROE (Return on Equity) and the liquidity rations LI (Rapid Liquidity), LC (Current Ratio), LS (Quick Liquidity) and LG (General liquidity). After having those ratios statistically exanimated through multivariate tests, specifically Cluster, Kruskal Wallis and Hotelling's T^2 analysis, made it possible conclusions about the purpose of the research.

For the present study, the nomenclature adopted was index to refer to indicators of stock exchanges, as the ISE or Ibovespa and ratios to reference the methodology of economic and financial analysis like ROA and LC, for example.

2.1 Sample Selection and Period Considered

An initial review of the companies that composed each one of the studied indexes, ISE and Ibovespa, showed that considering all the companies that were part of Ibovespa, approximately 40% were also part of ISE. Because of this influence, an analysis considering all the companies in those two indexes would be markedly impaired. Considering that, the analysis was made based on three companies groups: companies that were part of ISE and Ibovespa (named Group 1), companies that belonging to ISE and not to Ibovespa (named Group 2), companies belonging to Ibovespa and not to ISE (named Group 3), as stated before. Lopez, Garcia and Rodriguez (2007) adopt a similar procedure when analyzing the Dow Jones Index Sustainability. This grouping was done for the year 2013 and the four previous years (2012, 2011, 2010 and 2009). The groups were formed by year, thus a company that was part of ISE and not part of Ibovespa in a certain year (Group 2), could be part of both indexes (Group 1) in another year, for example.

A new separation was made, leaving in groups 2 and 3 only companies that were part of a single index in the last five years.

From these three new big groups formed, comparisons among groups were made and every company belonging to more than one group was added to the Group 1. After this process, the list of companies in each sample was formed.

The data necessary for the calculation of the financial ratios (of profitability and liquidity) was made in Economática® database. Thus, the data used in the re-search is from a secondary source. Companies that belonged to “Finance and In-surance Funds” sector in the database were excluded. This decision was taken because companies in this sector have some peculiarities when presenting its financial statements. To calculate some of the ratios, it was necessary to deducted income taxes (IR). The discount rate was consi-dered a 34%.

2.2 Analysis Tools

To make possible to formulate conclusions about the studied indexes, the use of statistical analysis was required. Hair at al. (2009, p.23) argue that the most part of the information available can be analyzed and understood with univariate statistical tests, but a large portion demand more complex multivariate statistical techniques to convert such data into useful information. Mainly (2008) states that, in many cases, better results are provided with the use of a single multivariate test than with the use of a large number of univa-riate tests.

The software used was STATISTICA® and after an initial analysis of the data, it could also be concluded that the three appropriate analyzes would be the Hotelling's T^2, Kruskal Wallis and the clustering analysis.

3 Data Analysis

3.1 Ratios

Profitability and liquidity ratios were calculated annually, from 2009 to 2013, for a total of 70 companies. To present the data, an average of every ratio, year by year, of all companies belonging to each of the proposed clusters was made; companies exclusive to ISE, companies exclusive Ibovespa and companies presented in both indexes was calculated. The results can be found on Table 1.

Table 1
Profitability and Liquidity average ratios
calculated for three groups.

	Exclusively ISE					Exclusively Ibovespa					ISE and Ibovespa simultaneously				
Ratios	2009	2010	2011	2012	2013	2009	2010	2011	2012	2013	2009	2010	2011	2012	2013
ROA	0,11	0,02	0,05	0,04	0,04	0,10	0,02	0,02	0,02	0,03	0,08	0,02	0,03	0,01	0,03
ROE	0,35	0,28	0,19	0,17	0,23	0,28	0,22	-0,59	0,11	0,60	0,22	0,22	0,17	0,12	0,17
ROI	0,15	0,02	0,06	0,06	0,05	0,25	0,04	0,04	0,03	0,05	0,30	0,08	0,09	0,02	0,11
LC	1,71	1,95	1,53	1,68	1,76	1,95	1,83	1,77	1,67	2,55	1,49	1,51	1,46	1,55	1,49
LI	0,65	1,01	0,55	0,57	0,62	0,76	0,73	0,77	0,65	0,79	0,58	0,61	0,55	0,62	0,58
LG	1,71	1,99	1,88	1,90	1,96	1,98	2,02	1,74	1,76	1,78	1,79	1,81	1,85	2,06	1,87
LS	1,46	1,77	1,31	1,40	1,52	1,57	1,50	1,45	1,36	2,25	1,26	1,25	1,19	1,19	1,29

It can be observed that the profitability index average values are very close. After 2010 the profitability ratios are smaller and that fact may be related to the global financial crisis, whose apex occurred in October 2008, with the collapse of Lehman Brothers bank. The average liquidity ratio values are also very close. Despite small differences, there is relative homogeneity of the among groups. This fact was confirmed by the statistical analysis presented on the following section. However, it is not possible to reach conclusions only with the comparison of the average rates, so statistical tests were applied.

3.2 Cluster Analysis

Cluster Analysis was performed for each year studied, analyzing the seven variables (rates) that are considered to form the economic and financial performance. The result of the Cluster Analysis made on the STATISTICA® software for the year of 2009, according to Ward's method, can be seen in Figure 1, below. The same was done for all years.

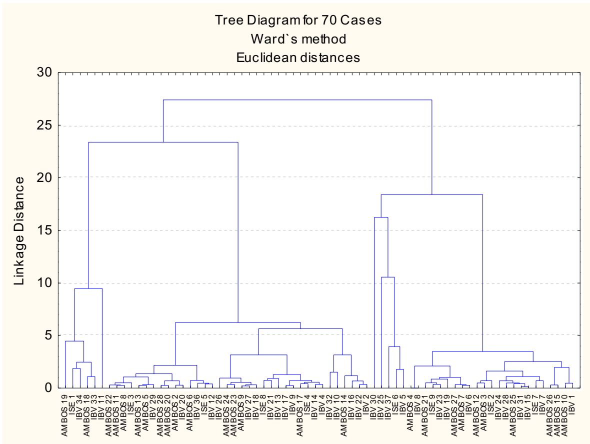

Fig.1
Result for the Cluster Analysis for 2009.

The formation of homogeneous clusters, containing only companies present in either Group 1, Group 2 or Group 3, cannot be observed. Also, analysis made for the same data with the Single Linkage method had simi0lar results, without the formation of homogeneous groups. For cluster analysis different methods were used as simple linkage, complete linkage and Ward's shown above. All had the same results.

For the other years, 2010, 2011, 2012 and 2013, similar result was found: despite small proximities in between companies belonging to a same group, the formation of homogeneous groups did not happened. The composition of the groups was more related to the sector to which the company belongs than the index.

3.3 Hotelling's T^2 Analysis

The Hotelling's T^2 test was done for the same variables, the liquidity and profitability ratios, in pairs of Groups. Thus, for each year, the analysis was made for companies exclusive from ISE and companies exclusive from Ibovespa (ISE*Ibovespa), to companies exclusive from Ibovespa and companies present in both indexes (Ibovespa*BOTH) and to take companies exclusive from ISE and companies present in both indices (ISE*BOTH). The p- value calculated for each year and each pair of Groups can be visualized on Table 2.

Table 1
Results for the T^2 Analysis from 2009 to 2010.

Test	2009	2010	2011	2012	2013
ISE*Ibovespa	0,55089	0,22669	0,209823	0,316442	0,542883
Ibovespa*Both	0,570682	0,622893	0,537263	0,342485	0,560155
ISE*BOTH	0,538241	0,321433	0,483678	0,093667	0,199955

As T^2 is a hypothesis test, p-value determines the acceptance or rejection of H_0, which means that with a certain level of significance (95%) the mean of both analyzed groups are the same. The acceptance of H_0 happens for any p-value greater than 0,05. In Table 2, p-values are always greater than 0.05, therefore, there is no difference between the means of the groups. It was also done Kruskal Wallis test to identify whether all populations have identical distribution functions (H_0) against the alternative hypothesis that at least two populations have different distribution functions. The test was performed for all ratios every year (univariate test) and only for LC in 2012 p-value was less than 0.05 indicating rejection of H_0. But when populations were compared in pairs was not confirmed difference between them.

4 Conclusions

Considering the economic and financial results obtained by the calculation of the profitability and liquidity ratios for the studied companies and the restrictions imposed by the statistical methods applied on this research, there was no difference found in between companies exclusively from ISE, companies exclusively from Ibovespa and companies presented to both indexes.

Based on that, it was concluded that there are no significant differences on the economic and financial performance of the companies studied, regardless of the proposed Groups. Furthermore, on the Cluster Analysis, it was observed certain proximity of companies according to their sectorial classification, following trends already observed and studied by other researchers. It indicates the possibility that the companies economic and financial performance is more influenced by the sector they belong or external variables than the efforts done towards sustainability.

Also, comparing the results with other similar published studies, it can be noted that the outcomes from this research is quite similar to the one found in the works of Rezende, Nunes and Portela (2008), Cavalcante, Bruni and Costa (2009) and Machado, Machado and Corrar (2009). Regarding to the study performed on the London Stock Exchange by Collison et al. (2008), the results are conflicting, since the authors ascertained that the financial performance of the shares owned by the FTSE4Good (the stock exchange sustainability index) is higher than the stocks present in other indexes. The results also differs to the study of Lopez, Garcia and Rodrigues (2007) about the Dow Jones Sustainability Index, that concluded that there is a negative effect on the financial performance of the companies due to the adoption of sustainability policies.

5 References

Andrade LP, Bressan AA, Iquiapaza RA, Moreira, BCM (2013) Determinantes de adesão ao Índice de Sustentabilidade Empresarial da BM&FBOVESPA e sua relação com o valor da empresa. Revista Brasileira de Finanças, Rio de Janeiro, v.11 , n. 2, p. 181-213.

Bolsa De Valores De São Paulo - BM&FBOVESPA (2014). Avaiable in: <http://isebvmf.com.br/?r=site/conteudo&id=1>

Business Strategy for Sustainable Development: Leadership Accountability for the 90's. (1992) Instituto Internacional para Desenvolvimento Sustentável (IISD). [S.L.]: IISD, 114 p.

Cavalcante LRMT, Bruni AL, Costa F JM (2009) Sustentabilidade empresarial e o valor das ações: uma análise da Bolsa de Valores de São Paulo. Revista de Gestão Social e Ambiental, [S.L.], v.3, n. 1, p. 70-86.

Collison, DL, Cobb G, Power DM, Stevenson LA (2008) The Financial Performance of the FTSE4Good Indices. Corporate Social Responsibility and Environmental Management. v. 15, p.14-28.

Cunha FAFS, Samanez CP (2013) Performance Analysis of Sustainable Investments in the Brazilian Stock Market: A Study About the Corporate Sustainability Index (ISE). Journal of Business Ethics, v.117, p.19-36.

Dow Jones Sustainability Index (2014). Avaiable in: < http://www.sustainability-indices.com/index-family-overview/djsi-family-overview/index.jsp>.

FTSE Index Series (2010). Avaiable in: <http://www.ftse.com/Indices/FTSE4Good_Index_Series/index.jsp>.

Hair JF, Black, B, Anderson RE, Tatham RL (2009) Análise Multivariada de dados. 6a edição. Porto Alegre: Bookman, 688 p.

Johannesburg Stock Exchange (2013). Avaiable in: < https://www.jse.co.za/services/market-data/indices/socially-responsible-investment-index >.

López MV, Garcia A, Rodriguez (2007) Sustainable Development and Corporate Performance: A Study Based on the Dow Jones Sustainability Index. Journal of Business Ethics, Granada, v.75, p. 285-300.

Machado MAV, Macedo MAS, Machado MR, Siqueira JRM (2012) Análise da Relação entre Investimentos Socioambientais e a Inclusão de Empresas no Índice de Sustentabilidade Empresarial - (ISE) da BM&FBOVESPA. Revista de Ciências da Administração, [S.L.], v. 14, n. 32, p. 141-156.

Machado MR, Machado MAV, Corrar LJ (2009) Desempenho do Índice de Sustentabilidade Empresarial (ISE) da Bolsa de Valores de São Paulo. Revista Universo Contábil, Blumenau, v.5, n.2, p. 24-38.

Mainly BFJ, (2008) Métodos Estatísticos Multivariados: uma Introdução. 3ª edição. Porto Alegre: Bookman, 229 p.

Malacrida MJC, Yamamoto MM (2006) Governança corporativa: nível de evidenciação das informações e sua relação com a volatilidade das ações do Ibovespa. Revista Contabilidade & Finanças, São Paulo, vol. 17, p. 65-79.

Nobre FS, Ribeiro REM (2013) Cognição e Sustentabilidade: Estudo de Casos Múltiplos no Índice de Sustentabilidade Empresarial da BM&Fbovespa. Revista de Ciência da Administração, Rio de Janeiro, v.17, n. 4, p.499-517.

Rezende IAC, Nunes JG, Portela SS (2008) Um Estudo Sobre o Desempenho Financeiro do Índice Bovespa de Sustentabilidade Empresarial. Revista de Educação e Pesquisa em Contabilidade, [S.L.], v. 2, n. 4, p. 93-122.

Souza MTS, Ribeiro HCM, Júnior CM, Corrêa R (2011) Perfil e Evolução da Pesquisa em Sustentabilidade Ambiental: uma Análise Bibliométrica. In: ENCONTRO DA ANPAD, 35., Rio de Janeiro.

Leverage organizational performance in a food industry: a case study of the improvement of product quality attributes with the use of multiple regression analysis

Kall E[1], Silveira OF da[2], Siluk JC[3]

Abstract: The likelihood of implementing improvements interested organizations to contribute to increase in performance. This improvement plan was carried out in CVI Soft Ltda industry, franchised The Coca-Cola Company, in quality control sectors, maintenance and production. Measuring the improvement plan, it requires the application of statistical tool correlating the dependent and independent variables. Methodologically analyzed samples for 10 consecutive days for a generic The line 03 in order to demonstrate the correlation between the gas loss (dependent variable) for the torque and sequence days (independent variables) and thus performing the multiple regression. Torque is the force applied on the cover in the system open / close and it is essential its standardization and control to reduce the loss in over 15% of gas during the day. There was a negative and strong correlation with carbonation and the sequence of days. Adjusting the regression equation with significant (ANOVA), it was found that the value of F (31.93067) is greater on the day being the sequence p (0.000481) lower beyond the adjusted R-squared (0, 77460933) most find themselves in this variable. Thus, it was found by multiple linear regression equation that allows one to predict the carbon dioxide reduction of correlation.

Keywords: Multiple Regression, correlation, improvement plan.

1 Introduction

The feasibility of implementing an improvement plan stimulates the interest on the subject of organizations in various industries because it contributes not only to improve the quality of products, services and processes, but also it allows a significant increase in organizational performance, in culture change and increasing human capital (SANTOS and MARTINS, 2008).

The plan aims to add improvements to deployment of strategic planning. However, according to Sellito and Ribeiro (2004) an important part of the strategic planning of organizations is the measuring of their results. If the measurement is inconsistent with the strategic goals, these cannot be achieved. To Bittici (1995) a system to measure results must have some capabilities: (i) to form the global view, avoiding local sub optimization; (ii) to deploy strategic objectives to operational levels; (iii) to provide the full understanding of structure of goals and conflicts; (iv) to adopt a hierarchical fashion, similar to a system of information, considering the operational capacity of the organization to collect and store the data required; and (v) to consider aspects of organizational culture.

It is known that the management system is a crucial ingredient of responsiveness to changes in the environment, because it determines the way in which the administration realizes the challenges, diagnoses their impacts, decides what to do and implements its decisions (ANSOFF; McDONNEL, 1993). And

1 **Elenice Kall** (eleniceka@gmail.com)
2 **Orlando Ferreira da Silveira** (orlandofsilveira@gmail.com)
3 **Julio Cezar Siluk** (jsiluk@ufsm.br)
Engenharia de Produção, Universidade Federal de Santa Catarina, SC, Brasil.
Centro de Tecnologia, Av. Roraima, n° 1000, Cidade Universitária,
Bairro Camobi, Santa Maria, RS, Brasil.

continuous improvement, according to Caffyn (1999), can be conceptualized ad a broad process focused on incremental innovation, which involves the entire organization.

However, to be able to measure the improvement plan it is necessary to accomplish an application of statistical tool so that the variables which are studied can be correlated. In order to check whether there is a relationship between two or more variables, or to determine whether the changes for one of the variables are accompanied by changes in the other one, a multiple regression analysis will be used to check for correlation between the loss of gas bottled beverages with torque.

For this work the variables studied were the effect of torque in plastic lids (torque) and the loss of gas in beverages, plastic covers tend to lose gas – especially if misapplied in the closing process – as days pass by, due to the chemical composition of the caps, which contains polypropylene, and the fact that they have undergone elastic deformation, the soda plastic bottled loses a certain amount of carbon dioxide (CO2), both through the walls of PET (polyethylene terephthalate) and the cover.

One of the goals of this improvement plan was to reach, basically, three sectors: quality control, maintenance, and production. Occasionally, one of the main purposes is to ensure the quality of 10 essential attributes for the enterprise sector of quality control for placing the rating. The attribute approached was the torque, which is the force applied on the lid in the open/close system. This force is not standardized or when not performed preventive maintenance on equipment in the specified period, it will generate and application in the covers by magnetic head out of the determined specification.

The level of carbonation will vary from product to product and for each there is a good effervescence. This is due to the flavor, taste and characteristics of different beverages. In general terms, fruit drinks are carbonated at low levels, colas and alcoholic beverages at medium levels, and other beverages such as tonics at high level to enable its dissolution in the liquid component in the carbonator (HAMMER and FRANCIS, 1993; TOCCHINI and NISIDA, 1995).

It is extremely important that, after its determination, the carbonation is maintained in established patter depending on the type of beverage and the degree of acceptance by the consumer (TOCCHINI and NISIDA, 1995; MARTINS, 2012).

The loss of carbon dioxide in beverages is an important factor to be considered in quality control of a product. This control involves not only the production stage, but also the characteristics of packaging systems and used for storage, transportation and distribution (DANTAS, 1999).

The study was conducted in the industry CVI Refrigerantes Ltd., franchised by The Coca-Cola Company and Heineken Brazil, with factory located in Santa Maria and Distribution Centers in Passo Fundo and Santa Cruz do Sul. CVI operates in the food producing, marketing lines and distributing beverages from The Coca-Cola Company, Heineken and Fonte Ijuí, with approximately 798 employees. The company has a factory in Santa Maria with 23,000 m^2 of built area and total area of 90,000 m^2, plus distribution centers in Passo Fundo and Santa Cruz do Sul. The total area covered by CVI is 126,533 km2, representing 44.9% of area and 25.3% of the population of the State of Rio Grande do Sul. It currently operates with 4 lines that include modern manufacturing equipment (1 line for filling cans, 2 lines for PET packaging and 1 line for returnable glass bottles), making it self-sustaining in glass containers, aluminum cans and PET. Currently there are several categories of products available, all within the field of beverages, such as soft drinks, beers, juices, teas, energy drinks, mineral water, flavored waters, chocolate beverages and sports drinks.

2 Objective

This paper aims to conduct a verification of the amount of gas loss in a particular drink that reaches the consumer as standardized as possible. And, on this aspect, find an equation which allows predicting the correlation reduction of carbon dioxide through a statistical technique known as multiple linear regression.

3 Methodology

To carry out the analysis of these data, scatter diagram, tests of correlation coefficient and regression analysis were used. Through regression analysis it is possible to calculate the value of a quantity in relation to the others, or combination of others (LEITE et al., 2006). By statistical process, it is determined an algebraic expression that relates the dependent variable (time – days) to the independent variables or explanatory of their behavior (SANVICENTE and SANTOS, 1995). The option to perform this study with multiple regression is due to the fact that statistical analysis technique exists in a large number of independent variables, able (or not) to explain the variation found on the dependent variable (HAIR, Jr et al., 2005), mentioned in the work, which is the loss of carbon dioxide.

In addition, multiple linear regression is useful for selecting which variables are really meaningful and that, therefore, contribute to a better adherence of the model.

Another important point is that the multiple regression equation allows you to add any number of independent variables, which can take continuous or discrete values (SAMOHYL, 2009).

The pairs of values of two variables may be placed in a cartesian diagram called "dispersion diagram". The advantage of building a scatter diagram is that, often a simple observation already gives a fairly good idea of how the two variables are related.

A measure of the degree and sign of the correlation is given by the covariance between two random variables X and Y, which is a numerical measure of linear association between them, and defined by (1):

$$\text{Cov(X, Y)} = \frac{1}{n}\left[\sum x.y - \frac{\sum x.\sum y}{n}\right]. \quad (1)$$

It is more convenient to use a measure of correlation, the correlation coefficient Pearson estimator as $\rho_{xy,}$ defined by (2):

$$r_{xy} = \frac{\text{Cov}(x,y)}{\hat{\sigma}_x \hat{\sigma}_y} = \frac{S_{xy}}{\sqrt{S_{xx}.S_{yy}}} \quad (2)$$

$$r_{xy} = \frac{\sum xy - \frac{\sum x . \sum y}{n}}{\left[\left[\sum x^2 - \frac{\left(\sum x\right)^2}{n}\right].\left[\sum y^2 - \frac{\left(\sum y\right)^2}{n}\right]\right]^{\frac{1}{2}}} = \frac{S_{xy}}{\left(S_{xx} . S_{yy}\right)^{\frac{1}{2}}} = \sqrt{\frac{S_{xy}.S_{xy}}{S_{xx}.S_{yy}}} = \sqrt{\frac{b.S_{xy}}{S_{yy}}}$$

Where: the sums of squares are (3):

$$S_{xy} = \sum x.y - \frac{\sum x.\sum y}{n}; \qquad S_{xx} = \sum x^2 - \frac{\left(\sum x\right)^2}{n}; \qquad S_{yy} = \sum y^2 - \frac{\left(\sum y\right)^2}{n} \quad (3)$$

n = number of observation pairs

The correlation coefficient r_{xy} is only an estimate of the population correlation coefficient ρ_{xy} and one must not forget that the value of r_{xy} is calculated based on the "n" data pairs.

Often the sample points can have a correlation and yet not population. In this case, there is a problem of inference, since $r_{xy} \neq 0$ is not guarantee that $\rho_{xy} \neq 0$. The problem can be solved by applying a hypothesis test to check if the value of rxy is consistent with the sample size n, in the significance level α, that there really is linear correlation between the variables.

H_0: $\rho = 0$ (there is no correlation between X and Y)
H_1: $\rho \neq 0$ (there is correlation between X and Y).

$$t_c = \frac{r_{xy} \cdot \sqrt{n-2}}{\sqrt{1-r^2_{xy}}} = \frac{r_{xy}}{S_r} \approx \text{ Distribution "t" of student with } n-2 \text{ degrees of liberty}$$

where: $S_r = \sqrt{\dfrac{1-r^2}{n-2}}$, standard error of the correlation coefficient

The correlation coefficient is a measure of linear relationship or more variables, and denoted by (*R*) indicates the closeness of the points to the regression line and the closer *R* is to 1.0, the closer the points are the linear regression; the closer *R* is to zero, the poorer is the adjustment of the regression line to the points (MAHER, 2001).

The square of R, known as the coefficient of determination or (R2) regression, aims to disclose as the independent variables explain the variation of the dependent variables, i.e., is a measure that seeks to reflect how the values of Y are related to X, varying from 0 to 1, so that the closer to 1 the better (LEITE et al., 2006).

According to Milone and Angelini (1995) correlation and regression are statistical technique that are based on the concepts of sampling to know how and if two statistical variables from the same population or not, are related to each other.

According to Gujarati (2000), possible relationships between the explanatory variables of the phenomena fall into "simple regression analysis" when studying the dependence of one variable with respect to a single explanatory variable, and in "multiple regression analysis" when the study includes more than one independent variable to explain the dependent variable.

More broadly, the techniques aim to generate a regression line that best fits a set of data points representing all data on certain variables, where the resulting estimates have a broader basis (LEITE et al., 2006).

Regression analysis aimed to investigate how the amount of gas and number of valves (independent variable) influence the elapsed time (dependent variable). The statistical tools available in the software *Statistica* were used for application testing.

4 Results

For a preliminary analysis of the existence of correlation between torque, time and carbonation, Table 1 and Figure 1 function as both exemplification and representation of the tests, which showed the torque behavior in relation to gas on line 03 along time. Samples of product X were analyzed along a 10-day period. A 50-percent variation in torque and 17.32 percent of gas loss were noticed, considering the reduction from the first to the last sample. The acceptable levels of gas loss cannot be higher than 5-8 percent; levels above that imply gas loss through the cap, thus showing that the main cause for gas loss was the plastic deformation provoked by the action of the magnetic heads.

Table 1
Carbonation and torque tests on line 03.

Sequency	Date	Torque (lb.in)	Carbonatacion (Vol)	
1º	05/04/2011	12	4,85	% Torque variation: 50% % Gas lost: 17,32%
2º	06/04/2011	10	4,57	
3º	07/04/2011	11	4,57	
4º	08/04/2011	8	4,51	
5º	13/04/2011	10	4,36	
6º	14/04/2011	12	4,28	
7º	15/04/2011	11	4,31	
8º	16/04/2011	10	4,46	
9º	18/04/2011	6	4,20	
10º	19/04/2011	6	4,01	

Fig.1
Graphic of the Carbonation and Torque Test on line 03.

As the purpose of this study was to find out an equation to predict the correlation of carbonic gas reduction by considering two independent variables (days and torque), first it was necessary to check the existence of correlation between those two variables.

The first step was to build the scatter plot, according to Figure 2, which shows the correlation. The closer the coefficient is to – 1 or + 1, the stronger the correlation is; on the other hand, the closer the coefficient is to zero, the weaker the correlation is. In this case, there is a negative, strong correlation.

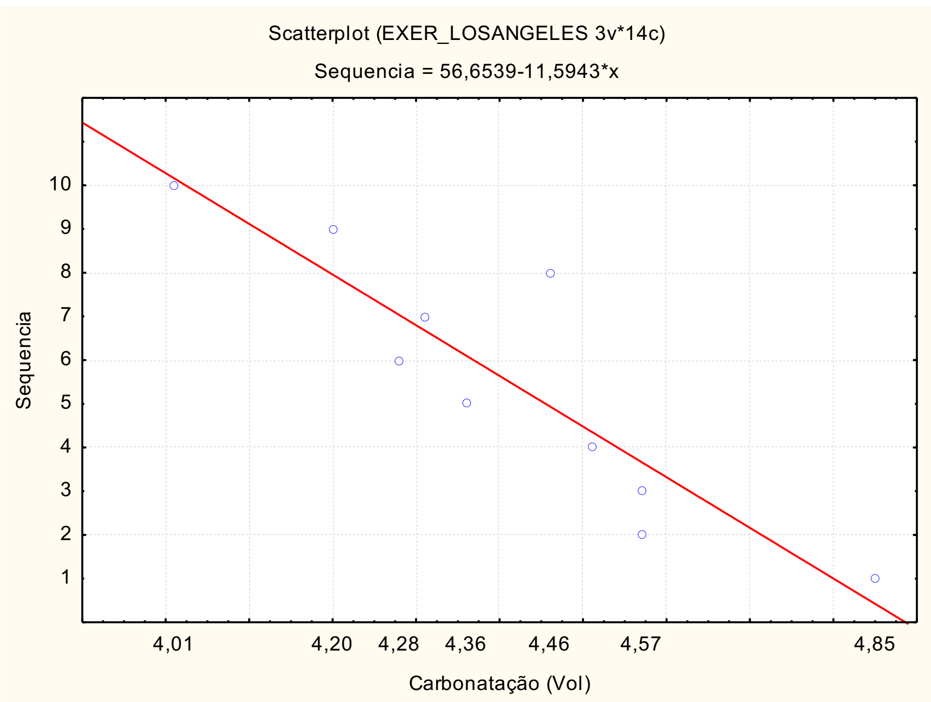

Fig.2
Graphic of dispersion.

The next step was to conduct a significant regression between the variables to find out which independent variable was the most suitable to the model. The table 2 shows the significant regression analysis between variables.

Table 2
Results of the multiple regression.

	Variable sequence days	*Variable days and torque sequence*	*Variable torque*
F	31,93067	14,61593	5,189359
p-value	0,000481	0,003170	0,052233
multiple R	0,89423304	0,89822040	0,62725627
R-Squared	0,79965273	0,80679988	0,39345042
Adjusted R-squared	0,77460933	0,75159985	0,31763173
comments	10	10	10

As can be seen in Table 2, by combining the three possibilities to adjust the regression equation, F value is higher for the day sequence, and p-value is lower in this variable. By analyzing the adjusted R-squared, the highest of them is in this variable.

For the test of model significance, two possibilities were considered from the selection shown in Table 2. Table 3 presents a comparison between the two regression models designed for the two best F values and the best adjusted R-squared. X_1 is the independent variable ‘day sequence’, X_2 is the independent variable ‘torque’, and Y is the dependent variable ‘gas loss’.

Table 3
Multiple regression models.

Model I	$Y = 4{,}791333 - 0{,}894233X_1$
Model II	$Y = 4{,}652776 - 0{,}826035X_1 + 0{,}108619X_2$

The best model that could be found was model I, as defined by the values seen in Table 2. However, as the values of adjusted R-squared for both models were close, the option was to analyze the adjusted R-squared, since it must be preferred to the R-squared; F statistic, from the variance analysis, combined with its p-value, is preferred to the adjusted R-squared. The other step was the normality test (Figure 3) of the parameter defined as ‘day sequence’. The independent variable ‘days’ was selected for this model.

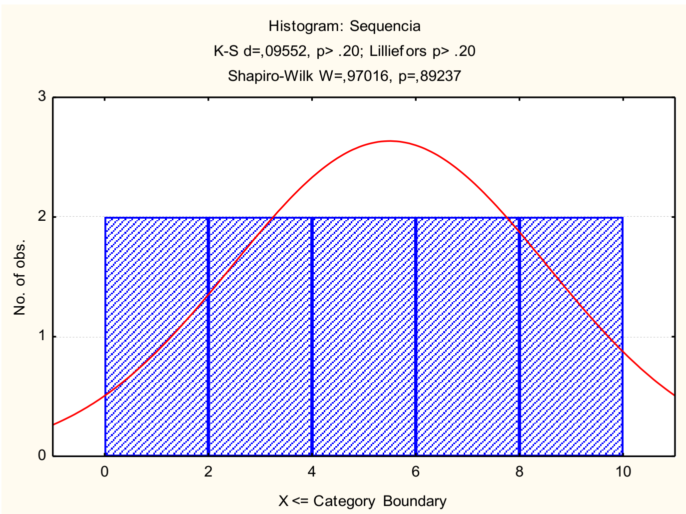

Fig.3
Analysis of normal sequence of days.

It is known that the p-value is the lowest significance level that leads to the rejection of the null hypothesis H_o; the lower the p-value, the more significant the test. In this case, p = 0.89237, that is, p < 5%, so it is accepted that H_o does not follow a normal distribution. The normality condition is not necessary for obtaining the estimators of minimum squares, but it is fundamental for defining the confidence intervals and significance tests. This is also evidenced in Figure 4, which illustrates the distribution of the regression residuals, indicating that they do not follow a normal distribution.

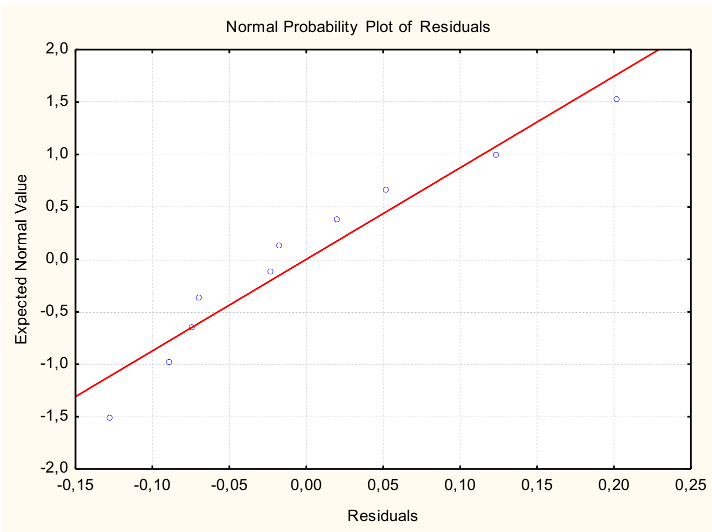

Fig.4
Analysis of normality of the regression residuals.

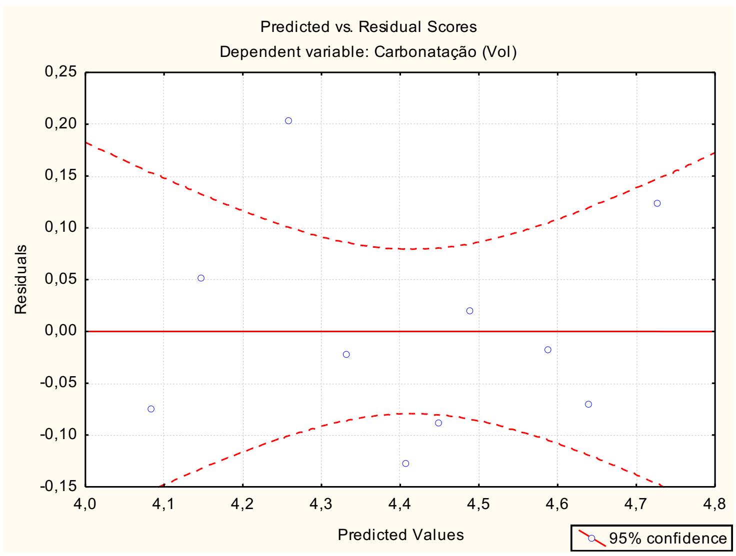

Fig.5
Analysis of homoscedasticity.

For this model, outliers have not been found. Outliers generate false estimations in the model. Besides, the standard residual has a mean value equal to zero and constant variance, which show the occurrence of homoscedasticity.

Regarding the assumption of independence, the existence of autocorrelation among data should be considered, i.e. whether an observation was influenced by or influenced the observations performed both before and after it (JORDAN, 2009). By using the Durbin-Watson test, it is possible to conclude that there is no independence among data; therefore, there is no autocorrelation.

The assumption of multicollinearity can be indirectly checked through the p-values of the coefficients obtained from the regression analysis. As all these values were extremely significant, even if there were multicollinearity, it would be overcome by the strength of relation existing between the variables (SAMOHYL, 2009). When there are more than two strongly related independent variables, there is multicollinearity. Multicollinearity significantly affects the coefficients of the regression equation by altering the value and even its sign in comparison to what would occur if this problem did not exist. The verification of existence of collinearity is performed through the examination of the correlation matrix by relating all the variables of the analysis, or by considering other criteria, such as the variance infraction vector (VIF). In this analysis, there is not problem of multicollinearity.

5 Conclusions

Finally, the main statistical assumptions of correlation and regression (normality, homoscedasticity, error independence, multicollinearity and linearity) were confirmed, thus evidencing the significance of the results obtained.

The main limitation of this mathematical and statistical model is the fact that the equation obtained does not faithfully represent the dynamical process that occurs in the procedure, which in this case is the individual application of each plastic cap by the magnetic head. The mathematical equation found is static.

It was noticed that there is a negative, strong correlation with both the carbonation and the day sequence; by performing the significant regression (ANOVA) to adjust the regression equation, it was found that the F value (31.93067) is higher for day sequence, and the p-value (0.000481) is lower in this variable. By analyzing the adjusted R-squared (0.77460933), the highest of them is in this variable. Thus, an equation to predict the correlation of carbonic gas reduction has been found through the statistical technique known as multiple linear regression.

6 References

ANSOFF, H. I.; MCDONNELL, E. J. (1993) Implantando a administração estratégica. 2 ed. São Paulo: Atlas.

BITITCI, U. (1995) Modelling of performance measurement systems in manufacturing enterprises. Int. J. Production Economics, Elsevier Science B.V., v. 42, p. 137-147.

CAFFYN, S. (1999) Development of a continuous improvement self-assessment tool. International Journal of Operations & Production Management. v. 19. n.1.

DANTAS, S.T. (1999) Embalagens e a sua interação com alimentos e bebidas. Campinas: CETEA/ITAL.

FRANCIS, A.J; HARMER, P.W. (1993) Zumos de frutas y bebidas refrescantes. Zaragoza: Acríbia.

GUJARATI, D.N. (2000) Econometria básica. São Paulo: Makron Books.

HAIR Jr, J.F., ANDERSON, R.E, TATHAM, R.L. , BLACK, W.C. (2005) Análise Multivariada de Dados. 5.ed. Porto Alegre: Bookman.

JORDAN, J.R. (2009) Modelagem estatística para ensaios de resistência na indústria de celulose e papel: Anais XXIX Encontro Nacional De Engenharia De Produção. Salvador (BA).

LEITE, R.M.; CLEMENTE, A.; GARCIA, R.. (2006) Análise de Regressão: uma ferramenta para a previsão de vendas. UFPR.

MAHER, M. (2001) Contabilidade de custos: criando valor para a administração. São Paulo: Atlas, cap.12.

MILONE, G.; ANGELINI, F. (1995) Estatística Aplicada. São Paulo: Atlas.

SAMOHYL, R. W. (2009) Controle Estatístico da qualidade. Rio de Janeiro: Elsevier.

SANTOS, A.B.; MARTINS, M.F. (2008) Modelo de referência para estruturar o Seis Sigma nas organizações. Gestão e Produção, São Carlos, v.15, n 1, jan./abr.

SANVICENTE, A.Z.; SANTOS, C. da C. (1995) Orçamento na administração de empresas: planejamento e controle. São Paulo: Atlas.

SELITTO, M.A.; RIBEIRO, J. L. D. (2004) Construção de indicadores para avaliação de conceitos intangíveis em sistemas produtivos. Gestão e Produção.Vol.11. Nº1, p.75-90, abr.

TOCCHINI, R.P.; NISIDA, A. L. A. C. (1995) Industrialização de refrigerantes. Campinas: ITAL.

WHITE MARTINS (2012) Carbonatação: a vida da bebida. Disponível em: <http://www.whitemartins.com.br>. Acesso em: 2 de dezembro 2012.

A quick and simple way to feed data for using in the implementation of software route planning: methodology, error analysis and case study

Domínguez-Caamaño P[1], Comesaña-Benavides JA, Prado-Prado JC

Abstract: This article aims to solve the problem of feeding data for the use of algorithms or methods of planning delivery routes. The proposed solution consists in using as input in the Route Planning Software (RPS) the corresponding coordinates to postcode where the customer is located, and not the coordinates of the customer, as to obtain the coordinates of the customer requires typically much time and effort. Also it is shown that the loss of precision inherent in the method is not important for long runs. This work is complemented with a case study where proposed methodology was used and good results were obtained; it aims to serve as an example of how this method is applicable to a real case.

Keywords: VRP; Zip Code; Geographic coordinates.

1 Introduction

There is abundant literature dealing with Vehicle Routing Problem (VRP), focusing mainly in the design methods with increasing accuracy and computational complexity.

Examples, known for their simplicity, are Savings Algorithm (Clarke & Wright, 1964) and 2-phase methods, such as petal and sweep (Ryan et al, 1993; Solomon, 1987). The first is based on minimizing the miles traveled by each vehicle to meet demand by drawing arcs between points whose assignment on the same route would generate maximum savings compared to serve each point independently; this process is repeated until all points belong to a route. The latter are simply ways of dividing the work areas into sub-areas more easily computable to be resolved with some other algorithm.

However there are also more complex solutions such as genetic algorithms (Holland, 1975), based on the evolution and natural selection, Ant-colony Optimization (Colorni et al, 1991), which mimic the behavior of ants when they seek food, or other techniques to those or other situations.

This important amount of different solutions/answers demonstrates the difficulty of finding an optimal solution to the problem. The number of alternatives is so big, that ways to reduce the number of possibilities to evaluate would be welcome. That is the philosophy of heuristics and metaheuristics.

Furthermore, the applicability of these methods, in a route planning system (RPS), to real transport processes is limited for several reasons:

- Growing and changing restrictions (delivery schedules, driving times, hygienic conditions, restrictions on working time of drivers, etc.).
- Feeding the positioning data for the algorithm requires a lot of manual work, especially if the company wants to establish a route planning system with a broad portfolio of customers already established.

1 **Pablo Domínguez Caamaño** (pablo.domínguez@gio.uvigo.es)
Grupo de Ingeniería de Organización (GIO).
Escola de Enxeñería Industrial,
Campus Lagoas-Marcosende, C/ Maxwell, 36310 Vigo, Spain.

In his article *Classical and modern heuristics for the vehicle routing problem* Gilbert Laporte (2000) suggests, that existing algorithms were sufficiently varied and accurate, and that probably it was time to get simpler and faster ways to implement them even losing some accuracy in resolution.

2 Objective

This article aims to solve a common problem, the difficulty of feeding data for the use of algorithms or methods for planning delivery routes.

The proposed solution is to use the corresponding coordinates to postcode where the customer is located as input in the RPS, instead of the coordinates of the customer. It is the same situation for suppliers, but we will focus on the client in this article.

The main disadvantage is possible loss of accuracy of the RPS, though a huge advantage could be achieved: frequently the data of zip code is already contained in the customer file, and in any case it is very easy to obtain.

With the proposed methodology, the coordinate data of the postal code can be assigned directly and automatically to each client.

Also the method used to characterize the error and display the results will be discussed in detail for the Spanish peninsular provinces.

Finally, proposed methodology is applied to a real case: a Spanish company with a fleet of 85 vehicles and over 20,000 delivery points. It had to face, with the assistance of the authors, the difficulties arising from the implementation of a route planning system.

This methodology is easy to extrapolate to other regions, but the conclusions and calculations are solely applicable to the mainland of Spain.

3 Methodology

The process is divided into three stages:

1. Allocation of geographical coordinates to postal codes
2. Calculation of distances between coordinates
3. Determination of the maximum error

3.1 Allocation of Geographical Coordinates to Postal Codes

As a table linking postal codes to geographic coordinates was not available, the authors had to get that information by themselves.

For this task the Google Maps APIs (Application Programming Interface) were used. This APIs provide location information from a postal code which can then be displayed on a map. This information is obtained accessing a URL that has to be composed of several parameters. In this case we have used the following:

```
http://maps.googleapis.com/maps/api/geocode/json?components=postal_code:ZCxxx&region=es&sensor=fals
e
```

where ZCxxx corresponds to the Zip Code for which information is requested.

In response to this query, Google Maps server provides various data, among which are the following:

- In section “results/formatted_address”, address is obtained in text format

- In section “results/geometry/location”:
  - “lng”, longitude in number format
  - “lat”, latitude in number format

- In section “results/geometry/bounds”:
  - “northeast/lat”: latitude of the northeast point of the rectangle used to display

the zip code
- "northeast/long": longitude of the same point
- "southwest/lat": latitude of the Southwest point of the rectangle used to display the zip code
- "southwest/long": longitude of the same point

The coordinates of the display rectangle may be interesting to display a zip code on a map, and even also to have a rough idea of the maximum dimensions of the area covered by the code.
It is important to note that there are valid postal codes not listed in the Google server and for which the information returned does not correspond to Spain, these points have been properly checked and debugged using textual address obtained. Many of these points corresponded to public entities postcodes and PO (Post-Office) boxes.

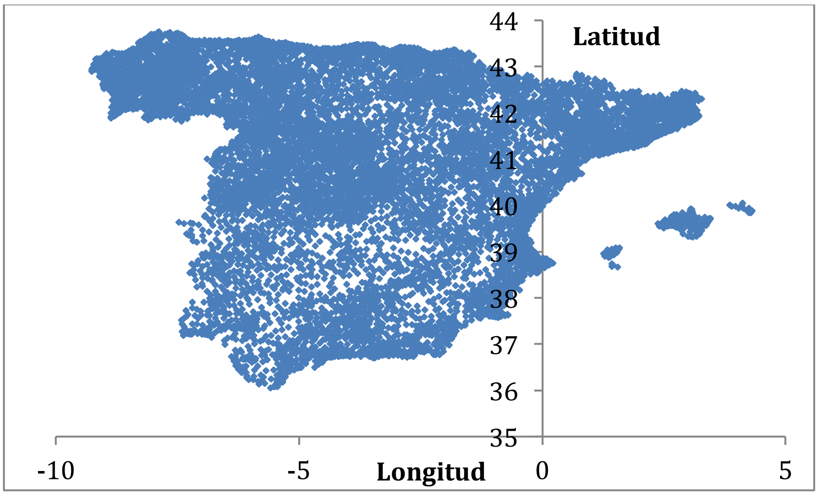

Fig.1
Distribution of postal codes in Spain.

As shown in Figure 2, there are notable differences by region. The north and coastal areas are more densely populated and therefore postal codes are closer together.

3.2 Calculation of Distances between Coordinates

Once all the coordinates were obtained, the method used to find the straight line distances had to be chosen. Three options were considered:

- *The Pythagorean Theorem*: it is the easiest solution, but it should be only used when the points are close enough to consider that Earth's surface is flat.
- *Haversine formula*: it considers the Earth a sphere, it is a simple formula with a much higher accuracy than the Pythagorean Theorem using spherical trigonometry (Robusto, 1957).
- *Vincenty's formulae* (Vincenty, 1975): they are two widely recognized iterative formulas. They consider the Earth to be an ellipsoid of revolution to parameterize its flattened shape at the poles, which guarantees high precision.

After different tests, Haversine formula has been selected for its simplicity and accuracy. It has been checked that the difference between this formula and distance in Google Maps is only a few tens of meters (Olivera et al, 2012).

Dist= 6378.7*{cos-1[sin(Lat1)*sin(Lat2) + (cos(Lat1)*cos(Lat2)*cos(Lon2-Lon1))]} (1.1)

being Lat1 and Lon1 the latitude and longitude of the first point and Lat2 and Lon2 of the second.

3.3 Determination of the Maximum Error

The error will be directly proportional to the size of the zip code where the customer is located.

In this study we wanted to obtain the maximum error committed, although as will be seen later in the case study, the actual error is always less, as the worst case scenario was considered.

The distances between all postal codes were calculated and then the minimum distance of each was found. This distance value gives an idea of the area occupied by the ZIP code. Also this value is greater than the distance needed to get out of that zip code. The maximum of these values was calculated by province.

Table 1
Maximum error (in km) by province.

Province	Max. Error	Province	Max. Error	Province	Max. Error
Álava	15.4	Granada	20.3	Palencia	16.1
Albacete	25.6	Guadalajara	13.4	Pontevedra	5.9
Alicante	12.9	Guipúzcoa	6.6	Salamanca	12.2
Almería	14.1	Huelva	14.1	Cantabria	9.4
Ávila	11.5	Huesca	12.3	Segovia	8.2
Badajoz	14.7	Jaén	15.7	Sevilla	17.6
Barcelona	7.9	León	9.2	Soria	13.1
Burgos	12.8	Lérida	10.5	Tarragona	9.5
Cáceres	16.3	La Rioja	13.4	Teruel	11.9
Cádiz	14.2	Lugo	10.5	Toledo	13.7
Castellón	10.3	Madrid	11.0	Valencia	10.9
Ciudad Real	16.0	Málaga	10.8	Valladolid	11.9
Córdoba	15.2	Murcia	12.1	Vizcaya	14.8
La Coruña	8.6	Navarra	9.3	Zamora	8.6
Cuenca	14.1	Orense	9.7	Zaragoza	12.9
Gerona	8.5	Asturias	14.0		

4 Case Study

The company under study is dedicated to the manufacture and distribution of raw materials to the customers' facilities. It is located in Galicia, in northwest Spain, and distributes mainly to the provinces of Orense and Pontevedra, with a portfolio of over 20,000 customers.

For transport it has a fleet of 85 trucks of different capacities, equipped with a GPS controlled by software in real time. The delivery routes are made every day by the shipping department staff based on their experience.

The project the authors develop in the company was focused on reducing transportation costs, that the alternatives considered (reduction of loading and unloading times, increase of resources utilization and other organizational improvements) so were intended to reduce the time and the total driving distance
This reduction was particularly promising because more than 50% of the cost of each truck depended on the kilometers traveled (mainly fuel and depreciation of the truck, but also maintenance and repairs), which could only be reduced improving routes.

4.1 Implementation Process

Purchasing route planning software was taken into consideration to carry out the route optimization project. But before buying, certain issues must be analyzed.

This software requests as starting data the coordinates of all customers, but this information was not available in the database of the company. It only provides address, zip code and name of the town. Using the address or the name of the town was quickly discarded, because these fields had not been entered standardized (partly due to the use of two official languages in that part of Spain: Spanish and Galician).

It was decided to manually enter the first 500 customers by revenue, representing high percentage of total turnover.

This work takes longer than provided (a part-time worker exclusively for 4 weeks) because there was some difficulty finding on the maps customers' facilities, as they are located mainly in rural areas and generally have not good access.

To georeference the remaining customers, the use of the same method was rejected for its high personnel cost and its limited impact on the total turnover of the company. So it was decided to use the approximate method discussed above. This task took less than two days whereas the same part-time worker would have taken almost 4 years at his current cadence of 25 localizations per day.

With this data collected, software was ready for use.

4.2 Results

The average error in this case is much lower than that described in the general methodology since the latter calculates errors for worst possible cases.

This error is calculated by finding the actual error of 500 points entered manually. The total average error was 3.65 km.

Table 2
Comparison of actual errors with the maximum (in km),
in the provinces in which the company operates.

Province	Max. Error (Methodology)	Max. Error REAL	Average Error REAL
La Coruña	8.56	5.24	3.39
Lugo	10.51	10.23	3.77
Madrid	11.04	10.99	10.98
Ourense	9.74	9.69	3.64
Asturias	13.99	12.82	7.24
Pontevedra	5.89	4.91	2.86
Salamanca	12.19	1.91	1.50
Zamora	8.63	4.65	2.11

5 Discussion and future research

The proposed methodology has proved practical, easy and quick to apply. The resulting error levels are acceptable or unacceptable according to the use intended for that data. For relatively long distances (national or international transport) an error of about 10 km is perfectly acceptable. However the degree of accuracy could be insufficient to provide good results for capillary distribution in small distances with many stops.

Some future research could be:

- Application of the method to other countries, in particular would be extremely interesting to others which have postcodes covering smaller areas, such as Portugal and UK.

- Calculation of one or more specific "wiggle factor", which characterizes more precisely the actual distance traveled. It could be calculated for Spain, by province, by type of road, by type of journey (urban or suburban), etc.

- This study could also be complemented with the implementation of the method exposed to different VRP, analyzing if it causes some decrease in the optimal results.

6 Conclusions

In this paper we have presented a methodology which is simple, affordable and reproducible to avoid manual work that requires the implementation of route calculation software.

The results obtained show that, although it might not be the most suitable for short-range or urban transport, is a sufficient approximation for transport of medium and long hauling.

The case study has shown a direct functional application that is intended to serve as an example of the application of this methodology.

7 References

Clarke, G. U., & Wright, J. W. (1964). Scheduling of vehicles from a central depot to a number of delivery points. Operations research.

Colorni, A., Dorigo, M., &Maniezzo, V. (1991).Distributed optimization by ant colonies.In Proceedings of the first European conference on artificial life.

Holland, J (1975): Adaptation in Natural and artificial systems. University of Michigan Press.

Olivera, O. F., Cuervo, J. A., & Ramos, F. N. G. (2012).Sistema de control de posición angular aplicado a dispositivos RF. Visión Electrónica: algo más que un estado sólido.

Vincenty, T. (1975).Direct and inverse solutions of geodesics on the ellipsoid with application of nested equations.Survey review.

Robusto C.C. (1957). The Cosine-Haversine Formula. The American Mathematical Monthly. Vol. 64, No. 1, pp. 38-40.

Ryan, D. M., Hjorring, C., & Glover, F. (1993).Extensions of the petal method for vehicle routeing. Journal of the Operational Research Society.

Solomon, M (1987): Algorithms for the vehicle routing and scheduling problem with time window constraints. Operations Research 35 254–264

An update of Wiggle factor for Spanish road transport

Domínguez-Caamaño P[1], Comesaña- Benavides JA, Prado-Prado JC

Abstract: The Wiggle Factor (WF) is a correction factor defined as the ratio between the real distance travelled by road and the straight line between the two points. It is commonly used to estimate route distances for land transport. Though WF is an approximation, certain degree of accuracy is required, because it is frequently used to calculate fuel costs (which represent approximately half of the total truck costs). This article shows that the most common Wiggle Factor, 1.2, is not a good approximation for Spanish roads. In addition, we present a methodology to calculate the WF that can be applied to other countries or specific zones.

Keywords: wiggle factor, road transport, routing

1 Introduction

Today, measuring distances between two points is available to everyone. There are numerous solutions that allow a basic internet user to know the distance between two points when given either the address (including post-code, name of the city, etc) or the coordinates. It is also a simple task to obtain the actual distances and even alternative routes.

This context is perfect for the proliferation of solutions to optimize transport distances. There are many solutions to vehicle routing problems (VRP), but all of them require to locate customers and suppliers on a graph, to calculate the distances between them.

With a very high number of clients, the straight line distances can be easily obtained, while finding the actual distances between points can be an arduous task.

Some mathematical approaches were developed and improved since the 60s (Christofides & Eilon, 1969; Love & Morris, 1979 y 1988; Berens & Körlig, 1985; Stokx & Tilanus, 1991). Some of those models were based on tachographic distances, but nowadays, software tools allow us to calculate a significantly higher number of routes easily.

To estimate the real distances, Cooper proposed the use of a factor of "curvature of the road" or Wiggle Factor (WF) in the 80's (Cooper, 1983). He determined a value of 1.2 for UK roads, which has been widely accepted and used by the scientific community (Ronen, 1988; Mckinnon & Ge, 2006; Rushton, 2010).

The main advantage of a WF against a mathematical approach is its simplicity, as sometimes ease of calculation and intuitive formulation could be as important as accuracy.

2 Objective

The aim of this paper is to establish a methodology for calculating a WF to suit specific needs.
To show the use of this methodology, a series of WF values are calculated for the mainland of Spain.

1 **Pablo Domínguez Caamaño** (pablo.domínguez@gio.uvigo.es)
Grupo de Ingeniería de Organización (GIO).
Escola de Enxeñería Industrial,
Campus Lagoas-Marcosende, C/ Maxwell, 36310 Vigo, Spain.

3 Methodology

The process is divided into three stages:

1. Selection of key points to calculate distances

The selected points depend on the type of path you want to analyze.

If a general WF is required a good option is to choose random points. However, if one wants to analyze a particular type of infrastructure, only points connected by one of those should be chosen.

If the points are too close, non-representative values could be obtained, thus one should choose them separated enough (with a minimum distance) and never in the same town.

2. Getting straight line and road distances

Straight distances can be easily calculated either by using spherical trigonometry or more accurate methods like Vincenty formulae (Vincenty, 1975).

To find distances by road, a simple and feasible option is to use *a GPS* navigation software or a route calculation system.

3. Calculation of WF and analysis of results

The WF for each path is obtained by dividing the road distance by the straight-line distance.

Thus, by analyzing a significant number of routes, a general WF can be found averaging individual WFs.

4 WF in Spanish roads

To determine this value we have followed the methodology presented above. The goal is to get two factors, one for any pathway and another exclusively for high-capacity routes (typically motorways).

4.1 Selection of key points to calculate distances

To obtain the first WF, 149 random points were selected, which generated over 11,000 routes.
For the second, 47 capitals of province generated 1,081 routes

4.2 Getting straight line and road distances

The straight line distances were obtained using the coordinates and the Haversine formula (Robusto, 1957). This formula uses spherical trigonometry to find the shortest distance, so an error is committed considering that the Earth is a sphere. This error is not significant if the points have similar latitudes.
Road distances were obtained using the APIs (Application Programming Interfaces) of Google Maps. Supplying the coordinates of two points, these APIs return the distance in kilometers between them.
This requires sending the Google Maps servers a query like this:

```
http://maps.googleapis.com/maps/api/distancematrix/json?origins=|lat1,lon1&destinations=|lat2,lon2
```

where Lat1, Lon1, Lat2 and Lon2 are the coordinates to the points for which distance is requested.
An example of this query is:

```
http://maps.googleapis.com/maps/api/distancematrix/json?origins=|43.0881092,-9.1566855&destinations=|42.5799573,-8.9617984
```

From this query, Google Maps servers send the distance and travel time, for which they use the following format:


```
{
  "destination_addresses" : [ "Rúa Mt Lorenzo Mene Trabad, 13, 15959 Ribeira, A Coruña, Spain" ],
  "origin_addresses" : [ "Unnamed Road, 15125, A Coruña, Spain" ],
  "rows" : [
    {
      "elements" : [
        {
          "distance" : {
            "text" : "79.5 km",
            "value" : 79480
          },
          "duration" : {
            "text" : "1 hour 30 mins",
            "value" : 5421
          },
          "status" : "OK"
        }
      ]
    }
  ],
  "status" : "OK"
}
```


As shown in the example, the sub-element "distance" has two values that include the distance. The first in textual format and the second in numeric format ("value", presented in meters)

This process, as described in the preceding paragraphs, was performed for all possible pairs of points.

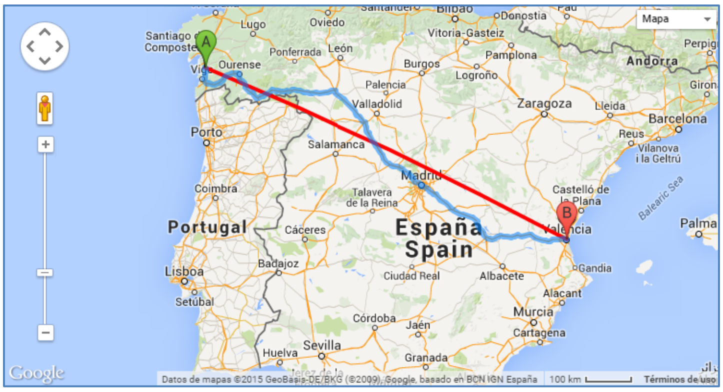

Fig.1
Distances between Pontevedra and Valencia.
Straight line distance (769 km) vs road distance (972 km). WF = 1.26.

4.3 Calculation of WF and analysis of results

A WF value was calculated for each route by dividing the actual road distance by the straight line distance.
Mean and Standard deviation have been calculated for each case.

Table 1
WF data.

Case	Mean	Std. dev.
Random points	1.36	0.157
Capitals	1.29	0.111

The results show that both mean and deviation are higher in the first case.

Most of the Spanish area (84.2%) is considered rural (INE, 2012). Thus, the first WF characterizes mainly road infrastructure in these areas.

The second WF characterizes high-capacity roads (typically motorways).

Therefore, for rural areas the first one must be used while the second one would be most suitable for long haul using high-capacity roads. Using a WF is not recommended for urban transport.

5 Discussion and future research

The Cooper's WF value 1.2 is the most widely used to date. In this paper we demonstrate that it is not a good approximation for the Spanish road infrastructure.

Furthermore, using the proposed methodology, different WF values can be easily calculated for specific geographical areas or infrastructure, which helps improving accuracy.

Future research could focus on the calculation of various WF with different levels of detail, or even differ-rent infrastructures such as railways.

6 Conclusions

In this paper we have presented a methodology to calculate a Wiggle Factor for any situation. This method-logy is simple enough to be applicable to other geographic areas without any specific software tool, which makes it very useful in cases when one tries to optimize transportation routes quickly and economically.

Moreover, the paper presents an update of the WF value in Spain, distinguishing two variants for different contexts.

7 References

Berens, W., & Körling, F. J. (1985). Estimating road distances by mathematical functions. European Journal of Operational Research.

Christofides, N., & Eilon, S. (1969). Expected distances in distribution problems. OR.

Cooper, J. C. (1983). The use of straight line distances in solutions to the vehicle scheduling problem. Journal of the Operational Research Society.

Instituto Nacional de Estadística (INE) (2012). "Cifras Oficiales de Población de los Municipios Españoles: Revisión Anual del Padrón Municipal"

Love, R. F., & Morris, J. G. (1979). Mathematical models of road travel distances. Management Science.

Love, R. F., & Morris, J. G. (1988). On estimating road distances by mathematical functions. European Journal of Operational Research.

McKinnon, A. C., & Ge, Y. (2006). The potential for reducing empty running by trucks: a retrospective analysis. International Journal of Physical Distribution & Logistics Management.

Robusto C.C. (1957). The Cosine-Haversine Formula. The American Mathematical Monthly. Vol. 64, No. 1, pp. 38-40.

Ronen, D. (1988). Perspectives on practical aspects of truck routing and scheduling. European journal of operational research.

Rushton, A (2010). The handbook of logistics and distribution management. Kogan Page Publishers.

Stokx, C. F. M., & Tilanus, C. B. (1991). Deriving route lengths from radial distances: Empirical evidence. European journal of operational research.

The Influence of the Crossover Operator on Genetic Algorithms Applied to the Job Shop Scheduling Problems

Modolo V[1], Menezes F[1], Grassi F[1], Pereira F[2]

Abstract: Due to its complexity, the job shop scheduling problem is classified as NP-hard and therefore, extremely difficult to solve. In general, these problems are addressed using metaheuristics optimization techniques such as the Genetic Algorithm (GA). In the search for better solutions using the GA, a number of different approaches of the method have been proposed varying - among other things - the form of representation of the solution, thus requiring the design of custom genetic operators. In theory, the form of representation and the operators may influence the generation of feasible solutions and, therefore, the use of traditional operators may be preferable. The objective of this article is to study the effects of the canonical crossover operators in a binary version of the GA, applied to the job shop environments, regarding the quality of the solution and the proportion of feasible solutions generated in the process of optimization.

Keywords: Production scheduling, Job shop, Genetic algorithm, Crossover operators.

1 Introduction

Combinatorial optimization problems are problems for which the difficulty of resolution grows exponentially, and fit the types of problems known in the literature as NP-hard (Fan; Zhang, 2010). The main difficulty has been the large number of possible solutions, which results in a very large search space, preventing the use of exact methods, such as branch-and-bound algorithm, in which the computational cost would be huge (Reeves, 1993). Therefore to deal with NP-hard combinatorial optimization problems, researchers have been using heuristics and meta-heuristics methods, due to several approaches and quickly finding sub-optimal solutions, or even optimal ones, in a reasonable computational time (Norving; Russel, 2004).

Among the combinatorial optimization problems, the job shop scheduling problems are one of the most recurring in the literature, which briefly is to allocate limited resources to perform a set of tasks (Pinedo, 2008; Jain; Meeran, 1999). In this context, the use of Genetic Algorithms (GA) has been widespread (Gonçalves et al, 2005; Lukaszewicz, 2005; Qing-Dao-Er-Ji; Wang, 2012; Wang; Zheng, 2002; Abdelmaguid, 2010). In the search for better solutions using the GA, various approaches have been proposed, such as the representation of the solution (Abdelmaguid, 2010). In general, the different representations require the customization of genetic operators which may compromise its efficacy. Deserves special attention in this case the crossover operator, which can produce a major impact on the number of solutions generated in the GA (Garen, 2002; Jain; Meeran, 1999).

Recently, a genetic algorithm with binary representation was proposed (DSGA), based on indirect representation of the solutions for the scheduling problem, using a concept of dynamic seed to produce solutions (Grassi; Triguis; Pereira, 2014). The approach makes use of the canonical operators, originally developed for the binary representation, in order to minimize the generation of non feasible solutions,

1 **Valdemar Modolo Júnior** (vmodolo@uninove.br)
Fenanda Morán Menezes (fernandamoran@uninove.edu.br)
Flavio Grassi (flaviograssi.fg@gmail.com)

2 **Fabio Henrique Pereira** (fabiohp@uninove.br)
Industrial Engineering Post Grad Program, Universidade Nove de Julho.
Francisco Matarazzo, Av., 612, 05001-100, Água Branca, São Paulo, Brazil.

which is a recurring problem in approaches involving specialized operators. That study highlights the efficiency of the dynamic seed approach in the generation of feasible solutions, but does not make any further investigation of the effects of different types of crossover operators. The objective of this article is to study the effects of the canonical crossover operators in the DSGA, applied to the scheduling problems in job shop environments, regarding the quality of the solution and the proportion of feasible solutions generated in the optimization process.

2 Job Shop Scheduling Problems

The Job Shop Scheduling Problem (JSSP) can be described as follows:

There are a finite number of jobs and machines, where a job is defined by a sequence of operations that must be performed in a given ordination, which are known as tasks. Each of these operations is performed by a machine that consumes certain amount of time, and each machine can perform only one operation at a time, where preemption is not allowed. The machines can be grouped according to its tasks in a real world environment (Pinedo, 2008).

In the Job Shop, the sequences of machines each job must be processed are fixed, so the problem to be solved is to determine the sequence of the jobs on each machine, such that the execution time elapsed since the beginning of the first job to the end of the last, is reduced to the minimal. This measure is known as makespan, and is often used as a benchmark for comparison of performance because it is one of the simplest criteria for measuring performance on scheduling problems (Rodammer; White, 1988).

3 Genetic Algorithm

Genetic Algorithm (GA) is a technique that consists in finding solutions based on mechanisms that mimic the Darwinian process of evolution. In general, it differs from other heuristic methods in the following aspects: it deals with a set of points known as population instead isolated points; it operates in an encoded area instead directly in the search space of the solutions, using the value of an objective function, called fitness; and it uses probabilistic transition rules, rather than deterministic ones (Goldberg, 1989).

The classic procedures performed by a GA is to create an initial population and calculate the fitness value of each point, called individuals or chromosomes. The development of new generations in this population is also carried out by inserting the chromosomes in the current population using genetic operators: the crossover and the mutation. The crossover operator determines the mechanism that combines two or more existing chromosomes to create two or more children; the mutation operator promotes random changes in chromosomes, in order to cover as much of the options and ensure a broader access to the search space.

One of the most critical steps in GA is the way in which the solutions are represented and the way the crossover operators work with them, because an inadequate definition of the representation may cause an increase in non-feasible solutions when individuals are modified by the action of the crossover and mutation.

Among the different approaches, the binary representation is considered the traditional one, wherein the solutions are encoded using binary strings of length *n*.

The motivation for the use of binary encoding comes from the theory of schemes (Holland, 1975). Being easy to use and handle, simple to analyze and theoretically there is no uniformity in the operators.

3.1 Crossover Operators used in a Binary Representation

As mentioned earlier in this research, the representation is one of the most important steps when one makes use of genetic algorithms, and for each type of representation of the solutions it also has distinct types of crossover operators, due the fact the way each chromosome is encoded is intrinsically related to the crossover operation. This means that certain types of crossover operators used in the binary representation does not make sense if applied to other representations. In the context of binary representation, we highlight the following three types of crossover operators: one-point crossover, uniform crossover, and the even odd crossover.

3.1.1 One-Point Crossover

This method randomly chooses one point of intersection, thereby dividing the chromosome into two parts. After the split, there is an exchange of the position among the called father 1 and father 2. One child will have the first segment of the father 1 and the last segment of the father 2, where the other child will be the reverse.

3.1.2 Uniform Crossover

The method used by uniform crossover operator is based on a randomly generated bit mask. In order to generates the first new chromosome (child 1), a bit mask, previously generated, is read sequentially (bit by bit), and when the mask bit is equal to 1, the child receives the bit value from the father 1, otherwise it receives the bit value from the father 2.The rule is reversed for the generation of the second child. Applied to GA, there is no substantial differences on the performance of the uniform crossover compared to the n points crossover when $n > 1$. The one-point crossover is the case when $n = 1$, where n is the number of points that will be chosen to segment the chromosome.

3.1.3 Even Odd Crossover

In the even odd crossover, the new generated child takes the bit values of the even alleles from one father and the odd alleles from the other father, according to their position. Then the reversed process takes place in order to generate the second child.

4 Materials and Methods

This paper deals with the Genetic Algorithm with Dynamic Seed as presented in (Grassi; Triguis; Pereira, 2014). The approach applies a classic GA as an inner level, in which the candidate solutions are generated through a permutation of a initial feasible solution called seed. To ensure the viability of the initial solution, the seed is generated based on the FIFO rule (first in, first out), which operates a permutation based on the binary chromosome.

Additionally, an external level runs to update the seed dynamically. After the execution of a number of classic GA generations in the inner level, the best solution obtained and the corresponding permuted seed are used in a new internal iteration of the GA.

The experiments were designed to evaluate the effects of crossover operators in the results of makespan and the proportion of feasible solutions. These experiments have been accomplished using a two-way ANOVA without replication, which means only one observation for each combination of the nominal variables. So, the interaction effects between the factors were not considered. A subset of JSSP benchmarks known as LA (Lawrence, 1984), were used in the experiments. The implementation of the method was performed using the GAlib, which is a GA library written in C ++ by Matthew Wall, from the Massachusetts Institute of Technology (GAlib, 2012).

Table 1 present the GA parameters adopted during the experiments. The choices of the values were mostly based on literature (Yamada, 2003; Mitchell, 1997).

5 Results

Crossover operators and rates were varied as defined in Table 1, and the results of the proposed approach was compared with Abdelmaguid (2010), who makes use of the AG with six usual representations for JSSP as follows: Operation-Based (OB), Random Key (RK), Preference List-Based (PL), Priority Rule-based (PR), Machine-Based (MB), and Job-Based (JB). Table 2 shows the makespan values obtained with each of the representations, in which N and BK stand for the number of operations and the best known makespan, respectively.

For the tested problems, the DSGA had equal or better results for all the approaches evaluated, but the LA04, in which the MB approach found the best known value, while the DSGA presented a gap of 0.8% compared to the earlier. In terms of computational times, however, the MB representation took an average of 550 seconds to solve problems with 50 operations, compared to about 35 seconds on the DSGA.

As expected, the higher the crossover rate, the higher the total number of evaluations, due a higher number of newly created different individuals that need to be evaluated. In fact, considering the LA01, the total number of evaluations is the parameter that is more affected in response to the crossover rate. It is also observed an influence of crossover rate, albeit smaller, the proportion of feasible solutions, as can be seen in Table 3 in the analysis of variance.

Table 1
GA parameters adopted.

Parameter	Value
Representation	Binary (DSGA)
Selection	Steady State
Replacement Rate	90%
Population Size	10
Crossover	One-Point (OP), Uniform (UN), Even Odd (EO)
Crossover Rate	30%, 50%, 70%, and 90%
Mutation	Flip Bit
Mutation Rate	1%
Generations	≥ 10,000 (25 inner and 400 externals)
Stop Criteria	400 * (25 generations without improvement)
Fitness Function	Simulation model coded in C language

Table 2
Best results obtained in each approach.

Problem	N	BK	OB	RK	PL	PR	MB	JB	DSGA
LA01	50	666	**666**	**666**	675	671	**666**	700	**666**
LA02	50	655	676	686	715	675	684	718	**655**
LA03	50	597	631	637	669	650	625	645	617
LA04	50	590	607	614	633	629	**590**	675	595
LA05	50	593	**593**	**593**	**593**	**593**	**593**	605	**593**

The results of the effects of the crossover operators and crossover rate over the makespan, the proportion of feasible solutions, and the total number of evaluations, for the LA02 problem, are presented in Table 4. Values in bold represent that the best known solution was obtained. The influence of the crossover rate on the proportion of feasible solutions is especially important because it is the reflection of a positive correlation between these two variables (correlation coefficient, R = 0.973367). This means that the higher the crossover rate, the more feasible solutions are generated. The results in this direction were similar for all other cases tested. Was observed in all cases (except in LA05 problem) a low negative correlation between the proportion of feasible solutions generated and the value of makespan (coefficient, R ≈ -0.5). This indicates that the generation of a higher number of feasible solutions can lead to better makespan values, as expected.

Table 3
Analysis of the effects of the factors over the responses to the LA01 problem: makespan (*mkp*), proportion of feasible solutions (*%fs*), and number of evaluations (*n*).

Source of Variation	*Mkp*	*%fs*	*n*
	p-value	*p-value*	*p-value*
Operators	0.779	0.844	0.517
Crossover Rate	0.145	0.034	0.000

Table 4
Results for the LA02 problem.

Operator	Rate	Makespan	% Feasible	Evaluations
ED	0.3	705	0.9269	52149
ED	0.5	667	0.9422	63216
ED	0.7	670	0.9464	74410
ED	0.9	670	0.9464	74410
OP	0.3	660	0.9318	52315
OP	0.5	667	0.9383	62994
OP	0.7	672	0.9478	74198
OP	0.9	655	0.9565	84957
UN	0.3	660	0.9314	52577
UN	0.5	710	0.9372	63081
UN	0.7	667	0.9490	74121
UN	0.9	672	0.9548	85145

6 Conclusions

This paper conducted a study of the effect of crossover operator in the performance of the genetic algorithm when applied to the job shop scheduling problem. The experiments were performed using a genetic algorithm schema with dynamic seed, which is based on an indirect binary representation of the solution.

By adopting the binary representation, unusual for this sort of problem, the DSGA allows the use of conventional operators, which in theory, are more efficient considering the generation of new feasible solution by crossing other viable solutions each other. The experiments demonstrate that, in general, the tested operators have no such a influence on the results. However, it was observed that the crossover rate has a positive correlation, and close to 1.0, leading a higher proportion of feasible solutions generated in the search process, therefore contributing to the convergence to better makespan values.

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8 References

Abdelmaguid, T. F. (2010) Representations in genetic algorithm for the job shop scheduling problem: a computational study. *Journal of Software Engineering and Applications*, 3:1155-1162.

Fan, K.; Zhang, R. (2010) An analysis of research in job shop scheduling problem (2000-2009). *IEEE International Conference on Advanced Management Science*, Chengdu (China), 1:282-288.

GAlib: *A C++ library of genetic algorithm components* [online]. Available from: http://lancet.mit.edu/ga/dist/ [Accessed November 19, 2012].

Garen, J. (2002) Multiobjective job-shop scheduling with genetic algorithms using a new representation and standard uniform crossover. *Workshop on Multiple Objective Metaheuristics*, Paris.

Goldberg, D. E. (1989) *Genetic algorithms in search, optimization and machine learning*. New York: Addison-Wesley.

Gonçalves, J. F., Mendes, J. J. M., Resende, M. G. C. (2005) A hybrid genetic algorithm for the job shop scheduling problem. *European Journal of Operational Research*, 167 (1):77-95.

Grassi, F.; Triguis, P. H.; Pereira, F. H. (2014) Dynamic seed genetic algorithm to solve job shop scheduling problems, *International Journal of Production Research*, submitted for review.

Holland, J. H. (1975) *Adaptation in natural and artificial systems*. University of Michigan Press.

Jain, A. S., Meeran, S. (1999) Deterministic job-shop scheduling: past, present and future. *European Journal of Operational Research*, 113 (2):390-434.

Lawrence, S. (1984) *Resource constrained project scheduling: an experimental investigation of heuristic scheduling techniques* (Supplement). PhD thesis, Carnegie-Mellon University.

Lukaszewicz, P. P. (2005) Metaheuristics for job shop scheduling problem, comparison of effective methods. PhD thesis, Aarhus School of Business.

Mitchell, T. M. (1997) *Machine Learning*. New York: McGraw-Hill.

Pinedo, M. L. (2008) Scheduling: Theory, algorithms, and systems. New York: Springer.

Qing-Dao-Er-Ji, R., Wang, Y. (2012) A new hybrid genetic algorithm for job shop scheduling problem. *Computers & Operations Research*, 39 (10):2291-2299.

Reeves, C. R. (2003) *Genetic algorithms*. In: Glover, F.& Kochenberger, G.A. (Eds.), *Handbook of metaheuristics*. Boston, USA: Kluwer Academic Publishers, 55-82.

Rodammer, F. A., White, Jr. K. P. (1998) A Recent Survey Of Production Scheduling. *IEEE Transaction on Systems, Man and Cybernetics*. 18(6):841-851.

Russel, S.; Norvig, P. (2002) *Artificial Intelligence: A Modern Approach*. Englewood Cliff: Prentice Hall.

Wang, L., Zheng, D. Z. (2002) A modified genetic algorithm for job shop scheduling. *International Journal of Advanced Manufacturing Technology*, 20 (1):72- 76.

Yamada, T. (2003) Studies on metaheuristics for jobshop and flowshop scheduling problems. PhD thesis, Kyoto University.

Controlling Production in Hybrid Make-to-Stock/Make-to-Order Manufacturing

Oliveira P[1], Pereira M[2], Barros P[3], Pereira G[4], Dias L[5], Fernandes N[6], Carmo-Silva Sthor[7]

Abstract: The hybrid make-to-stock/make-to-order manufacturing is a well-known strategy that captures the benefits of both make-to-stock and make-to-order strategies. This paper addresses this hybrid environment in a two-stage flow shop system with an intermediate buffer between stages. The study provided guidelines for selecting an appropriate production control mechanism for releasing orders to the MTO stage, when the MTS stage is operated under a simple base-stock replenishment policy. Results show that workload based order release can be a suitable approach to production control in this hybrid production environment.

Keywords: hybrid make-to-order/ make-to-stock; Base-stock; POLCA; WLC.

1 Introduction

Worldwide competition is compelling manufacturing companies to shorten delivery times (Morikawa et al. 2014), while offering high product variety. The hybrid make-to-stock (MTS)/make-to-order (MTO) manufacturing allows companies to delay differentiation, reducing delivery times and inventory costs in comparison to the pure MTO and MTS strategies, respectively.

Manufacturing MTS and MTO items in two stages is a challenging task. In the MTS stage, common components or semi-finished products are firstly produced to an intermediate inventory. In the MTO stage, the semi-finished components are assigned to customer orders for customization. The intermediate inventory acts as a decoupling point between stages. High inventory of semi-finished products means high holding costs, whereas low inventory may increase the waiting time of orders and delivery times due to stock-outs. Therefore, in addition to inventory decisions, order release and dispatching decisions should determine the company capability to quote short and reliable delivery times and, thus, to remain competitive. In spite of this, most research on inventory location in supply chains ignores the intricacies of scheduling, typically assuming that orders are processed in the sequence in which they arrive to the production system (Kaminskya and Kayab, 2008).

In this paper, we study the controlled release of orders to the MTO, combined with inventory replenishment using a Base-stock policy (Kimball 1988; Lee and Zipkin 1992) at the MTS stage. The production control mechanisms applied at the MTO stage are workload Control (WLC) (Bertran and Wingaard, 1986; Kingsman 2000; Stevenson et al., 2005) and POLCA (paired-cell overlapping loops of cards with authorization) (Suri, 1998). The objective is to satisfy the MTO demand within competitive delivery times and, at the same time, to avoid the stock-outs of semi-finished products made to stock. The controlled release of orders to the MTO stage ensures that orders are not released too early or too late, while maintaining the workload at workstations low and stable. Inventory replenishment according to a Base-stock policy ensures that the semi-finished products' buffer is filled to the required level, without a rigid order release plan to the first stage.

Most of the workload-based order release studies found in the literature refer to job shops and MTO manufacturing. Research effort in the area of workload control for MTS-MTO systems with

1 Universidade do Minho, Portugal (pg27695@alunos.uminho.pt)
2 Universidade do Minho, Portugal (pg26620@alunos.uminho.pt)
3 Universidade do Minho, Portugal (pg28497@alunos.uminho.pt)
4 Universidade do Minho, Portugal (gui@dps.uminho.pt)
5 Universidade do Minho, Portugal (lsd@dps.uminho.pt)
6 Instituto Politécnico de Castelo Branco, Portugal (nogf@ipcb.pt)
7 Universidade do Minho, Portugal (scarmo@dps.uminho.pt)

unidirectional production flows is rather limited. Moreover, to the best of our knowledge WLC and POLCA hardly have been compared in this environment. This paper seeks to address this research gap, by investigating the impact of load-based order release in the context of the hybrid MTS-MTO production environment above described. Discrete event simulation is used to model and analyse the system performance under the production control mechanisms referred. In particularly the following research questions are addressed: what is the level of inventory that should be held at the intermediate buffer of semi-finished products in order to obtain a given fill rate? How should orders be released to the MTO stage?

The remainder of this paper is organized as follows. In Section 2, we present the simulation study carried out, including the simulation model, the experimental set-up and the performance measures considered. In Section 3, we discuss the results of the simulation study, and finally, in Section 4 of the paper, we summarize key results and managerial implications.

2 Simulation Study

We consider a simulation model of a hypothetical two-stage manufacturing system with unidirectional production flows. Stage one consists of workstations 1, 2 and 3, and manufactures common components from raw materials. Stage two consists of workstations 4, 5 and 6, and manufactures end items to order, according to the customer specifications, from components made at stage one. Whenever a customer order arrives a common component available in the intermediate buffer is allocated to the order. We assume that each customer order requires just one component. However, when a customer order arrives and finds the intermediate buffer empty, the order is backordered. Backorders are filled after the common components become available following processing at stage one. The first stage is capable of manufacturing two different common components that are then customised in the second stage into, virtually, an infinite number of end products.

As customer orders arrive their operation times are identified and due dates established. It is assumed that all orders are accepted and enough raw materials are always available in the beginning of the first stage. Orders inter-arrival times follow an exponential distribution and, as in previous studies (e.g., Oosterman et al., 2000), due dates are market driven and set by adding a uniformly distributed time allowance to the order arrival time. In this study, the allowance varies between 25 and 45 time units. This leads to approximately 8% of orders being tardy when immediate release of orders to the second stage is used, for a fill rate level of 90%. This has been verified through preliminary simulation tests. The 90% fill rate level means that 90% of arriving customer orders are filled from inventory and then made immediately available for release into the second stage.

In the simulation model, operations' processing times follow an exponential distribution, with a mean of one time unit. The arrival rate combined with the routings and processing times ensures that utilisation is 90% at all workstations, except at workstations four and six. These have 20% of protective capacity. This means that, in the second stage, workstation five is a bottleneck. Moreover, we have made the following assumptions: (a) workstations operate asynchronously; (b) workstations capacity remains constant over time and no breakdowns have been modelled; (c) set-up times are sequence-independent and included in the operation processing times; (d) distances and transportation times are assumed to be negligible; (e) information of production control events is transmitted instantly.

2.1 Production Control at the Two Production Stages

Production Control addresses two main functions: order release and materials flow control. Order release determines the time and the orders to be released into each production stage. Release decisions are usually based on order urgency and on its influence on the current shop floor situation (Henrich et al., 2004). Materials flow control coordinates the flow of materials and production needs throughout the production process. This essentially involves workstation activation, i.e., the start of processing when materials are available and taking decisions for moving production orders between workstations. Clearly, priority-dispatching rules play an important role within materials flow control. These determine which orders in queue should be selected next for processing once a workstation becomes idle.

In the production system considered, an arriving customer order will consume a semi-finished product from the intermediate buffer and flows immediately into a pre-shop pool, waiting its release to the second production stage. So, orders must wait in the pool for capacity availability at the second stage. The use of a pre-shop pool can reduce the level of work-in-process (WIP) and allow better control over the flow of production orders through the shop. Orders in the pool are sequenced according to their urgency, i.e., to their due date, and released under the control of a specific release method. When a customer order arrives at the production system, an MTS order is also released to the first stage for the replenishment of the common component consumed by the customer order. Base-stock control is applied at the first stage of processing for production control. Under this mechanism, demand information is simultaneously transmitted to all workstations of stage one when a customer order arrives to the production system. The idea is that all workstations know about each customer order as it arrives and start immediately to manufacture a replacement item.

The role of priority dispatching is a very modest one when order release control is applied, because the choice among jobs is limited due to short queues (Land and Gaalman 1998). Thus in this study shop floor dispatching at both stages is based on the *first-come-first-served* (FCFS) priority dispatching rule that supports the natural flow of the orders through the shop, stabilising operation throughput times.

2.2 Experimental Design and Performance Measures

Thirty-six simulation cases were tested (2 order release mechanisms; 9 workload norms/ POLCA cards; and 2 levels of the fill rate), and each test case runs 100 replicates. The time horizon for a simulation run was 93000 time units and only data of the last 90000 time units were collected.

The release of orders to the second stage of production was tested at two levels, i.e., under POLCA control and under Workload Control (WLC). POLCA operates by providing a fixed number of production authorisation cards at each pair of workstations. POLCA uses overlapping loops of cards between workstations. These ensure that workstations will only process orders for which capacity has been reserved at the next downstream workstation in the manufacturing routing of the order. Cards are not part number specific and can be acquired by any order waiting release in the pre-shop pool or entering the first workstations of the pair. Cards are attached to an order at the first workstation of the pair and detached after its completion at the second workstation. Detached cards are sent back to the first workstation, where they can be attached to new production orders entering the system. In our study we consider that one order requires just one production authorisation card from each pair of workstations in the routing of the order.

WLC operates by releasing orders to the shop floor at fixed time intervals, of 4 time units in our study, in such a way that each workstation is provided with a balanced inflow of work and workstations' maximum limits of workload authorized, i.e. the norms, are not exceed. Workload accounting is based on the corrected aggregate load approach (Oosterman et al., 2000). At the moment of order release to the shop floor, there is a contribution to load of each workstation which the released order will visit. After operation completion, this contribution is deducted from the workload of the respective workstation.

The mechanism applied to release orders to the second stage of processing was tested at 9 levels of restriction by tightening workload norms (in the case of workload control), or by restricting the number of available cards *per overlapping loop* (in the case of POLCA), stepwise down from infinity. Norm levels are limits imposed to the workload allowed at workstations. Infinity means that no limit is imposed on the workload that can be released to the shop. Card counts are limits on the number of cards that can be used to operate the production system. When infinity is assumed, this means that no restriction is imposed on the number of jobs that can be released to the shop or entering *overlapping loops*.

The order fill rate, which is the percentage of orders filled from the semi-finished products buffer, was tested at two levels, namely 90% and 99%. Note that the fill rate is expected to approach 100% as the semi-finished products inventory increases and tends to infinity. Thus, Base-stock control aims at determining the minimum inventory at each workstation of the first stage to achieve the desired fill rate, i.e., 90% and 99%. This was determined through pre-test simulation runs.

Performance was measured using the percentage of tardy orders, the standard deviation of lateness (StdL), the shop throughput time STT) and the total throughput time (TTT). The STT refers to the time that elapses between order release to the second stage and order completion. The TTT is the STT plus the pool delay and plus the time that orders wait for semi-finished products availability. We also recorded the average inventory of semi-finished products required to achieve a given fill rate and the order waiting time, i.e. the time that orders wait for semi-finished products availability at the intermediate buffer.

3 Simulation Results and Discussion

This section discusses the results of the simulation study described in the previous section. Comparisons between the production control mechanisms are based on the Student paired t-test. Results are summarised in Table 1 and in Figure 1. In Figure 1 the percentage of tardy orders, the total throughput time and the standard deviation of lateness are plotted against the shop throughput time for different combinations of the experimental factors. By comparing plotted curves we can determine the differences in performance between production control mechanisms. A marker on a curve is the result of simulating the mechanisms at a specific workload norm or card count. Nine workload norm levels/card counts have been simulated, including infinity. Infinity means periodic unrestrictive release of orders to shop floor in the WLC curve and immediate release in the POLCA curve, and refers to the rightmost mark on each curve.

Table 1
Average inventory of semi-finished products and order waiting time.

Performance results	90% Fill Rate	99% Fill Rate
Average Inventory	15.3	38.9
Order waiting time	1.20	0.08

From Table 1 it can be observed that, as expected, for a higher fill rate a higher average inventory of semi-finished products is required. It also results in a lower order waiting time for semi-finished products. Increasing the fill rate from 90% to 99% increases the average inventory of semi-finished products about 154%, i.e., from 15.3 to 38.9 units and decreases the order waiting time about 93%, i.e. from 1.2 time units to 0.08 time units.

From Figure 1 it can be observed that increasing the fill rate from 90% to 99%, leads to a lower percentage of tardy orders for both mechanisms applied to the MTO stage. A higher fill rate means a higher probability of orders being filled from the intermediate buffer of semi-finished products, and therefore, lower shop throughput times throughout the MTO stage and lower percentages of tardy orders are likely to result. However, this is obtained at the cost of having a higher inventory of semi-finished products between production stages. Although a lower percentage of tardy orders is obtained, this seems not to be due to a reduction in total throughput time as this slightly increases with the fill rate (see Figure 1b). So, there has to be a reduction in the standard deviation of lateness for the 99% fill rate to justify the tardy orders curve behaviour, as in fact it happens.

Note that a lower percentage of tardy orders may result from a lower average lateness and/or a lower variance of the lateness. The former is achieved by having lower total throughput times. Since the total throughput time is the shop throughput time plus the pool delay and the time that orders wait for semi-finished products availability, and having into account that the order waiting time for semi-finished products is lower under a 99% fill rate, as shown in Table 1, we can conclude that increasing the fill rate increases the pre-shop pool delay of orders.

Results also show that WLC outperforms POLCA for the percentage of tardy orders under both, 90% and 99% fill rate. One possible explanation and conclusion for this, is that the workload-based release of WLC is a better strategy for orders' release in production situations with high-variety, customization and unidirectional production flows, than the one adopted by POLCA, solely based on the number of jobs, and not on their workload.

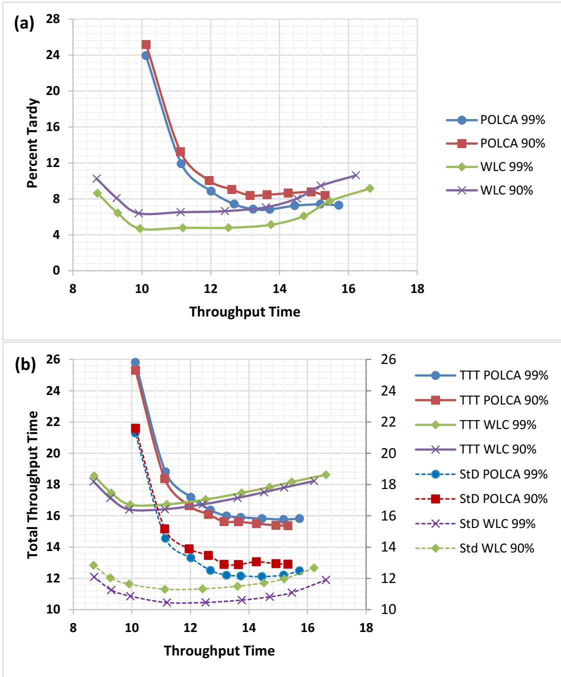

Fig.1
Performance results for:
(a) percentage of tardy orders;
(b) total throughput time (TTT);
and standard deviation of lateness (StD Lateness).

4 Conclusions and Managerial Implications

The main goal of this research was to extend the application of workload control (WLC) theory to the hybrid make-to-stock/ make-to-order (MTS-MTO) production environment. In the study it was verified that WLC outperforms POLCA in the ability to deliver orders on time. This was verified for different levels of service to the customer surrogated by the fill rate from inventory to arriving customer orders. Therefore, unless practical advantages can be envisaged by the use of car-based mechanisms, such as POLCA, WLC should be used to control the release of order to the MTO stage.

The results also show that simulation can be used to determine the suitable levels of inventory of semi-finished products for achieving a given fill rate. The ability of discrete-event simulation not only for evaluating the performance of production control mechanisms, but also for tuning the control parameters for high performance can be seen as appealing functionalities to managers in practice.

Evaluating the impact of broader sets of replenishment control policies and shop configurations in context of the hybrid MTS-MTO production is an issue that deserves further investigation and will be addressed by the authors in future work.

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6 References

Bertrand, J. W. M., and Wingaard, J. (1986). The structuring of production control systems. International Journal of Operations & Production Management, 6(2), 5-20.

Henrich, P., Land, M. and Gaalman, G.J.C. (2004). Exploring applicability of the workload control concept, International Journal of Production Economics, 90 (2), 187-198.

Kaminskya, P. and Kayab, O. (2008). Inventory positioning, scheduling and lead-time quotation in supply chains, International Journal of Production Economics 114 (1) 276–293.

Kimball, G., (1988). General principles of inventory control. Journal of Manufacturing and Operations Management, 1(1), 119-130.

Kingsman, B.G., (2000). Modelling input-output workload control for dynamic capacity planning in production planning systems, International Journal of Production Economics, 68(1), 73-93.

Land, M.J. and Gaalman, G. (1998) The performance of workload control concepts in job shops: Improving the release method, International Journal of Production Economics 56-57 (1) 347-364.

Lee, Y.J. and Zipkin, P. (1992). Tandem queues with planned inventories. Operations Research, 40(5), 936-947.

Morikawa, K., Takahashi, K. and Hirotani, D. (2014). Make-to-stock policies for a multistage serial system under a make-to-order production environment. International Journal of Production Economics, 147, 30–37.

Oosterman, B., Land, M. and Gaalman, G. (2000). The influence of shop characteristics on workload control. International Journal of Production Economics, 68(1), 107-119.

Stevenson, M., Hendry, L. C., and Kingsman, B. G. (2005). A review of production planning and control: the applicability of key concepts to the make-to-order industry. International journal of production research, 43(5), 869-898.

Suri, R. (1998). Quick response manufacturing: a companywide approach to reducing lead times. Productivity Press.

Comparison of different production strategies for the economic lot scheduling problem under different environments. A simulation study

Cortés-Fibla R[1], Vidal-Carreras PI[2], García- Sabater JP[3]

Abstract: In the present work we carry out a simulation study to compare the performance of production strategies for the Economic Lot Scheduling Problem (ELSP). The search for the production strategy for the ELSP with the best performance has necessarily to introduce the consideration of the production environment. We suggest some elements affecting the production environment, such as utilization, number of items, and stochastic behavior on demand. Under this approach, we compare, through a simulation study, the cost of five different production strategies. The results of this study confirm that the performance a production strategy is strongly dependant on utilization and number of items.

Keywords: ELSP; Scheduling; Simulation; Complexity; Uncertainty.

1 Introduction

The economic order quantity (EOQ) inventory model, was presented by (Harris 1913). Since then, inventory management has been an area of intensive research, with a great number of published works, since it is a key activity, and thus an area of concern, in any manufacturing facility. A particular area of research in inventory management is the economic lot scheduling problem (ELSP), which focuses on accommodating cyclical production patterns of several items on a single facility. The solution to the ELSP involves two critical decisions. On the one hand, the lot-sizing decision, that is, determining the quantity of each item to be produced to minimize total costs. On the other hand, the scheduling decision, that is, deciding when the items are produced. Since it is not the intention of this paper to present an extensive review of the literature, we will limit our citations mostly to those papers that were directly related to this paper.

The simplest approach to solve the ELSP lot-sizing decision is the Independent Solution (IS), which in fact uses the economic order quantity defined in (Harris 1913) to determine the lot-size for each product. The IS approach ignores any condition for feasibility, and therefore it is common to find situations in which the optimal solution under this approach is not feasible. Other relevant methods in the literature to solve this problem are: Common Cycle (CC) (Hanssmann 1962), Basic Period (BP) (Bomberger 1966), Extended Basic Period (EBP) (Elmaghraby 1978) and Lot-Sizing Variation (Dobson 1987).

Regarding the ELSP scheduling decision, one of the first rules of scheduling is attributed to Delporte and Thomas (Delporte & Thomas 1977), who set a series of heuristics to establish the order in which items are to be manufactured. Some interesting simulation studies presented in the literature are (Vergin & Lee 1978; Leachman & Gascon 1988; Kou & Yang 2009; Löhndorf et al. 2014). In (Levén & Segerstedt 2007), an interesting scheduling policy is presented, described with a simple and small numerical example. As regards demand type, in (Sox et al. 1999) the authors refer to the problem where demand is assumed to be time varying as stochastic economic lot scheduling problem, and present a

1 **Raúl Cortés Fibla** (racorfi@omp.upv.es)
2 **Pilar Isabel Vidal Carreras** (pivicar@omp.upv.es)
Grupo ROGLE.
3 **Jose Pedro Garcia Sabater** (jpgarcia@omp.upv.es)
Grupo ROGLE.
Dpto. de Organización de Empresas.
Universidad Politécnica de Valencia. Camino de Vera S/N, 46022 Valencia.

complete literature review. Another interesting and up to date SELSP review is presented in (Winands et al. 2011).

We employ the term complexity to refer to the static or structural complexity of the problem (Frizelle 1996), and not in relation to the algorithmic complexity of the mathematical problem, which actually has been proven to be NP-Hard (Hsu 1983). For a given variant of the ELSP problem, there are several factors that affect the complexity of the problem depending on their specific values in the data set. We call these factors drivers of complexity. In this paper, we consider only the effect of utilization and number of items as drivers of complexity. As regards uncertainty, it is frequent to find, in real situations in industry where ELSP arises, uncertainty in relation to the behavior of some data throughout the planning horizon. In this paper, we consider the stochastic behavior of demand as a driver of uncertainty**.** The objective of our simulation study is to compare the behavior of five different production strategies under different environments of complexity and uncertainty.

2 Problem definition and description of the strategies

We consider the classic ELSP problem of lot sizing and scheduling several items *i=1..g* on a single machine, where only one product can be produced at a time, with the objective of minimizing the average total costs. We assume the following behavior for the rest of the parameters of the problem:

- The production rate per item, p_i is deterministic and constant.
- Production setup times A_i, and setup costs c_i, are independent of the production sequence.
- Inventory holding costs h_i, are proportional to the inventory levels I_i.
- Product demand rates d_i are stochastic, but stationary.
- Shortages result in lost sales.
- Production capacity is sufficient to meet demand.

The objective of any production strategy is to minimize the total cost, *TC*, resulting from the sum of inventory holding costs, setup costs, and lost sales costs. For our simulation study, we have considered five different productions strategies, which we will describe according to the classification introduced in (Winands et al. 2011), based on the critical elements of the production plan, i.e. lot-sizing and scheduling policy.

Heuristics 1 & 2

Heuristics 1 and 2 are based on the classical "order point mechanism" (*s, Q*), where production orders are released only when inventory falls under a certain reorder stock level s_i. Should the inventory of two different articles be below *s*, the article with the lowest run out, as defined in (Segerstedt 1999), is released. The lot size is fixed for each item along the planning horizon based on a specific lot-sizing criterion.. In this case, Heuristic 1 uses the IS approach for the cycle time T^{IS} calculation, while Heuristic 2 uses the CC approach to calculate the cycle time T^{CC}. The corresponding lot sizes $Q^{IS}{}_i$, $Q^{CC}{}_i$ are defined in (3.1) and (3.2) respectively:

$$Q^{IS}{}_i = d_i T^{IS}{}_i = \sqrt{\frac{2A_i d_i}{h_i(1-\frac{d_i}{p_i})}} \tag{3.1}$$

$$Q^{CC}{}_i = d_i T^{CC} = d_i \sqrt{\frac{2\sum_{i=1}^{g} A_i}{\sum_{i=1}^{g} h_i d_i (1-\frac{d_i}{p_i})}} \tag{3.2}$$

Heuristic 3

Heuristic 3 is based on the stable cycle time heuristic (SCT) presented in (Fransoo 1993). The aim of this production strategy is to keep the variance of the cycle times as low as possible. Target cycle times, are calculated using the heuristic defined in (Doll & Whybark 1972), including a feasibility check based on (Leachman & Gascon 1988). We name this cycle time T^{SCT} and the corresponding lot-sizes Q_i are defined in (3.3):

$$Q_i = s_i + d_i T^{SCT} - I_i \tag{3.3}$$

The scheduling policy is based on the run-out times, so that the product with the shortest run-out is scheduled in first place for production. Once this production order is finished the next product is selected for production. We have included a minimum run-length to avoid too short cycle lengths that may lead to very high setup costs. See (Fransoo 1993), for more details on this procedure.

Heuristic 4

In Heuristic 4 we consider the dynamic cycle length heuristic introduced in (Leachman & Gascon 1988). This production strategy is based on the concept of *slack* between batches. There is a *positive slack* between two particular batches when the inventory level of the second item is large enough to avoid a stock out situation during the time it takes to the batch of the first item to be completed. Conversely, there is a *negative slack* when the inventory level of the second item is not large enough to avoid a stock out situation. In this production strategy, the cycle time is calculated on the basis of the basic period cycle times heuristic as in (Doll & Whybark 1972). This fundamental cycle, T^{BP} is used to calculate the corresponding lot sizes, as in (3.4):

$$Q_i = s_i + d_i T^{BP} - I_i \tag{3.4}$$

Again, as regards the scheduling policy, the items are prearranged based on their run out times. The production strategy intends to reduce the stock outs by observing the slack for every item on the schedule. If the slack for an item is negative, the fundamental cycle time is proportionally reduced so that the slack for every item is positive. Then, the production order of the first item on the schedule is released with the recalculated batch size according to the reduced cycle time. Once this production order is finished the procedure starts from the beginning, arranging the products and calculating the slack time of every item again, considering the fundamental cycle, T^{BP}. As in Heuristic 3, we have included a minimum run-length to avoid too short cycle lengths that may lead to very high setup costs. See (Leachman & Gascon 1988) for more details on this preocedure.

Heuristic 5

Heuristic 5 is based on the heuristic procedure presented by Leven and Segersted in (Levén & Segerstedt 2007), based on (Leachman & Gascon 1988). In this production strategy the lot sizing criterion is based on the optimal cycle time for each item, calculated by the IS approach as in (3.1). The most significant aspect of this strategy is that successive batches of the same item are treated explicitly, since according to the lot sizing criterion described, it is possible that several batches of the same item can be scheduled before the first batch of other item in the schedule. Again, the heuristic arranges the products according to their run out. Then, the feasibility of the schedule is checked, so that if any of the batches has a negative slack, the batch sizes will be decreased by a scaling factor. After doing that, the batches need to be arranged again and the feasibility check carried out. If the schedule is still not feasible, a new reduction should be made and further iterations should run until a feasible schedule is found. This scheduling procedure will start every time a production batch is finished, and look ahead at a predetermined number of batches, which in our study is 8 batches. See (Levén & Segerstedt 2007) for more details on this procedure.

3 Simulation model

To evaluate the performance of the heuristics described in section 3, we have developed a simulation model of discrete events with the SIMIO simulation software. The architecture of this model is formed by the simplest structure: Source – Server – Sink, being the server who decides both the schedule and the lot size by means of algorithms developed in C #, in which the heuristics have been implemented.

Experimental factors

For the simulation study we worked with the basic Bomberger 10-item data set (Bomberger 1966). Many studies in the literature have used this same data set (Segerstedt 1999), (Soman et al. 2006),(Doll & Whybark 1972), (Qiu & Chang 2009), (Holmbom et al. 2013). It is well known that this data set is particularly complex to handle, strongly heterogeneous, with a wide range of values for some features of the items, for instance demand or production rates.

The first driver of complexity mentioned in the introduction is the utilization level. We have run experiments with the aforementioned data set, with 4 different levels of utilization, by increasing demand rates, in each case ($\rho = \sum_{i=1}^{g} \frac{d_i}{p_i}$): *0.22; 0.44; 0.66; 0.88.*

As described in the introduction, we also consider the variation of number of items, to be an element that introduces complexity in the problem. To consider this driver of complexity, we have defined three equivalent data sets, for 20, 30 and 40 items, from the basic 10-item Bomberger data set. The data set of 20 items consists of two basic10-item data set, where the demand rate for each item has been reduced two-fold, so that the level utilization remains unchanged. The same procedure has been used to build the 30 and 40-item data sets.

Finally, to analyze the effect of situations of uncertainty, we considered the effect of stochastic demand. Thus, the actual demand considered in the simulation study is stationary stochastic from a normal distribution, mean d_i, with three different coefficients of variance, *0.1, 0.3, 0.5.*
We consider the total cost as the sum of three cost components: Setup cost, Inventory holding cost, and Non delivery cost. Non delivery costs are usually difficult to determine, and therefore can introduce arbitrariness in the results (Edward A. Silver, David F. Pyke 1998). In our simulation study, as in (Soman et al. 2006), we have considered a lost sales of 10% of the product cost.

Simulation dynamics

All simulations are run over 960 production days, representing 4 production years, as in (Brander et al. 2005). After a 960-days warm-up time, the average annual total cost is calculated. This warm-up is necessary to override the effect that some of the initial conditions, particularly the initial stock, may have on the comparison of the different production strategies in the simulation study. In (Vidal-carreras et al. 2009) the authors demonstrated that a warm-up period between 600 and 1000 days is adequate to obtain stable results with some of the more commonly employed heuristics in simulation studies for the ELSP. The algorithm corresponding to each simulation strategy described in Section 2 was programmed in our model for the decisions regarding lot sizing and scheduling to be made in each case. At the end of each period the demand for each item is generated, and the inventory levels are updated. Every time a production run ends, the inventory levels are also updated.

4 Simulation results and discussion

The aim of our simulation study was to evaluate the influence of complexity and uncertainty of the environment on the performance of different strategies. We considered the annual average cost as the main performance measure of the strategies. The total cost for the IS approach, which as explained in the introduction is a lower bound for the problem, is given by (5.1)

$$TC = \sum_{i=1}^{g} \sqrt{2A_i h_i d_i \left(1 - \frac{d_i}{p_i}\right)} \qquad (5.1)$$

Figure 1 shows the total average cost for the production strategies described in section 2, at different utilization levels, considering a demand coefficient of variance of 0.3, with the 10, 20, 30 and 40 items data set described.

As depicted in the picture, at low utilization levels (below 0.44), regardless of the number f items, the best performance, actually quite near to the lower bound, is alwas obtained by the strategies based on the IS approach cycle time, (s,Q^{IS}) and Leven & Segersted. For the rest of the strategies, as expected, the cost performance is worse at this utilization levels, since they are using a lot sizing criterion based on non optimal cycle time (CC and BP). This different cycle times are defined to simplify the problem, i.e. reduce the complexity, of finding a feasible production schedule which, at this level, is already simple enough. At higher levels of utilization, this behavior changes significantly. The complexity of the problem of finding a feasible schedule is considerably higher, so strategies based on CC o BP, such as (s,Q^{CC}), Fransoo and Leachman&Gascon tend to perform better. Therefore the (s,Q^{CC}) strategy has a reasonably good performance at utilization of *0.66,* compared to the rest of the strategies. However, when the utilization increases to *0.88,* the number of stockouts with this strategy increases considerably, leading to a high impact of the lost sales cost and a bad performance of the strategy. This effect is even more evident when the number of items increases. The performance of the Fransoo and Leachman&Gascon strategies, both with cycle times based on the BP approach, is considerably better in comparison to the rest of the strategies, at higher utilization levels. With both strategies, the number of sockouts is practically none, even at utilization of *0.88.* The leaachman&Gascon method has a better performance compared to the Fransoo method in both, setup and holding costs, since it adapts the cycle length to a more feasible schedule. It is interesting to observe that the Leven&Segersted production strategy, based on IS, keeps an acceptable cost performance, even at utilization of *0.88*, due to its capability of adapting the cycle times to a feasible schedule.

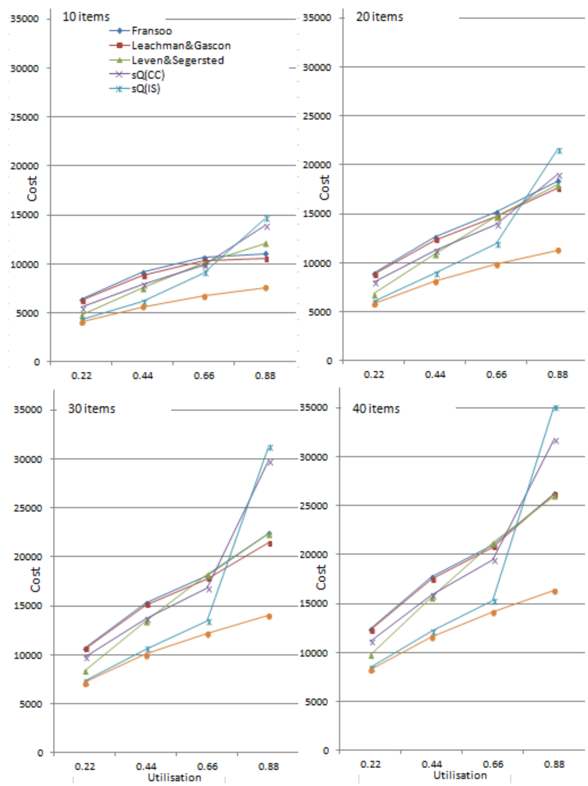

Fig.1
Influence of utilization and number of items
on Total Average Costs. (CoV 0.30).

With reference to the effect of uncertainty, driven by the stochastic behavior of demand, we have observed an interesting effect related to the influence of variation in demand in relation to the utilization level. Figure 2, shows the effect of the increase of the coefficient of variance in demand rates with the 10 items data set. At low utilization levels (*0.22*), the effect of the coefficient of variance is almost imperceptible, whereas at high utilization (*0.88*) this effect is quitly more significant, especially for Heuristics 1, and 2 that don´t have the capability of adapting the cycle times. At his utilization level, the production schedule is almost at its limit of feasibility so that any variation in the level of demand has an observable result in costs.

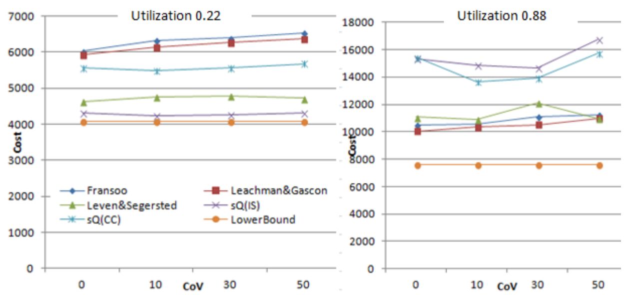

Fig.1
Effect of increasing CoV in demand rates
at different utilization levels (10 items Data Set).

5 Conclusions and further research

The simulation study carried out in this work intended to demonstrate that search for the production strategy for the ELSP with the best performance has necessarily to introduce the consideration of the production environment. There are many elements that determine this production environment. We classified them in two main categories: drivers of complexity and drivers of uncertainty. Particularly in this paper, we considered utilization and number of items as drivers of complexity, and stochastic behavior of demand as driver of uncertainty. In the conclusion of their survey, (Winands et al. 2011), suggest that research should pay more attention to the comparison between different policies. The results of our simulation study confirm that the performance a production strategy is strongly dependant on utilization and number of items. In our opinion, this conclusion is absolutely key for industrial applications of the ELSP, where the scenario changes drastically, sometimes even in the same facility when, for instance, facing seasonal demand. We have demonstrated that the conclusions drawn from a study of a particular production strategy conducted under specific conditions, may not apply or may even cause opposite results than expected, when applied under different conditions. We intend to go deeper into this conclusion introducing new drivers of complexity and uncertainty, as those mentioned in the introduction. Another interesting area of study that could help supplement and reinforce the conclusions of this study is the use of hyper-heuristics (see (Burke et al. 2013)), as they can prove useful in seeking the most appropriate production strategy for a particular scenario of complexity of uncertainty of the ELSP. Finally we consider also to be an interesting area of work the possibility of analyzing, through a large scale simulation study, the influence that experimental factors such as the simulation period, the period of warmup, or the initial stocks may have in performance of the production strategies.

6 References

Bomberger, E.E., 1966. A Dynamic Programming Approach to a Lot Size Scheduling Problem. Management Science, 12(11), pp.778–784.

Brander, P. & Forsberg, R., 2006. Determination of safety stocks for cyclic schedules with stochastic demands. International Journal of Production Economics, 104(2), pp.271–295.

Brander, P., Levén, E. & Segerstedt, A., 2005. Lot sizes in a capacity constrained facility—a simulation study of stationary stochastic demand. International Journal of Production Economics, 93-94, pp.375–386.

Burke, E.K. et al., 2013. Hyper-heuristics: a survey of the state of the art. Journal of the Operational Research Society, 64(12), pp.1695–1724.

Delporte, C.M. & Thomas, L.J., 1977. Lot sizing and sequencing for n products on one facility.,

Dobson, G., 1987. Economic lot-scheduling problem: achieving feasibility using time-varying lot sizes. Operations Research, 35(5), pp.764–771.

Doll, C.L. & Whybark, D.C., 1972. An Iterative Procedure For The Single-Machine Multi-Product Lot Scheduling Problem. ,

Edward A. Silver, David F. Pyke, R.P., 1998. Inventory Management And Production Planning And Scheduling, 3rd Ed. Wiley.

Elmaghraby, S.E., 1978. The economic lot scheduling problem (ELSP): review and extensions. Management Science, 24(6), pp.587–598.

Fransoo, J.C., 1993. Production Control and demand managament in capacited flow process industries. Technische Universiteit Eindhoven.

Frizelle, G.D.M., 1996. Getting e measure of coimplexity. Manufacturing Engineer, 75(6), pp.268–270.

Hanssmann, F., 1962. Operations Research in Production and Inventory Control, New York: John Wiley and Sons.

Harris, F.W., 1913. How Many Parts to Make at Once. The magazine of Management, 10(2), pp.135–6–152. Available at: http://pubsonline.informs.org/doi/abs/10.1287/opre.38.6.947.

Holmbom, M., Segerstedt, A. & van der Sluis, E., 2013. A solution procedure for Economic Lot Scheduling Problems even in high utilisation facilities. International Journal of Production Research, 51(12), pp.3765–3777.

Hsu, W.L., 1983. On the general feasibility test of scheduling lot sizes for several products on one machine. Management Science, 29(1), pp.93–105.

Kou, Y. & Yang, J.J., 2009. A Simulation-Based Methodology for Lot-Size Optimization. Key Engineering Materials, 392-394, pp.866–872.

Leachman, R.C. & Gascon, A., 1988. A Heuristic Scheduling Policy for Multi-Item, Single-Machine Production Systems with Time-Varying, Stochastic Demands. Management Science, 34(3), pp.377–390.

Levén, E. & Segerstedt, A., 2007. A scheduling policy for adjusting economic lot quantities to a feasible solution. European Journal of Operational Research, 179(2), pp.414–423.

Löhndorf, N., Riel, M. & Minner, S., 2014. Simulation optimization for the stochastic economic lot scheduling problem with sequence-dependent setup times. International Journal of Production Economics, 157, pp.170–176.

Qiu, X. & Chang, H., 2009. A Hybrid Genetic Algorithm For Solving The Economic Lot Scheduling Problem (ELSP). , (July), pp.12–15.

Segerstedt, A., 1999. Lot sizes in a capacity constrained facility with available initial inventories. International Journal of Production Economics, 59(1-3), pp.469–475.

Soman, C.A., Pieter van Donk, D. & Gaalman, G., 2006. Comparison of dynamic scheduling policies for hybrid make-to-order and make-to-stock production systems with stochastic demand. International Journal of Production Economics, 104(2), pp.441–453.

Sox, C.R. et al., 1999. A review of the stochastic lot scheduling problem. International Journal of Production Economics, 62(3), pp.181–200.

Vergin, R.C. & Lee, T.N., 1978. Scheduling Rules For The Multiple Product. , 16(1), pp.64–74.

Vidal-carreras, P.I. et al., 2009. Estabilidad del horizonte de programación en la aplicación de heurísticas al problema del ELSP con Coproducción Deliberada.

Winands, E.M.M., Adan, I.J.B.F. & van Houtum, G.J., 2011. The stochastic economic lot scheduling problem: A survey. European Journal of Operational Research, 210(1), pp.1–9.

Development of a simulation study for a production line in an automotive company

Lima M[1], Ramos AL[2], Alvelos H[3]

Abstract: The demand for competitive products with low price and high quality standards is mandatory in the contemporary competitive global market. To achieve these targets, companies need to increase their productivity, which means that they need to produce more units in less time with considerable quality standards. In this work, it is developed a simulation study for an automotive company to analyze the dynamics of a line that produce backrests for the back part of cars. The main objective is to evaluate the current operations and to determine some possible ways to improve the productivity of the line by eliminating waste. The case study reported in this paper is part of the outcome of the business internship program sponsored by the Department of Economics, Management and Industrial Engineering of University of Aveiro, Portugal, for the students in the Industrial Engineering and Management master program.

Keywords: automotive company; production line; productivity; simulation.

1 Introduction

The ultimate goal of the majority of the organizations is to eliminate the waste in their systems in order to reduce the costs for the company and consequently, to allow the company to drop off the price of the manufactured goods maintaining high quality standards.

The company has to explore the productive system to find the sources of waste and to eliminate them so, it has to identify the hidden and unhidden wastes, to classify them, to define priorities of action, to find the root causes for the wastes in analysis and to enumerate and evaluate possible solutions, implementing the best solution (Gupta and Jain, 2013). Lean manufacturing concepts and tools are proving to be a good practice for those organizations who want to become more competitive through waste reduction and value-added creation. The advantages of implementing lean principles and tools are, for example, significantly reduced inventory and lead times, better delivery performance, improved space and resource utilization, and enhanced productivity and quality (Pavnaskar et al., 2003). In addition, simulation techniques are probably one of the best engineering tools to analyze the performance of complex industrial systems, enabling the development of a computer based replica of the system in analysis with the incorporation of complex interdependencies and uncertainties (Villarreal and Alanís, 2011). Simulation enables companies to capture the dynamics of their systems and to evaluate different scenarios through the analysis of a broad set of performance measures.

In this work, simulation will be used to study a manufacturing line dedicated to the production of a backrest to incorporate in vehicles. Since automotive industry is a sector that started implementing the lean manufacturing concepts a long time ago, the lines of the company are already stabilized and balanced so, the main idea was to explore deeper the operations of the line to search for wastes and test the possible solutions to eliminate or reduce them in order to increase the overall productivity of the system.

The case study reported in this paper is the outcome of the business internship program sponsored by the Department of Economics, Management and Industrial Engineering of University of Aveiro, Portugal, for the students in the Industrial Engineering and Management master program.

1 **Mafalda Lima** (mafalda.lima@ua.pt)
2 **Ana Luísa Ramos** (aramos@ua.pt)
3 **Helena Alvelos** (helena.alvelos@ua.pt)
Department of Economics, Management and Industrial Engineering,
University of Aveiro, Campus de Santiago, Aveiro, Portugal.

2 System-in-analysis: the production line and the process

The system-in-analysis in this study is a production line that belongs to a multinational company in the automotive sector which produces several car products in factories spread all over the world. This specific factory, in Portugal, only produces cushions and backrests for the vehicles. The company wants to analyze the backrest production line because this specific product is a newest one in the shop-floor and consequently, is not so well-known and controlled as the others produced in the factory.

The process flow chart is illustrated in Figure 1. The production line has five main workstations (WS) and two dedicated full-time workers. The raw materials (RM) and the wires (W) are the main inputs of the line processes and the subgroups (SG) are the main outputs of the processes, being also inputs for the subsequent processes along the line. The final product is the assembled backrest.

The first three workstations are welding machines and are operated by worker 1. This worker is also in charge of the welding inspection operation. In this inspection the product may follow three paths: i) the product pass the inspection and follows to workstation 4 transported by a hook, ii) the product does not comply with the quality requirements but it can be reworked to be recovered, and iii) the product is scrap (has defects impossible to recover) and is transported to the scrap jig. These three situations happen with different frequencies that correspond to the percentages of 97%, 2% and 1%, respectively.

After the welding inspection there is another welding workstation, operated by worker 2, and finally there is an assembly workstation, also assigned to worker 2. After this final workstation there is a small packaging operation performed by worker 2.

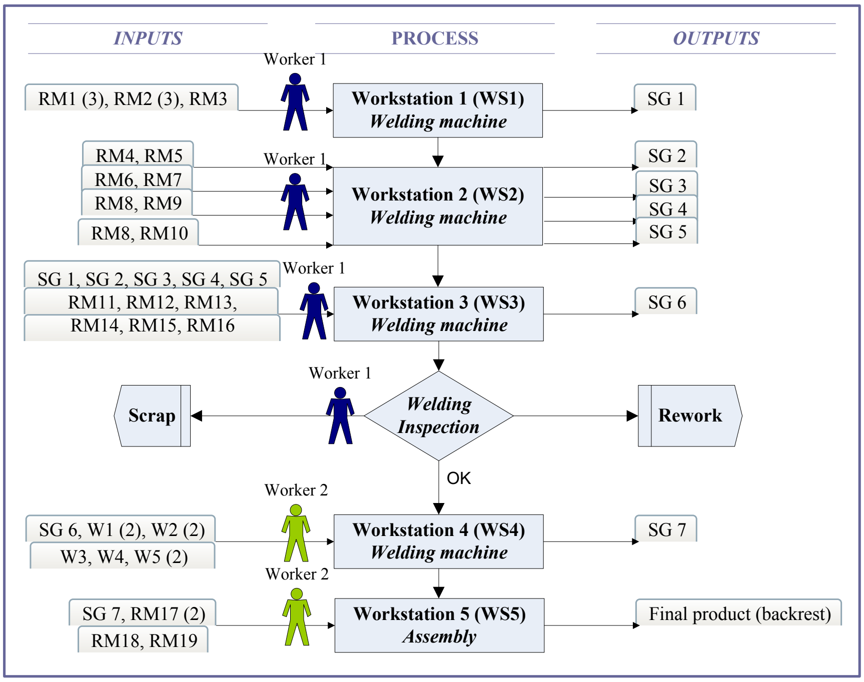

Fig.1
Backrest Process Flow.

The company's goal regarding the number of backrests to produce is 448 backrests per day which corresponds to 32 jigs each day (each jig has 14 backrests). One problem that the company is facing is that with the two existing shifts the production target is not reached so, the company was forced to add an half a shift. This measure, as expected, increases the costs for the company.

The company is also facing some problems with the third welding machine (WS3) and the assembly workstation (WS5). The operators are forced to stop the production several times a week due to defects caused by these two machines. The maintenance or engineering team needs between ten minutes to an hour to repair both machines. The second welding machine has also problems. Sometimes, when the worker is preparing the materials for the machine, the sensor does not detect the raw materials in spite of their presence and correct position. This happens because the sensor does not always work properly and the worker has to remove the materials and put them in place again (he lost some seconds doing this operation).

Since the use of simulation is particularly advantageous when the complexity or operational variability of the systems under study renders the application of purely analytical models impossible, it was decided to develop a simulation study to evaluate the current operations of the production line and to test some possible ways to improve the productivity of the line by eliminating waste.

3 Simulation study

In recent years, a lot of research in how to develop a simulation study has been made and it is possible to conclude that the required steps to achieve the best path include problem formulation, conceptual modelling and data collection, operational modelling, verification and validation (V&V), experimentation, and output analysis (Kelton et al., 2010). These steps were the ones followed in this study.

A simulation model of the current operation of the production line was developed in order to document the current state of the system in analysis, identify waste in the process, and improving its productivity. The relevant operational performance measures (KPIs) such as throughput, schedule utilization of resources, cycle times, work-in-process, and queue statistics were analyzed to allow the proposal of a set of changes to the existing manufacturing operations. The model was developed using Arena® software from Rockwell Software.

In developing the simulation model, particular care was taken to model the production line as close to reality as possible. In this stage it was necessary to determine which data would be necessary to use in the model and if this information was available.

The line has two shifts of operation. The first one operates from 6.00 a.m. to 2.30 p.m. and the second sift operates from 2.30 p.m. to 11.00 p.m.. The shift includes break periods, lunch/dinner times and periods for cleaning the equipments. The availability of data for the processing times of the tasks involved in the line allowed the fitting of proper distributions to these data (theoretical and empirical). The distributions and its parameters were selected using the Arena's software module Input Analyzer (Table 1). The distributions obtained were analyzed through visual inspection, square error value and p-value, in order to guarantee a "good" fit.

Table 1
Probabilistic distribution for workstations processing times in seconds (Input Analyzer).

	Operator (seconds)	Machine (seconds)
1st Workstation	*Empirical*	16
2nd Workstation	TRIA(19.5, 23, 29.5)	Was not considered (instantaneous)
3rd Workstation	*Empirical*	NORM(81.9, 1.84)
Self inspection	*Empirical*	Not applicable
4th Workstation	*Empirical*	*Empirical*
5th Workstation	59.5 + WEIB(10.2, 1.61)	
Packaging	51.5 + 30 * BETA(1.58, 0.783)	Not applicable

The operational model was developed using several modules from Arena software templates and it was developed a 2D animation model (Figure 2) illustrating the dynamic behavior of resources, buffers, and transporters.

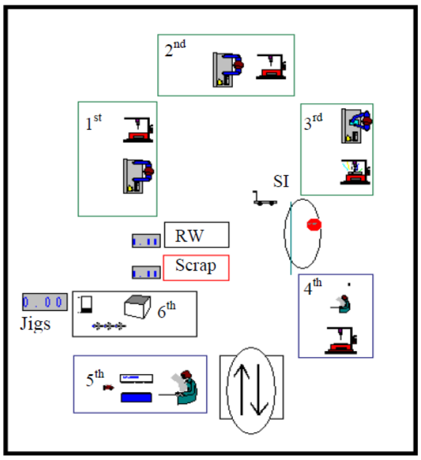

Fig.2
Animation model (2D) of the production line.

After the operational modeling phase of the study it was conducted the V&V phase and the results were analyzed. It was possible to found that the line only produces between 26 and 27 jigs per day which is not the desired target output. The line is balanced in terms of workers' utilization. In terms of machine utilization there is a small difference between machines held by operator one and by operator 2. In the WS2 there is a significant difference between the number of backrests that enter and the ones that leave the workstation. This problem appears to be a good opportunity to improve the operations and increase the line productivity.

4 Simulation-based analysis of strategies for possible improvements in the production line

4.1 Scenarios in analysis

The difference between the backrests that enter and leave the WS2 reinforced the idea that this operation needs to be further analyzed and improved. So, the first scenario to test refers to the improvement of the operation of the sensor on WS2 before assembly the materials to weld (increases one second on the preparation of the materials by worker 1 and eliminates the failure on the welding machine 2). The downtime of this machine corresponds to the time when the worker takes out the materials of the machine, touch the sensor and put back again the materials.

The second scenario corresponds to the improvement in the sensor and to a change in the layout of the line. This potential improvement derives from the observation of the line during the internship. It is noticed that worker 2 has to walk a considerable distance to go from WS4 to WS5 (more or less four steps which corresponds to approximately 3.5 seconds). After changing the layout this time was reduced for approxi-mately 1.5 seconds.

On the third scenario it was tested, additionally, the hypothesis of transferring the final packaging operation from worker 2 to worker 1. This action was defined after analyzing the utilization rates of the workers.

4.2 Results

Analyzing the results obtained in the different simulations it can be concluded that with the introduction of relatively small modifications the system-in-analysis is able to finish more backrests that those which are finished currently.

In the current situation (scenario without improvements) the line only produces between 26 and 27 jigs per day with two working shifts. This output value increases in the majority of the defined and tested scenarios, reaching a mean value of 28 jigs per day in the third scenario (Figure 3). This corresponds to a throughput of more (approximately) twenty backrests per day comparing with the current solution.

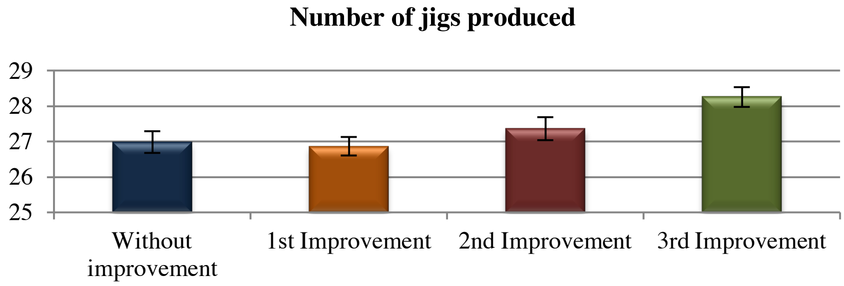

Fig.3
Number of jigs produced per day in the different scenarios
(statistical estimates of the performance measure based on 95% confidence intervals).

In the Figure 4 it is presented the cycle time of WS5 (the time between backrests leaving WS5) and the cycle time of the line (after packaging). It is on the third scenario that is observed the smallest cycle time and also where is observed the smallest time lost with the packaging operation.

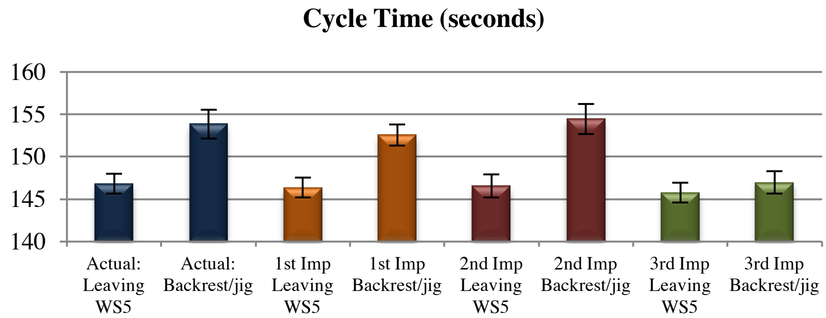

Fig.4
Cycle time of WS5 and of the line in the different scenarios
(statistical estimates of the performance measure based on 95% confidence intervals).

The results of these simple experimental scenarios need to be further explored but it seems obvious that with small improvements the line can increase its throughput. The desired productivity target is not yet achieved, with these two working shifts, but the company is analyzing other scenarios. This simulation study needs some refinements but the outcome of this high-level analysis is promising and the decision-makers are taken it into account.

5 Conclusions

This project can be considered as a successful case study of university/industry interaction in the industrial engineering field. The student who accompanied the project on site was crucial in this process, as she combined the knowledge of the tool being used (simulation) with the perception gained on the production process details.

The simulation study needs refinements but, it is clear for the company that simulation is a valuable tool to support operations management. Simulation techniques involve considerable costs (software, training), but the benefits of avoiding disrupting systems or implementing “poor” operational solutions can faster outweigh the initial investment (Ramos et al., 2015).

This work can be used to show the benefits that companies can get from these collaborative studies and the advantages that can be achieved through the use of simulation to design and analyze manufacturing systems.

6 References

Gupta, S. and S. Jain. 2013. "A literature review of lean manufacturing". International Journal of Management Science and Engineering Management. 8(4) pp. 241–249.

Kelton, W., R. Sadowski and N. Swets. 2010. Simulation with Arena, 5th ed., McGraw-Hill Higher Education, New York.

Pavnaskar, S., J. Gershenson and A. Jambekar. 2003. "Classification scheme for lean manufacturing tools" International Journal of Production Research, 41 (13), pp. 3075–3090.

Ramos, A., J. Ferreira and F. Bernardes. 2015. "Improving the Productivity of a Packaging Line Using Lean Manufacturing Tools and Simulation", in Proceedings of the 2015 International Conference on Industrial Engineering and Operations Management (IEOM 2015), Dubai – UAE, pp. 1721-1726.

Villarreal, B. and M. Alanís. 2011. "A simulation approach to improve assembly line performance", International Journal of Industrial Engineering, 18(6), pp. 283-290.

Evaluating Perceptions on Executive Support in Project Management

Felekoglu B[1] and Ozmehmet Tasan S[2]

Abstract: Executive managers are responsible to set long-term objectives for their companies, formulate strategies to reach these objectives and enable implementing these strategies through projects. Effective management of each project is therefore necessary for the future of the company. Previous research suggests that executive support is important in project management. This support can reveal itself in many ways. It is important to ensure that project team really feels supported as much as executives feel that they provided the necessary support. This study investigates if senior managers and project teams have a similar view on executive support. Since innovative projects are strategically essential and usually considered as key projects in the project portfolio, this study focuses on executive support during new product development (NPD) projects using real data collected from NPD projects. In order to investigate the difference between perceptions of executives and project teams on support, a set of hypotheses were developed and tested. The results of this study show that although as a generalization executive support is important in project management process, there are different perceptions of the project team and executives on the manifestation of this support which are detailed in this paper. Implications are discussed in the conclusion.

Keywords: Executive support; Project management; Perception; New product development.

1 Introduction

Recent research on project management not only focuses on the factors affecting success of the project but also on how projects contribute to the strategic goals of organization. Executive managers are responsible to set long-term objectives for their companies, analyze and formulate strategies to reach these objectives and implement strategies through projects. The strategic alignment of projects becomes vital to save and effectively use organization resources (Too and Weaver 2014). For this reason, executive managers need to take part in project portfolio process, which ensures that only the most valuable projects are approved and managed across the entire organization. Moreover, previous research has shown that their support is also needed during the implementation of the projects that are selected. Especially in new product development (NPD) projects this support even becomes vital since those projects are flagship projects in the portfolio.

Executive support in NPD projects can reveal itself in many ways. This support can be a facilitator in one organization where it is a barrier in the other depending on people's perception; which is affected by personal and group characteristics such as expertise, experience and hierarchical level (Rubenstein et al. 1976). New product team leaders who perceive high senior management support are more likely to be successful (Barczak and Wilemon 1992) as they are more likely to become more interested in the project, take greater ownership and be more willing to take risks (Swink 2000). Not only team leaders but also other NPD personnel who perceive involvement of executive in NPD become more enthusiastic about the project, more interested to perform their tasks in coordination with others and more willing to take risks (Rodríguez et al. 2008).

In the NPD context, executives and the NPD teams can be viewed as two different groups of people having their own group structure, norms and values. The perceived similarities within each group would

1 **Burcu Felekoglu** (burcu.felekoglu@deu.edu.tr)
2 **Seren Ozmehmet Tasan** (seren.ozmehmet@deu.edu.tr)
Department of Industrial Engineering,
Dokuz Eylul University, Buca Izmir, Turkey.

naturally suggest an intergroup perception difference. NPD team's perception of executive support during the NPD project is, therefore, likely to be different from executive's perception of providing the necessary support to the project team. Literature gives an indication of the difference between perceptions of top managers and NPD team members (Rubenstein et al. 1976, Barczak and Wilemon 2003) but there is a lack of empirical investigation on how perceptions of executive and NPD team might differ for the support provided by executives. This study aims to fill this gap.

The remainder of the paper is organized as follows. In section 2, a detailed literature review is provided on technical and social aspects of executive support in NPD projects. In section 3, the perception difference in executive support is investigated in terms of suggested hypotheses. In section 4, research methodology is explained. Analysis and findings are presented in section 5. Finally, section 6 concludes this study with the implications for theory and practice.

2 Literature Review

Based on a detailed review of the literature, the supportive behaviours of executives at NPD projects were classified in two groups, namely, technical and social support and these will be explained in the following subsections.

2.1 Technical Support

In this study, technical support refers to executive's supportive activities related to the managerial and process requirements of the project and these activities are important for the progress of the project. They are often mandated in the companies' operating procedures or formal NPD processes. Traditionally, technical activities by which senior management supports in NPD projects were considered as strategic planning and resource allocation. These activities hold their importance in today's NPD setting and can be extended to include setting direction, determining the relative priority of the project and reviewing the progress.

Support of executives in NPD projects by *strategic planning* entails setting the critical milestones for evaluation, determining the flow of activities and identifying the timing of key events. It is not micro managing, but setting the boundaries inside which the NPD team has flexibility to plan their activities (Wheelwright and Clark 1995).

Perhaps the most frequently referred support of senior management in NPD projects is by providing resources (e.g. Bao and Yang 2004, Barczak and Wilemon 2003, Carbonell and Rodríguez-Escudero 2009, Cooper and Kleinschmidt 1996, Gomes et al. 2001, Green 1995, McDonald and Eastlack Jr 1971, Reilly et al. 2003, Rodríguez et al. 2008, Swink 2000). Any NPD project requires mainly three types of resources, which are financial, physical and human resources. It is senior management's responsibility to make sure that the ongoing NPD projects have appropriate *financial resources*. Assigning appropriate people to the key roles of the project is also a critical role of senior management. Again senior management will invest in the development of *human resources* as needed. NPD project teams also need *physical resources* such as facilities, rooms and equipments to carry out their work.

As each NPD project is part of a bigger portfolio of projects within the overall NPD strategy of the organization, it is important that executives *set clear direction* to the project team to keep the project within this broader picture and to keep the team focused on a specific goal (Swink 2000). NPD team members were found to become less prone to team stressors and anxiety when the executive supports the vision of the project (Akgün et al. 2007).

Executives also support NPD projects by *determining the relative priority* of the NPD project (Green 1995). This helps to build a trusted relationship between the NPD team and executives, to enable executives better allocate the limited resources of the organization and better address the individual NPD project need and to ensure internal support for the project.

Another activity by which senior management supports NPD projects is to *actively review the NPD project progress*. One of the primary ways of executive involvement in NPD projects is through review meetings (Barczak and Wilemon 2003, McDonald and Eastlack Jr 1971, Bonner et al. 2002). The supportive role not only requires executive to review the progress of the project in light of changes to plans, commitments or objectives but also to take the necessary actions as a result of their review (Wheelwright and Clark 1995).

Although the supportive technical involvement of executive is deemed to be helpful, it would be prudent to also consider "social aspects" of their involvement.

2.2 Social Support

Social support of executives in NPD projects refers to the executive's supportive activities in which they spend time and be in contact with the NPD team or the other people in relation to the NPD project, mostly to deal with the psychological and social aspects of the NPD team requirements.
Throughout the development process, the NPD team may need support from other functions or working groups who are not a part of the core NPD team. Senior management can disseminate results to the others (Green 1995) and help to *secure and sustain this internal support* (Reilly et al. 2003, Wheelwright and Clark 1995).

During an NPD project the team might need knowledge sources outside the company. The team can seek external help themselves, however, these initiations may be easier and more effective if the team has guidance and help from senior management in reaching relevant external resources (Green 1995). This is because the senior management has the position to see the big picture and use their extensive network to reach relevant external resources and therefore the ability to *secure help from outside the company* more easily and quickly (Wheelwright and Clark 1995).

NPD is a collective effort. Each NPD project requires coordinated teamwork. *Encouraging teamwork between functional groups* is another supportive activity of executive in an NPD project (Rodríguez et al. 2008). When compared to the routine activities of an organisation, NPD requires tighter integration between functional departments.

Communication between NPD team members is critical for their exchange of knowledge. Executive support positively influences willingness of team members to exchange knowledge (in terms of donating and collecting) with the other team members (Lin 2007). Executive can provide *an organisational setting which stimulates communication*.

Another supportive activity of executive is their *guidance to the NPD team in dealing with unforeseen contingencies.* The team can most probably overcome the minor abrupt changes and problems. However, when the team encounters major unanticipated circumstances, they need guidance to deal with these situations. Senior management can help the team in those times by providing guidance (Reilly et al. 2003, Wheelwright and Clark 1995). This guidance may be through sharing experience, giving advice, providing resource, or securing external help.

The NPD team is likely to experience stress and conflicts throughout the NPD project (Barczak and Wilemon 2003). The team is, therefore, prone to make mistakes or experience interim failures from time to time within the unpredictable nature of NPD. Senior management can support the NPD team by being *prepared to accept occasional failures as a natural part of NPD* (Rodríguez et al. 2008).

Another supportive activity of executive is to *create an open atmosphere*. Increased employee autonomy is part of the socio-technical system and reflects the participative approach to leadership. This participative leadership approach puts emphasis on creating an atmosphere where members of the work group feel enthusiastic and comfortable enough to share their ideas and thoughts (Carbonell and Rodríguez-Escudero 2009, Hunt 1980). It is senior management who encourages this open atmosphere.

In summary, seven technical and seven social supportive activities of executives were identified and in the next section the importance of understanding the differences in perceptions for executive support will be explained and hypotheses will be developed.

3 Differences in Perception and Hypotheses Development

As discussed above there are different ways by which executive can support an NPD team. However, executives and NPD team members might have different perceptions about the executive support in the NPD project. Understanding the mismatch between perceptions of these two groups is important for both parties. After all, people learn more from differences, than similarities. This awareness can help them better empathize each others' feelings and expectations. In addition, project success is more likely to be influenced by the extent to which the team perceives that they are supported by executive than the extent to which executive feels that they are being supportive. If the team has not felt the supportive involvement of their executive, it matters little how much executive thinks that they have been supportive. In fact, a study of in-depth interviews with NPD team members qualitatively reveals that NPD team members feel little support of their senior managers (Barczak and Wilemon 2003). This common feeling of being neglected by senior management, leads us to the following hypotheses:

$H_{1\text{-}14}$ The level of executive support in NPD projects perceived by executives is higher than the level perceived by the NPD team.
1-14 refers to each of seven technical and seven social supportive activities of executives which were written italics and explained in the literature review above.

4 Research Methodology and Findings

In this study, the difference in views of executives and NPD team on executive support in NPD projects was statistically investigated. Data was collected at project level and for each project, responses of both executive representative and NPD team representative were collected. 14 measurement items are used which cor-respond to the 14 sub-hypotheses that were introduced in section 3. Respondents were asked to indicate the degree of their agreement with each statement on a five-point Likert scale from "strongly disagree" to "strongly agree".

The hypotheses were tested with one-tailed Wilcoxon's paired signed ranks test at the 0.05 significance level using the data for supportive technical and social activities of executives collected from both executive and NPD team representatives.

The results of the Wilcoxon's paired signed ranks test are summarized in Table 1. Significant values are written with asterisks. The resulting one-tailed p values indicate that executives perceived significantly higher level of support in the NPD project for seven of the 14 measurement items of executive supportive activities than the NPD team.

Table 1
Wilcoxon's paired signed ranks test results – measurement items of executive supportive activities.

		$H_{1\text{-}14}$ 1-tailed p value
Technical supportive activities	1. Executive set a clear direction to the project team	0.0062*
	2. Executive determined the relative priority of this project	0.0054*
	3. Executive had an active role in strategic planning of the project	0.0045*
	4. Executive provided sufficient financial resources to the project	0.0505
	5. Executive allocated appropriate physical resources (e.g., facilities, rooms, equipments) to the project	0.0409*
	6. Executive assigned appropriate people to the key roles of the project	0.1446
	7. Executive actively reviewed the progress of the project in light of changes to plans, commitments or objectives	0.0446*
Social Supportive activities	8. Executive played an active role in building support for the project within the company	0.1949
	9. Executive was available to secure help for the project from outside the company when needed	0.0166*
	10. Executive encouraged teamwork between functional groups (e.g., R&D and Marketing)	0.0681
	11. Executive provided an organizational setting for the project team which stimulated communication among team members	0.3669
	12. Executive was available to guide the project team to respond to unexpected events or deal with unforeseen contingencies when needed	0.0222*
	13. Executive was prepared to accept occasional failures as a natural part of new product development	0.1056
	14. Executive created an atmosphere where the project team was free to raise questions or concerns	0.2420

*Significance level: $p < 0.05$

5 Conclusion

This study demonstrated how views of executives and NPD teams on executive support differ. The results indicated that executives perceive a higher level of support than the NPD team perceives. More specifically, although executives thinks that they set a clear direction to the team, provide necessary physical resources, have active role in strategic planning of the project and in reviewing the progress of the project, determine its relative priority, are available to secure help from outside the company and to guide the team through unexpected events, the team thinks that they do to a significantly lesser extent. This finding confirms that there is a mismatch between perceptions of these two groups. It also complements the findings of Barczak and Wilemon (2003) indicating that NPD team members perceive lesser support from their top managers but provides more detail on the aspects of support which are seen as insufficient by the team. Awareness of this difference in perceptions is important for both parties as it might help them to better empathize each others' feelings and expectations. Hidden expectations might depreciate team morale and ultimately their performance. Mutual understanding of needs and building a shared language might foster effective collective effort, which eventually might improve work satisfaction and bring better performance.

References

Akgün, A.E., Byrne, J.C., Lynn, G.S. and Keskin, H. (2007). Team stressors, management support, and project and process outcomes in new product development projects. *Technovation,* **27,** 628-639.

Bao, G.M. and Yang, J. (2004). Dynamic Competences and Technological Innovation in Chinese Enterprises. *2004 Engineering Management Conference.* IEEE International.

Barczak, G. and Wilemon, D. (1992). Successful new product team leaders. *Industrial Marketing Management,* **21,** 61-68.

Barczak, G. and Wilemon, D. (2003). Team member experiences in new product development: views from the trenches. *R & D Management,* **33,** 463-479.

Bonner, J.M., Ruekert, R.W. and Walker, O.C. (2002). Upper management control of new product development projects and project performance. *Journal of Product Innovation Management,* **19,** 233-245.

Carbonell, P. and Rodríguez-Escudero, A.I. (2009). Relationships among team's organizational context, innovation speed, and technological uncertainty: An empirical analysis. *Journal of Engineering and Technology Management,* **26,** 28-45.

Cooper, R.G. and Kleinschmidt, E.J. (1996). Winning businesses in product development: The critical success factors. *Research Technology Management,* **39,** 18-30.

Gomes, J., Weerd-Nederhof, P.D., Pearson, A. and Fissher, O. (2001). Senior Management Support in New Product Development Process. *Creativity and Innovation Management,* **10,** 234-242.

Green, S.G. (1995). Top management support of R&D projects: A strategic leadership perspective. *IEEE Transactions on Engineering Management,* **42,** 223.

Hunt, G.T. (1980). *Communication Skills in the Organization* New Jersey: Prentice-Hall.

Lin, H.-F. (2007). Knowledge sharing and firm innovation capability: an empirical study. *International Journal of Manpower,* **28,** 315-332.

Mcdonald, P.R. and Eastlack Jr, J.O. (1971). Top management involvement with new products: Majority of CEO's report participation. *Business Horizons,* **14,** 23-31.

Reilly, R.R., Chen, J.Y. and Lynn, G.S. (2003). Power and empowerment: The role of top management support and team empowerment in new product development. *Technology Management for Reshaping the World*, 282-289.

Rodríguez, N.G., Pérez, M.J.S. and Gutiérrez, J.a.T. (2008). Can a good organizational climate compensate for a lack of top management commitment to new product development? *Journal of Business Research,* **61,** 118-131.

Rubenstein, A.H., Chakrabarti, A.K., Okeefe, R.D., Souder, W.E. and Young, H.C. (1976). Factors Influencing Innovation Success at Project Level. *Research Management,* **19,** 15-20.

Swink, M. (2000). Technological innovativeness as a moderator of new product design integration and top management support. *Journal of Product Innovation Management,* **17,** 208-220.

Too, E.G. and Weaver, P. (2014). The managenent of project management: A conceptual framework for project governance. *International Journal of Project Management,* **32,** 1382-1394.

Wheelwright, S.C. and Clark, K.B. (1995). *Leading Product Development* New York: The Free Press.

Application of Data Mining Techniques and Competitive Intelligence for efficiency gains in Public Service Selection Exam Agencies

Junior R R S[1], Neumann C[2]

Abstract: This paper is based on the application of massive data mining techniques to databases related to Public Service Selection Exams to highlight specific knowledge skills discovery. The main observation pointed out was related to the high absence rate, especially by candidates who are exempt from the registration fee. The information regarding the absence rate is exploited to obtain higher efficiency, saving resources in renting facilities, allowing investment in anti-fraud technologies and eventually, reduction in registration fees, allowing for a greater number of people to participate in Public Service Selection Exams. This is clearly a competitive advantage over peer companies. This paper demonstrates, using simulations and under certain assumptions, that there is no risk in using a "7% excess-capacity" rate in the examination rooms.

Keywords: Competitive intelligence; Data Mining; Efficiency gains; public service selection exams; simulation.

1 Introduction

In general, the Brazilian society regards positively admission to public service through selection exams, seeing an opportunity for all citizens to access public office positions based on merit rather than relying on personal relationships, sponsorship or kinship. Initially, this paper's objective is to extract knowledge from databases derived from candidates registered in Public Service Selection Exams using data mining techniques. Furthermore, the knowledge demonstrated in the initial stage was explored through competitive intelligence, seeking efficiency gains in the use of resources for use in Public Service Selection Exams Agencies. If the services provided by the Public Service Selection Exams Agencies are efficient, there is a possibility to increase investments in security and other aspects related to the applications of the exams, as well as a reduction of registration fees.

1 **Roberto Rosa da Silveira Junior** (robertojr@cespe.unb.br)
Dpto de Ciência da Computação.
2 **Clóvis Neumann** (clovisneumann@unb.br)
Dpto de Egenharia de Produção.
Universidade de Brasília. Campus Universitário Darcy Ribeiro,
Brasília - CEP 70910-900, Brazil.

2 Related papers

Several articles approach the extraction of knowledge using data mining techniques. Freitas CMDS, Nedel LP et al (2008), provides an overview of the issues dealing with knowledge discovery and visualization of information on social networks, specifying a structure for data representation, a set of data mining techniques for knowledge acquisition and a learning mechanism machine to act rationally on the environment and improve performance in future tasks. There are also articles published about competitive intelligence and the advantages of its use in organizations, as demonstrated by Canongia C, Santos DM, Zackiewicz M (2004) and Colauto RD, Gonçalves CM et al (2004).

3 Theoretical Framework

3.1 Global Process Data Mining and Competitive Intelligence

According to Ragab AHM, Noaman AY et al (2014), data mining is the process of knowledge extraction from large databases. Its techniques apply advanced computing methods to discover unknown relationships, summarize results of analysis observed in data sets and demonstrate clear and understandable relationships between data. According to Witten IH, Frank E, and Hall MA (2011), there are essentially four techniques, namely: *Classification*: learning technique that provides a data set, a sample of examples, which support the classification of a set of unknown data; *Association*: learning technique that seeks an association between some characteristics in data sets; *Clustering*: learning technique that seeks to find, within a set of data, elements which are grouped in a given pattern, and *numerical prediction*: learning technique to predict numerical quantities (non-discrete).

Currently, the strong relationship between information management, knowledge management and competitive intelligence is easily noticeable. It is understood that information management operates with explicit knowledge, while knowledge management operates with tacit knowledge. As for competitive intelligence (CI), it operates with both of them, explicit and tacit knowledge, and is characterized as a process. The CI establishes relationships and interconnections between information management and know-ledge management (Valentim MLP (2002)).

4 Methodology

The methodology for this paper includes the discovery of knowledge through data mining techniques and its use as an organizational competitive intelligence. For the process of knowledge discovery, we will use the consolidated steps of the overall process known as KDD, explained by Fayyad UM, Piatetsky-Shapiro G et al (1996): *selection*, *pre-processing*, *transformation*, *data mining* (*DM)* and *evaluation / interpretation*. Later, competitive intelligence will be used, adding a descriptive statistical analysis to verify important cost-related information to perform simulations. With the simulations, the competitive intelligence can be established for gaining competitive advantage through service efficiency increase (with cost savings) in application of exams by Public Service Selection Exams Agencies.

4.1 Selection, pre-processing, transformation data, data mining and Evaluation

The necessary data is selected and collected. The data used in the analysis was provided by the Brazilian Research on Evaluation and Selection Center and Event Promotion (Cebraspe), also known as Cespe, which started its activities in the 70s, conducting admission exams to the University of Brasilia (UnB). After the Constitution of 1988 was promulgated, Cespe also began conducting Public Service Selection Exams. The pre-processing is the transformation of the data. In this paper, two tools were used in this step, namely: The Database Management System (DBMS) *SQL Server Express (Microsoft)* and the *GNU RStudio Statistical Data Analysis*. The status of of applications processing was standardized. Applications paid through invoices or other barcode documents, such as the GRU (Union Payment Form) were labeled as the “Invoice” category. For the attendance situation in selection exams, the following categories were considered: "absent", "present", "eliminated" and "not summoned for examination" (description assigned to the records of candidates whose payment situation is equivalent to "canceled registration").

Disqualifications of applicants during the exams for reasons stated in the exam notice (event rules) were grouped in the "Eliminated" category.

Initially, the technical classification with logistic regression algorithm was used to find a relationship between the attributes with a response variable. As a response variable, the attendance situation was chosen, that is, the intention is to verify which attributes influence the attendance of candidates (categories).

Once the previous step is concluded, all predictor variables significantly associated with the response variable were selected. Using a decision tree it is possible to obtain an induction model in "yes-no" format, to be constructed dividing the different classes according to their attributes. The result obtained is shown in Figure 1 below:

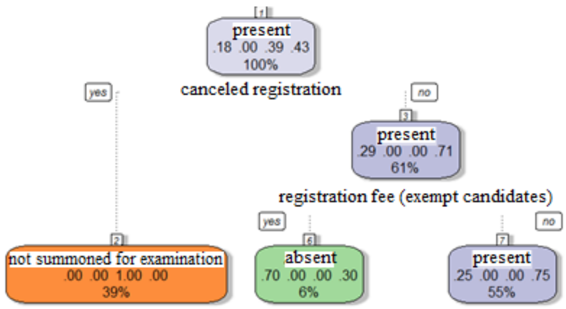

Fig.1
Decision tree obtained with the predictor variables.

The decision tree displays a structure with a four-variable response, namely: "absent" (green color is highlighted), "eliminated ", "not summoned to the exams" (orange color is highlighted) and "present" (purple color is highlighted). Since the number of occurrences for the "Eliminated" variable was insignificant, the structure failed to represent this variable.

After analysis of the decision tree and using business knowledge, it followed that the list presented by the “not summoned to the exams" category was unnecessary. However, the other relationship was a surprise, since, despite the suspicion that the abstention rate for the candidates exempted from the registration fee (exempt candidates) would be higher than that of candidates who paid the admission fee, the discrepancy was greater than expected. What the decision tree shows is that 70 percent of participants who are exempt from registration fees did not attend the location in which the exams were administered.

4.2 Application of competitive intelligence

The usefulness of the analysis of the burden imposed by exempt candidates who were absent was proved. However, this paper’s approach was to use the information regarding the absence ratio for all applicants, which stands at more than 1/4 of the properly allocated candidates. As mentioned before, since this is a more significant number, it offers, in principle and depending on feasibility, a higher possibility for savings.

The search for efficiency in the services provided through the optimization of resources, that is, the search for a competitive advantage making the most efficient use of the exam sites, requires using the information regarding the absence, taking into account the following: **a)** ensure administration of the exams without risk to the candidates, seeking to always have proper facilities for the exams; **b)** provide facilities with enough spare positions to bear candidates not contemplated in the admission log list, caused by force of injunctions, unidentified payments by the agency responsible for the exams or any inconsistency in bank service charges.

Data for surveys of costs

In order to verify cost reduction it is necessary, in the first place, to locate and analyze cost data regarding the facilities designated to carry out the exams. The survey used two databases, namely:

1. The candidates database aforementioned in subsection "Selection, pre-processing and transformation data". General information about registered candidates database: Total candidates: 3,783,863; Total candidates, effectively registrated: 2,261,400; Total exams (events): 27 and Total exam rooms: 51,074.

2. A spreadsheet of facilities designated to carry out exams, including rent rates, used in events during March/2014, provided by the sector responsible for renting facilities designated to carry out exams. Here we highlight the following:

The spreadsheet included 1,231 facilities designated to carry out exams and the average rent rate was R$ 2,716.12. Since the base date for the information was March 2014, the inflation rate corresponding to the elapsed period (March / 2014 to December / 2014), of 5.10%, was applied. The updated average rate after adjusting for inflation was R$ 2,854.64. Costs related to hiring Coordinators, deputy coordinators, room supervisors and other important staff in Public Service Selection Exams were informed by Cespe‘s sector responsible for hiring, using the price currently practiced (without corrections). The same sector also reported the reserve percentage, when appropriate, for each of the staff member.

An important information from the sector responsible for facilities designated to carry out exams was that there is always a spare room reserved for contingencies and risks, that is, to serve candidates who have injunctions, or to consider candidates whose invoices were not processed by banks, even when actually paid, etc. The spare rooms have an average capacity for 30 candidates. *Historically, the usage of the spare room never exceeded 40%. Therefore, the remaining 60%, or 18 seats, in the spare room can be used for candidates belonging to rooms with exhausted capacity (oversized to account for absences).*

The expected number of absentees, usual in Public Service Selection Exams, will be called "*Controlled Absention*" (CA). The number of attendees in excess of expectations in a given exam room will be called "*Unexpected Attendance*" (UA)

According to the data collected to estimate costs, the mode of the absence percentage was 25%. Thus, the simulations can be performed with the absentee percentage inferior to the mode, seeking an ideal percentage of "*Controlled Absention*" (CA), considering the business aspects already placed, which must be met for the proper conduct of selection exams.

4.3 Simulations

Simulation is a technique used for both the design and evaluation of new systems, as well as for the physical reconfiguration or changes in control and (or) existing systems operation rules. The applications of simulation have increased in all areas, assisting managers in decision-making of complex problems and enabling a better understanding of processes in organizations (Sakurada N, Miyake DI (2009)).

For the simulation in place, the instructions used were based on database standard language (SQL), the candidates database, and a database management system (*SQL Server Express - Microsoft®)*. The simulations were carried out according to the following steps for each (integer) percentage rate below the mode:

1. Establishment of the percentage to be simulated as input (initiates at 24, the first integer below the mode of 25); **2.** Summarization in temporary table of all the exam rooms containing the following information: event, exam room, number of registered candidates, absent candidates, absence percentage and amount of UA. The UA information was obtained for each room calculating the product between the number of candidates in the room and the percentage to be simulated, rounding to the next whole number (if the number obtained is not full). This result is subtracted from the number of absentees in the room. If the result is a positive number, then there is an indication that the number of absentees was smaller than the expected absentees (occurrence of the "UA"). **3.** Summarization in temporary table of all the exam rooms, containing the number of exam rooms, the number of rooms with UA and the number of candidates that were classified as UA. **4.** Count of the occurrences (exam sites) where the number of candidates classified as UA may gene-rate some kind of problem due to insufficient places in the spare room.

In this case, only rooms which had an UA superior than 18 were considered, because, as reported by the responsible sector for hiring facilities designated to carry out exams, there will always be up to 30 spare places, with the possibility for 18 candidates, considering the UA (60% capacity as reported earlier). Also considered were the facilities in which the quantity of candidates classified as UA surpasses the amount of rooms, given that the average number of rooms per facility is also 18.

Considering 8% of CA applied to each room, that is, increasing its capacity in virtual terms, only two rooms presented problems. Even in this case, it would be difficult to experience any kind of real problem, given that in these places there were no candidates with injunction (leaving a greater capacity in the spare rooms). Nonetheless, since the requirement was to use 60% of the spare room (18 seats), not 30 seats (average capacity of the spare rooms), the simulation ensures the use of 7% of CA (with zero problem). The probability of UA in a room, according to the data used in the simulation, is less than 5%.

Table 1
Results of simulations.

Controlled Absention (CA) percentage tested	Rooms designated to carry out exams with problems
24%	1147
…	…
9%	20
8%	2
7%	0

5 Conclusions

This paper demonstrated it is possible for Public Service Selection Exams Agencies to analyze registration data through data mining techniques, emphasizing certain aspects that are not always clear to managers and decision makers. As noted, it was still possible to explore, seeking competitive advantage, the results obtained though data mining techniques. Obviously, to obtain competitive advantages, the study should consider certain security, quality and business rules principles that permeate the organization. Knowing the business rules is essential to easily realize the opportunities to be exploited, such as competitive advantages, from any highlight.

The minimum safe level for CAs, for purposes of renting facilities (spare rooms), of 7% is feasible, without harm or consequences due to lack of capacity (100% of the facilities designated to carry out exams), as observed in the analysis of the data used in the simulation, which represent a fairly significant and diverse sample. The possibility of using a higher percentage of CAs safely is not ruled out, providing financial returns and greater competitive advantage, as long as the principle of spare room capacity, of 18 participants (60%), is increased. In this case, it is necessary to conduct a risk analysis to decrease the 40% percentage of spare rooms capacity for contingency situations (candidates not included in the registration, designated under injunctions or unidentified payments by the Public Service Selection Exams Agencies due to inconsistencies in bank procedures).

It is emphasized that this analysis considered specific aspects of capacity, whereas there will be a spare room for every 18 rooms designated. Certain aspects, such as room supervisors training, procedures to relocate candidates to spare rooms, etc, were not considered. It is thus recommended the implementation of additional measures to the competitive intelligence such as: **a)** The formalization of these instructions in case of UAs in rooms; **b)** Implementation of team training to properly relocate candidates to spare rooms without constraints, among others.

If the CA level considered was 7% for each designated room, considering a cost of R$ 11.93 per candidate as per the obtained data, considering only the designation coss for each candidate (excluding printing, drafting and other costs) and considering 2,261,400 designated candidates (distributed in rooms) in 27 exams used in the simulation, the savingscould reach R$ 1,888,495.14 (one million, eight hundred eighty-eight thousand, four hundred ninety-five reais and fourteen cents).

With the financial savings obtained, it would be possible to invest in security procedures in Public Service Selection Exams to prevent fraud. There is also the possibility of a reduction in fees, allowing more citizens to apply. The strengthening and increase in credibility of the Public Service Selection Exams procedures are essential to reduce the discretionary appointment of employees by government officials and to ensure that the public in general is served by the most capable people.

6 References

Canongia C, Santos DM, Zackiewicz M (2004) Foresight, inteligência competitiva e gestão do conhecimento: instrumentos para a Gestão da inovação. Gestão & Produção. Avaliable via DIALOG. http://www.scielo.br/pdf/gp/v11n2/a09v11n2.pdf. Cited 8 Dez 2014.

Colauto RD, Gonçalves CM et al (2004). Os fatores críticos de sucesso como suporte ao sistema de inteligência competitiva: o caso de uma empresa brasileira. Revista de Administração Mackenzie Ano 5, N.2, P. 119-146. . Available via DIALOG. http://editorarevistas.mackenzie.br/index.php/RAM/article/view/58/58. Cited 18 Dez 2014

Fayyad UM, Piatetsky-Shapiro G et al (1996) Advances in Knowledge Discovery & Data Mining. 1 ed. American Association for Artificial Intelligence, Menlo Park, Califórnia,. 611 pages.

Witten IH, Frank E, and Hall MA (2011) Data Mining: Practical Machine Learning Tools and Techniques, Third Edition, 3 edition.Burlington, MA: Morgan Kaufmann, pág. 90, 445.

Freitas CMDS, Nedel LP et al (2008) Extração de Conhecimento e Análise Visual de Redes Sociais. Anais do XXVIII Congresso da SBC. Available via DIALOG. http://softwarelivre.org/articles/0035/8363/Extra%C3%A7%C3%A3o_de_Conhecimento_e_An%C3%A1lise_Visual_de_Redes_Sociais.pdf. Cited 16 Dez 2014

Ragab AHM, Noaman AY et al (2014) A Comparative Analysis of Classification Algorithms for Students College Enrollment Approval Using Data Mining. Workshop on Interaction Design in Educational Environments (IDEE).

Sakurada N, Miyake DI (2009) Aplicação de simuladores de eventos discretos no processo de modelagem de sistemas de operações de serviços. Available via DIALOG. http://www.scielo.br/pdf/gp/v16n1/v16n1a04.pdf. Cited 20 Nov 2014

Valentim MLP (2002) Inteligência competitiva em organizações: dado, informação e conhecimento. DataGramaZero, Rio de Janeiro, v.3. Available via DIALOG. http://www.dgz.org.br/ago02/Art_02.htm. Cited 2 Dez 2014.

Performance Evaluation of Order Acceptance Decision under Static and Dynamic Settings

Sujan Piya, Ahm Shamsuzzoha[1]

Abstract: This paper develops two different methods of order acceptance and rejection decision (OAD). The developed methods represent decision making under static and dynamic settings respectively. These methods are analyzed using arena simulation software and comparisons are made to understand the situation under which one OAD setting outperforms others.

Keywords: Order Acceptance; Simulation; Static and Dynamic Decision.

1 Introduction

One of the major strategic decisions in MTO system is to decide on which order to accept from the customer and which to reject. Basically, there are two situations at which company makes such decision. Paper such as (Piya et al., 2012) has considered dynamic situation where the company makes decision as soon as customer arrives with their order in the system. On the other hand, company may make such decision at a point of time in the period after accumulating some orders as considered in Fabrice and Roel, 2011. Making decision under such situation constitutes static decision. From the discussion it can be noticed that there are papers dedicated to static setting of OAD and others on dynamic setting. No attempt has been made to study the situation under which specific setting is better than the other.

2 Objective

The objective of this paper is to develop two OAD methods, representing static and dynamic settings under flow shop production system. For both methods OAD is based on the available capacity with respect to the due date and profit.

3 Methods

3.1 Dynamic OAD: Once a new customer arrives with certain information such as batch size and due date the company will check the present workload in the system. If the new order could be fitted within the existing workload, the order will then be scheduled for production and expected completion time determined. If it is less than or equal to the exogenously fixed due date, then the order will be checked further for expected profit. If the expected profit is at least equal to the minimum profit margin earmarked, then the order will be accepted.

1 **Sujan Piya** (sujan@squ.edu.om)
Ahm Shamsuzzoha (ahsh@squ.edu.om)
Department of Mechanical and Industrial Engineering,
College of Engineering, Sultan Qaboos University, Sultanate of Oman.

3.2 Static OAD: OAD under static setting works on a periodic basis. In this setting orders that arrive within certain time window of a period is accumulated and OAD is done once the time window of a given period is completed. Therefore, this setting represents selection of order from an order sets based on some criteria. It means that before the OAD is done, the order will remain in the order pool. At the decision point, based on all the accumulated orders in the order pool and past orders production schedule will be generated using earliest due date (EDD) dispatching rule. This helps to know the expected completion time of each new order.

4 Result

Table 1 shows the results of numerical analysis conducted using ARENA software. From the table it is obvious that as compared to dynamic setting, more orders are rejected in static settings. The reason is that in this setting orders are accumulated for decision making and accepted orders are dispatched all at once creating long queues in the initial workstation rather than making decision immediately after each arrival and start production. However, even though rejections are more, the difference in total profit is not drastic. It indicates that static setting is more selective in the decision process and tries to accept profitable orders. In terms of tardiness, static OAD is significantly better than that of the dynamic system. The reason is that in dynamic setting more orders are accepted without being able to take the decision by streamlining the schedule based on different orders. Also, in terms of average time the order spent on the system static system is better.

Table 1
Simulation result for OAD.

Parameters	OAD	
	Dynamic	Static
Accepted orders	176	154
Orders rejected	19	41
Total Profit ($)	494.51	468.40
Average tardyness (days)	2.31	0.83
Average time in the system (hr)	32.76	14.74

4 Conclusion

This paper developed static and dynamic models of OAD in a flow shop production environment. Numerical analysis is carried out to evaluate the performance of these models. Analysis indicates that each setting is effective under the given situation and based on the objective function of manufacturer. This research can be extended to consider the problem in a Job shop production system.

References

Piya S, Katsuhiko T, Katsumi M (2012) Order Acceptance Decision in Make Order System: Satisfaction Level Based Approach. Operations and Supply Chain Management: An International Journal, 5(2), 84-96.

Fabrice, T.N., and Roel, L., 2011, "Exact algorithms for a generaliz- ation of the order acceptance and scheduling problem in a single-machine environment", *Computers and Operations Research*, 38 (1), 367-378.

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A simulation-optimization approach for production planning and scheduling

Moniz S[1], Marques A, Carvalho S, Pinho de Sousa J

Abstract: In this paper, we propose and assess a Simulation-Optimization (SO) method to solve a real world planning and scheduling problem that has been addressed by the authors in the metal working industry. We present an experimental study comparing the iterative SO approach developed by Kim and Kim (2001) with our SO method that considers new types of capacity and production constraints in the optimization model. Preliminary computational results have shown that the proposed method tends to outperform Kim and Kim (2001) approach, both in terms of total products produced and value of the objective function.

Keywords: Production planning, Scheduling, Simulation-Optimization, Discrete-event simulation, Linear Programing.

1 Introduction

Market competitiveness pushes industrial companies towards a continuous improvement of production systems. Production planning and scheduling are often viewed as critical functions to reduce operational costs and to improve the performance of those systems. In general terms, planning and scheduling problems comprise the allocation of resources to competing customer orders across a time horizon that ranges between several days and one year. The related problems are very difficult to solve due to their combinatorial character, the fact that they are very resource constrained, and to high levels of uncertainty. This paper addresses part of these problems by proposing a new Simulation-Optimization (SO) method.

Production planning decisions are related to tactical decisions made for medium-term time horizons and aim at determining optimized production mixes, lot sizes, assignment of orders to work-centers, and release plans. Resource allocation decisions and capacity constraints are often modelled in an aggregated way. On the contrary, scheduling decisions concern operational decisions made for relatively short time horizons and aim at obtaining feasible production schedules at the level of the shop floor. Scheduling then involves decisions such as ordering and sequencing of the operations in the work-centers. Since, in practice, planning and scheduling decisions are deeply interconnected, research has been focused on solving the integrated planning-scheduling problem (Moniz, Barbosa-Póvoa, Pinho de Sousa, & Duarte, 2014).

To efficiently solve the planning and scheduling problem, models must accurately consider the lead time of the production line. This lead time can be defined as the total time between the release of the product to the shop floor and its output at the end of the line, ready to satisfy the demand. The critical decisions here are to determine, for each product, the quantity and the timing when it should be released to the shop floor. However, it is known that when the release rate leads to a workload that is close to the line capacity, the lead time significantly increases (Hopp & Spearman, 2001). So release decisions depend on the estimation of the lead time and this time depends on the resources utilization that depend on the release decisions. This circular dependency has been addressed by several authors in the past (Modigliani & Hohn, 1955). More recently this challenge has also been addressed by (Kacar, Irdem, & Uzsoy, 2012; Safaei, Moattar Husseini, Z.-Farahani, Jolai, & Ghodsypour, 2010; Sel & Bilgen, 2014) by applying clearing functions or simulation-optimization approaches. Interesting reviews in this area have been published by (Figueira & Almada-Lobo, 2014; Negahban & Smith, 2014; Pahl, Voß, & Woodruff, 2007).

1 **Samuel Moniz** (samuel.moniz@inesctec.pt)
INESC TEC.

In this work, we improve the SO feedback loop by proposing new capacity constraints for the optimization (LP) model. The innovative characteristic of the proposed constraints relies comes from the fact that the total processing time is estimated and handled in the left side of the capacity constraints. Moreover we introduce additional constraints that account for the excess of amount released by the optimization model. The remainder of the paper is structured as follows. In section 2 a literature review is presented. The case study is introduced in section 3, and it is followed by a section described the SO approach. Then in section 5, we present some computational results. Finally, section 6 provides some concluding remarks.

2 Literature review

A straightforward way to model the production lead lime is to consider that it is constant and independent of the workload. This approach is generally considered in Material Requirements Planning (MRP) systems and in the most mathematical programing models for solving planning problems (Missbauer & Uzsoy, 2011; Pochet & Wolsey, 2006). The main problem associated with this approach is that the derived production plans tend to overestimate the effective capacity of the production system, especially when the resources of the production system have high utilization rates. To tackle this problem models use additional parameters, attempting to capture the nonlinear behaviour between workload and production lead time (Pahl et al., 2007).

In early papers, orders release is constrained by extended lead time parameters that are incorporated in the capacity constraints of an LP model. Hung and Leachman (1996) perform production planning with the fractional lead times being estimated for a given release plan and allowed to be spread over several time periods. Byrne and Bakir (1999) propose the adjustment of the available work-center capacity based on the effective work-center load obtained in the simulation. Kim and Kim (2001) extended the two previous works by proposing new capacity constraints of the LP model that simultaneously estimate the lead times and the effective capacity of the work-centers. Later Byrne and Hossain (2005) modify the left side of the capacity constraints to consider an effective load ratio per product, operation, and work-center; and the right side with the probability of availability of the work-center.

More recently, general approaches using SO have been proposed. Acar, Kadipasaoglu, and Day (2009) develop a general approach that uses a simulation model to provide lower bounds to a mathematical programming model. Bang and Kim (2010) address the production planning and scheduling problem of semiconductor wafer fabrication, and propose an iterative optimization approach involving three steps. In each iteration, the values of waiting time and the inventory level in the bottleneck workstation obtained in simulation are used for updating the parameters of the LP model. In a recent work, Marques, de Sousa, and Rönnqvist (2014) develop a SO approach for short term planning of forest operations.

3 Case study

In this paper, we address the production planning and scheduling problem of a job shop manufacturing system that produces engineered metal components. Customer orders specify quantities and delivery dates. There are 6 work-centers and the number of machines in each work-center is depicted in Figure 1. The product routings and operational costs are assumed to be known. The case is deterministic and involves the production of 4 types of products during 3 weeks. It is assumed that the available time per week is 2,400 minutes. The objective is to minimize the operational costs by determining the allocation of the products to work-centers and the corresponding sequencing. The discrete-event simulation model has been built in SIMIO and a FIFO dispatching rule has been used in the work-centers. The exception is the first work-center (C01) that alternates processing in a cyclical way among the products that have been released.

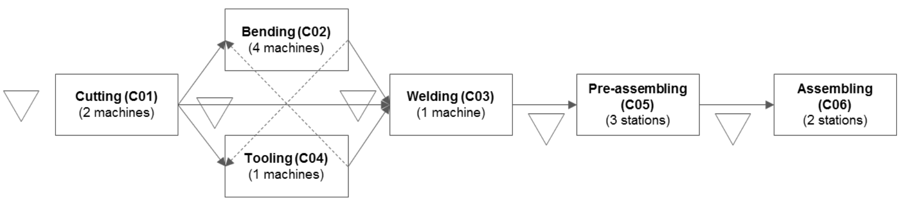

Fig.1
Production system.

4 Simulation-optimization approaches

The iterative SO approach that has been tested is based on the procedure proposed by Byrne and Bakir (1999) and then adapted by Kim and Kim (2001), and has been classified as Recursive Optimization Simulation Approach (Figueira & Almada-Lobo, 2014). The first step consists in running a LP model to determine the release plan. In the second step a discrete-event simulation model runs with the release plan previously determined by the LP model. Statistics concerning the loading ratios and work-centers utilization are collected during the simulation. In a third step, the capacity constraints of the LP model are adjusted with the loading ratios and the work-centers utilization parameters, as obtained by the simulation. The procedure stops after a determined number of iterations has been reached.

4.1 Kim-Kim (KK) approach

The LP model of Kim and Kim (2001) is given by expressions (1-5). The model considers four types of continuous variables. X_{ip} define the amount of product released at time p; Y_{it} are auxiliary continuous variables that define the quantity of output of product i at time t; I_{it} represent the inventory amount; and B_{it} represent the backorder amount for each product and time interval.

The objective function (1) is to minimize the total costs, by considering production (c_{it}), inventory (h_{it}), and backorder (π_{it}) costs. The capacity constraints (2) have, at the right side, the work-center utilization parameters (u_{kt}) and, at the left side, the loading ratio ($e_{ijk(p,t)}$) of product i and operation j on work-center k and period t, when the product release occurs in period p, such that $p \leq t$. Both u_{kt} and $e_{ijk(p,t)}$ parameters are updated in each iteration of the procedure. The processing time of product i in operation j and work-center k is given by a_{ijk}. Constraints (3) express the relation between product releases and production affected by the loading ratio parameter. Constraints (4) are the inventory balance, and constraints (5) enforce the non-negativity of variables. For more details concerning this LP model please see Kim and Kim (2001).

$$\min \sum_{t=1}^{T} \sum_{i=1}^{N} (c_{it} Y_{it} + h_{it} I_{it} + \pi_{it} B_{it}) \tag{1}$$

$$\sum_{i=1}^{N} \sum_{j=1}^{M_i} \sum_{p=1}^{t} e_{ijk(p,t)} a_{ijk} X_{ip} \leq u_{kt} C_{kt} \quad \forall k \in K, t \in T \tag{2}$$

$$Y_{it} = \sum_{p=1}^{t} \sum_{k=1}^{K} e_{iM_i k(p,t)} X_{ip} \quad \forall i \in I, t \in T \tag{3}$$

$$I_{it} - B_{it} = I_{i,t-1} - B_{it-1} + Y_{it} - d_{it} \quad \forall i \in I, t \in T \tag{4}$$

$$Y_{it}, X_{it}, I_{it}, B_{it} \geq 0 \tag{5}$$

4.2 Proposed approach

In the KK approach the values for the $e_{ijk(p,t)}$ parameters are computed after each simulation run and refer to each planning period of the optimization model. If the initial release plan (determined by the LP model) is far from the optimal solution, the estimated loading ratios retrieved by the simulation may wrongly guide the SO approach and can lead to very poor solutions. The approach proposed in this work replaces constraints (2-3) by constraints (6-7) and considers one additional type of constraints (6) to impose an upper bound on the release amounts.

In our approach, we iteratively estimate the average loading ratios relative to any time period of the release plan, instead of obtaining loading ratios to fixed time periods as done by (Hung & Leachman, 1996; Kim & Kim, 2001). The new parameters ($e^{*}_{ijk\theta}$) represent the loading ratios of operation j and work-center k at time θ relative to the release of product i. Constraints (6-7) result from the introduction of the new loading ratio parameters into constraints (2-5). Finally, constraints (8) are applied only to the subset of products that have output production in the optimization model larger than the effective production in the simulation model. For those products, we set the upper bound Y_i^* for the release variable so as to correct the excess of product release.

$$\sum_{i=1}^{N}\sum_{j=1}^{M_i}\sum_{\theta=0}^{LeadTime_i} e_{ijk\theta}^{*} a_{ijk} X_{it-\theta} \le C_{kt} \quad \forall k \in K, t \in T \tag{6}$$

$$Y_{it} = \sum_{k=1}^{K}\sum_{\theta=0}^{LeadTime_i} e_{iM_ik\theta}^{*} X_{it-\theta} \quad \forall i \in I, t \in T \tag{7}$$

$$\sum_{t \in T} X_{it} \le Y_i^* \quad \forall i \in I^* \tag{8}$$

5 Computational results

Preliminary computational results show that the KK approach rapidly converges to solutions where the total output of the production plan obtained by the LP model is similar to the total output resulting from the simulation model. Nevertheless, the use of the loading ratio and work-center utilization parameters in the capacity constraints results in better solutions, both in terms of total output and objective function value. In particular, since the work-center utilization parameters are computed based on the values of the previous simulation run, the increase of the amount released in the LP model will be strongly constrained in the next iterations. Therefore, we can say that the KK algorithm serves well the purpose of getting feasible production plans and schedules, however it is quite limited in improving solutions during the iterative approach. On the contrary, considering the LP model with constraints (6-8), the total output of the production line tends to increase, and the total cost of the production plan tends to be lower, when compared with the results obtained by the KK approach.

Table 1
Proposed approach results.

Period	Product	Iteration 1		Iteration 2		Iteration 3	
		Release	Output	Release	Output	Release	Output
1	1	48	48	115	115	137	136
	2	203	203	192	161	178	148
	3	207	207	184	175	186	162
	4	260	260	260	260	260	260
2	1	52	52	96	96	89	89
	2	253	253	220	215	230	221
	3	163	163	169	170	164	167
	4	200	200	200	200	200	200
3	1	132	132	18	18	0	0
	2	235	235	369	344	375	351
	3	138	138	84	88	89	98
	4	140	140	140	140	140	140
Total output		2,031	2,031	2,047	1,982	2,048	1,972
Obj. function			772,666.6		820,838.9		834,226.2

Table 1 summarizes the preliminary results for the new approach. In the third iteration the total output and objective function value outperform the KK approach in more than 10%. The results of the following iterations show, as well, that the results of the proposed approach always outperform the KK results. However, convergence cannot be guaranteed. A relevant practical aspect of this algorithm is that it can provide reliable planning and scheduling solutions in less than 3 minutes. The LP model was implemented using ILOG/CPLEX version 12.5.1 and the simulation model was built in SIMIO, running on an Intel Core i7-4700Q with 12 GB of RAM.

6 Conclusions

This paper presented and assessed a new Simulation-Optimization (SO) approach for solving production planning and scheduling problems. A new loading ratio parameter has been proposed and an additional set of constraints that impose an upper bound on the amount of products released has also been introduced. The performance of the approach (KK) suggested by Kim and Kim (2001) and the proposed SO method have been compared in a real world planning and scheduling problem from the metal working industry.

Preliminary results show that the KK approach rapidly converges to feasible production plans. Nevertheless, the solutions obtained tend to be poor in what concerns the total output and objective function value. In general, the method proposed in this paper clearly outperforms the KK procedure.

These findings are consistent with the results obtained by Irdem, Kacar, and Uzsoy (2010) that demonstrate the convergence of KK approach and with the results presented by Kacar et al. (2012) that show that the solutions obtained by the KK approach are outperformed by clearing functions methods.

Finally, the preliminary results presented in this paper suggest that the performance of iterative SO approaches, such as (Byrne & Bakir, 1999; Hung & Leachman, 1996; Kim & Kim, 2001), can be improved by developing new types of capacity constraints and bounds for the LP model, based on the results provided by the simulation runs.

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8 References

Acar, Y., Kadipasaoglu, S. N., & Day, J. M. (2009). Incorporating uncertainty in optimal decision making: Integrating mixed integer programming and simulation to solve combinatorial problems. *Computers & Industrial Engineering, 56*(1), 106-112.

Bang, J.-Y., & Kim, Y.-D. (2010). Hierarchical production planning for semiconductor wafer fabrication based on linear programming and discrete-event simulation. *Automation Science and Engineering, IEEE Transactions on, 7*(2), 326-336.

Byrne, M., & Bakir, M. (1999). Production planning using a hybrid simulation–analytical approach. *International Journal of Production Economics, 59*(1), 305-311.

Byrne, M., & Hossain, M. (2005). Production planning: An improved hybrid approach. *International Journal of Production Economics, 93*, 225-229.

Figueira, G., & Almada-Lobo, B. (2014). Hybrid simulation–optimization methods: A taxonomy and discussion. *Simulation Modelling Practice and Theory, 46*, 118-134.

Hopp, W. J., & Spearman, M. L. (2001). *Factory physics : foundations of manufacturing management*. Boston: Irwin/McGraw-Hill.

Hung, Y.-F., & Leachman, R. C. (1996). A production planning methodology for semiconductor manufacturing based on iterative simulation and linear programming calculations. *Semiconductor Manufacturing, IEEE Transactions on, 9*(2), 257-269.

Irdem, D., Kacar, N. B., & Uzsoy, R. (2010). An exploratory analysis of two iterative linear programming—simulation approaches for production planning. *Semiconductor Manufacturing, IEEE Transactions on, 23*(3), 442-455.

Kacar, N. B., Irdem, D. F., & Uzsoy, R. (2012). An experimental comparison of production planning using clearing functions and iterative linear programming-simulation algorithms. *Semiconductor Manufacturing, IEEE Transactions on, 25*(1), 104-117.

Kim, B., & Kim, S. (2001). Extended model for a hybrid production planning approach. *International Journal of Production Economics, 73*(2), 165-173.

Marques, A. F., de Sousa, J. P., & Rönnqvist, M. (2014). Combining optimization and simulation tools for short-term planning of forest operations. *Scandinavian Journal of Forest Research, 29*(sup1), 166-177.

Missbauer, H., & Uzsoy, R. (2011). Optimization models of production planning problems *Planning Production and Inventories in the Extended Enterprise* (pp. 437-507): Springer.

Modigliani, F., & Hohn, F. E. (1955). Production planning over time and the nature of the expectation and planning horizon. *Econometrica, Journal of the Econometric Society*, 46-66.

Moniz, S., Barbosa-Póvoa, A. P., Pinho de Sousa, J., & Duarte, P. (2014). A solution methodology for scheduling problems in batch plants. *Industrial & engineering chemistry research*. doi: 10.1021/ie403129y

Negahban, A., & Smith, J. S. (2014). Simulation for manufacturing system design and operation: Literature review and analysis. *Journal of Manufacturing Systems, 33*(2), 241-261.

Pahl, J., Voß, S., & Woodruff, D. L. (2007). Production planning with load dependent lead times: an update of research. *Annals of Operations Research, 153*(1), 297-345.

Pochet, Y., & Wolsey, L. A. (2006). *Production planning by mixed integer programming*: Springer Science & Business Media.

Safaei, A., Moattar Husseini, S., Z.-Farahani, R., Jolai, F., & Ghodsypour, S. (2010). Integrated multi-site production-distribution planning in supply chain by hybrid modelling. *International journal of production research, 48*(14), 4043-4069.

Sel, Ç., & Bilgen, B. (2014). Hybrid simulation and MIP based heuristic algorithm for the production and distribution planning in the soft drink industry. *Journal of Manufacturing Systems, 33*(3), 385-399.

A Mixed-Integer Linear Programming Model for Slots Allocation in Congested Airports

Araúzo JA[1], Ramírez-Ferrero M[2], Villafáñez- Cardeñoso FA[3], López-Paredes A[4]

Abstract: Airlines that intend to fly to/from airports need to obtain a permission to use the full range of airport infrastructure. The permission, which is given by an airport coordinator, is named time slot. The objective of this paper is to develop a mixed-integer linear programming (MILP) model aimed to allocate slots according to the airlines' preferences and the capacity constraints currently specified for the airports in the Europe. Unlike other works, our proposal includes the possibility to reject flights when the slots demand exceeds the airport capacity. The proposed MILP model has been implemented by OpenSolver for Excel and tested with randomly generated examples.

Keywords: Operational Research; Airport Slot Allocation; Linear Programming.

1 Introduction

Airport coordinators allocate slots in a two-stage process: primary and secondary slot allocation. The first one produces the main allocation; later, the second one allows the transfer of slots among airlines, subject to the coordinator's approval.

The primary allocation of slots in European airports is an administrative process governed by the EU Regulation 95/93 (Council Of The European Communities 1993) and the global principles defined by the International Air Transport Association (IATA 2012). The procedure, which is based in historical rights (the so-called grandfather rights), has the advantage of reducing transaction costs, but it is not an efficient system from the economic point of view.

2 Objectives

The aim of this paper is to develop a mixed-integer linear programming (MILP) model with the objective of allocating airport capacity more efficiently and accommodating the schedule to fit airlines' preferences.

1 **José Alberto Araúzo Araúzo** (arauzo@eii.uva.es)
Dpto. de Organización de Empresas y CIM.
Escuela de Ingenierías Industriales.
Universidad de Valladolid. Po/ del Cauce 59, 47011, Valladolid, Spain.

2 **Marío Ramírez-Ferrero** (mario@insisoc.org)

3 **Félix Antonio Villafáñez Cardeñoso** (villafafelix@yahoo.es)
INSISOC Group, Universidad de Valladolid,
Edificio de I+D, Po de Belén s/n, 47011 Valladolid, Spain.

4 **Adolfo López Paredes** (adolfo@insisoc.org)
Dpto. de Organización de Empresas y CIM.
Escuela de Ingenierías Industriales.
Universidad de Valladolid. Po/ del Cauce 59, 47011, Valladolid, Spain.

3 Methods

The airport slot allocation problem is formulated as a mixed-integer linear programming problem in which the total utility (sum of each airline's utility) must be maximized subject to: (1) capacity constraints which limit the number of arrivals and departures that can occur in a specific time interval and (2) scheduling constraints that force the departure of each flight to happen after a minimum turnaround time from its arrival.

The model is an extension of the model proposed in Zografos, Salouras and Madas (2012), in which we have included the possibility of flights to be rejected when the demand of slots exceeds the airport capacity.

4 Results

To validate and assess the proposed MILP model, we have implemented it by means of OpenSolver for MS Excel. The model has been used to solve some scenarios in which the problem size and the load factor have been varied.

5 Conclusion

Test results show that this approach is able to deal with big size and overloaded problems. This will permit, for future works, to develop models for several interconnected airports.

References

Council Of The European Communities (1993) European Council Regulation (EEC) No. 95/93 of January 1993 on Common Rules for the Allocation of Slots at Community Airports. Official Journal of the European Union, L 14, 22.01.1993, Brussels, Belgium.

IATA (2012) Joint IATA/AEA position on the Commission's proposal for a regulation on the slot allocation rules at Union airports. COM 2001/827.

Zografos K., Salouras Y., Madas M.A. (2012) Dealing with the efficient allocation of scarce resources at congested airports", Transportation Research Part C: Emerging Technologies, 21(1), pp. 244-256.

LOGISTICS, PRODUCTION AND INFORMATION SYSTEMS

[Extended Abstracts]

A conceptual model to manage supply sequences in automotive industry for Nissan Barcelona

Bautista J[1], **Fortuny-Santos J**[2]

Abstract: This paper presents an action research experience in *Douki-Seisan* in cooperation with the Nissan Factory in Barcelona. Three suppliers are involved in the experience to improve the way they perform *synchro* deliveries of parts to Nissan. Supplier issues are analysed and a decision making tool is developed for a supplier.

Keywords: Lean Manufacturing; *Douki-Seisan*; Supply Chain Management.

1 Introduction

This paper discusses an action research experience in three suppliers of the Nissan factory in Barcelona. Each automaker may have a different manufacturing philosophy but currently all relate to the lean manufacturing paradigm. In order to re-build the Japanese economy after World War II, with none of the financial resources or economies of scale available to the American auto giants, the Japanese automotive industry realized that, if they were to take on the American automakers, they would have to work in a different way. Toyota developed the Toyota Production System (TPS), a low-inventory, mixed-model approach in which material was pulled "just-in-time" (JIT) through the manufacturing process, without wasteful activities and with a set of employees engaged in improving the system. (Sugimori et al., 1977; Ohno, 1988). The term "lean manufacturing" -famous through "The machine that changed the world" (Womack et al. 1990)- is a generalization of the TPS that can be extended to other contexts. The core of lean is founded on the concept of continuous improvement and the elimination of unproductive manufacturing practices or *waste*.

Adopting lean manufacturing affects the way a company is managed and how it structures its relations with employees, customers and suppliers. When a firm has achieved a certain degree of leanness, it tries to extend lean manufacturing practices to its suppliers (David and Eben-Chaime 2003). However, different automotive suppliers have different capabilities and therefore they may require a significant reorganization in order to implement management methods prescribed by the client company. In consequence, the aim of our research is the development of a methodology to (i) identify the level of leanness in three suppliers and their capability and willingness to adopt lean tools in order to cut waste and unevenness in their relations with Nissan; (ii) identify the necessary conditions to extend lean manufacturing to suppliers; and (iii) develop the tools to fulfil such conditions (processes used within a facility and over distribution connections in order to improve delivery and manufacturing of parts). This methodology can be extended to the suppliers of the suppliers in order to guarantee a real supply network management.

1 **Joaquín Bautista** (joaquin.bautista@upc.edu)
OPE Research Group, Dept. Organización de Empresas,
Universitat Politècnica de Catalunya, ETSEIB,
Avda Diagonal, 647, 7th Floor, 08028 Barcelona, Spain.

2 **Jordi Fortuny-Santos** (jordi.fortuny@upc.edu)
OPE Research Group, Dept. Organización de Empresas,
Universitat Politècnica de Catalunya, EPSEM,
Avda Bases de Manresa, 61-73, 08242 Manresa (Barcelona), Spain.

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2 Understanding *Douki-Seisan* and the Nissan Production Way

This paper is based on a research project conducted at the Barcelona School of Engineering (ETSEIB) promoted by Nissan Motor Ibérica. The Nissan production system is far less popular than TPS, and thus, the first step of our methodology is to understand the particularities of lean manufacturing at Nissan. Beyond a theoretical background, section 2, mostly written after Bautista (2004), corresponds to qualitative research methodology based on interviews with engineers and area managers at Nissan's Barcelona plant in order to adjust our investigation to the needs of the company. Following Schwandt (2000), academics were directly involved with Nissan's participants in an attempt to fully understand the *Douki-Seisan* concept (DS) by means of collaborative work on this project.

The postwar aim of Nissan was the same than that of Toyota, but these companies developed different tools based in different principles, and therefore in the 1980s both manufacturing systems were different although some methods were the same (Cusumano, 1989). The differences include a preference for automation and information systems in Nissan. In 1971, Nissan started using a computerized system to coordinate vehicle orders with materials and component procurement, in house parts production, transport and final delivery of completed automobiles to dealers (Cusumano 1989).

In the 1990s, Nissan developed the Nissan Production Way (NPW) to outline its synchronized production philosophy: to manufacture according to the real consumer order while coordinating all operations and materials. The two pillars of the NPW are (De Goldfiem 2003):

1. Never ending synchronization with the customer in terms of Quality, Cost and Time. The term *Douki-Seisan* means synchronous manufacturing. It involves sequenced and simultaneous/synchronized production: After a customer places an order with a dealer, there has to be synchronization between the manufacturer, the supplier and the dealer with an efficient process flow without any disruptions. This requires sharing information and an efficient procurement and manufacturing system.

2. Never ending quest to identify problems and put in place solutions: Identify gaps between desired manufacturing state and present manufacturing settings.

At Nissan, DS is an ideal state of a production plant where all the processes get information from the customers at same time, in order to establish a continuous flow, free of defects without changes in the scheduled sequence. This means that all processes can have advanced information on demand and therefore types and quantities of products can be scheduled and sequenced. Then, all processes can start their setup operations. In conclusion, DS can be described as a manufacturing methodology that transfers customers' orders to all the processes at same time in order to achieve a continuous and smooth production flow with zero product defects, zero equipment breakdowns, minimal setup time, minimal inventories and no bureaucracy in the manufacturing process.

DS has two important targets: (i) products must be manufactured following the scheduled order and (ii) existing defects must be detected before products leave the manufacturing process. These features allow a reliable and smooth operation of the manufacturing process, without much delay and with fewer inventories between stations. If all the steps of the process could be synchronized, then work in process inventory would disappear.

Nissan insists on the importance of keeping the manufacturing sequence that was previously scheduled for its mixed-product assembly lines. This way, all processes can manufacture parts and subassemblies according to the same schedule and inventories are not necessary. Nissan has some indicators to track the performance of the manufacturing process:

Actual Production Lead Tim*e* (*APLT*). This term refers to work-in-process inventory (*WIP*) and is measured as the time that the manufacturing process can be fulfilled with the available inventories (Equation 1).

$$APLT = \sum_{\forall \, process} \frac{WIP_{process}}{Daily\_production_{process}} \tag{1}$$

Scheduled Sequence Achievement Ratio (*SSAR*). Equation 2 shows the percentage of vehicles that keep the scheduled sequence (vehicles not overtaken by other vehicles.

$$SSAR_{Line} = \frac{Vehicles\_not\_overtaken_{line}}{Total\_Vehicles_{line}} \tag{2}$$

Scheduled Time Achievement *(STAR*). Equation 3 shows the percentage vehicles that reach the end of the process on time (less than ± 1 hour margin with respect to the scheduled time).

$$STAR_{Line} = \frac{Vehicles\_on\_Time_{line}}{Total\_Vehicles_{line}} \tag{3}$$

DS encompasses five different types (or categories) of activities that refer to different elements:

- Category 1: The assembly line sticks to the scheduled deadline and scheduled sequence.
- Category 2: Parts and subassemblies manufactured in the assembly plant flow toward the assembly line as they are processed in perfect synchronicity.
- Category 3: Suppliers produce and deliver according to the schedule. The assembly line and the suppliers are synchronized.
- Category 4: Transportation facilities (ships, trucks) are managed in order to avoid delays in delivery and final products waiting to be shipped.
- Category 5: DS aims at synchronization with the customer. Order Lead Time (Time from customer order received to customer order delivered) has to be short (Car assembled and delivered to customer within two weeks of order). This requires a flexible manufacturing system and the cooperation of the dealers and the sales department.

3 Improving the capabilities of suppliers

According to the DS concept, the following step is to extend synchronous manufacturing and synchronous delivery to suppliers, aiming at the achievement of DS category 3, which is about improving the capabilities of suppliers in order to remove the risks associated with batch manufacturing (inventories and shortages).

This improvement project requires assessing the present situation, defining the desired situation and finally discovering how to reach the final situation from the starting point. The assessment of the level of leanness of the suppliers was done by means of interviews. Currently, some models (See Almomani et al, 2014) are available to formally evaluate practices that refer to inventory, team approach, processes, maintenance, layout/handling, suppliers, setups, quality, and scheduling/control. Depending on the results of the survey, it may be necessary to extend lean thinking to suppliers in order to help them understand lean manufacturing and develop the necessary work procedures. Examples on how to do it can be found in MacDuffie and Helper (1999) who describe the experience of six suppliers of Honda in North America. The methodology can be used by any lean company. Once the supplier is on the maturity path towards lean manufacturing, the car manufacturer may implement a supplier management system that includes supplier selection, improvement, certification and evaluation, for the objectives of continuous improvement, cost reduction and elimination of wasteful activities (Guo and Xu, 2007).

Taking into account the importance of synchronization and keeping the scheduled sequence, the desired situation can be expressed as: (i) The scheduled sequence should not have to be changed and

SSAR (Equation 2) should be over 90%); (ii) If suppliers should know the information about the scheduled sequence in advance then suppliers could manufacture their products according to their client's sequence and put them in bins; (iii) Transportation to the client's plant would be done in sorted containers, full of sorted bins -thus, workers on the assembly line would easily find the parts that they need, and in the necessary order-.

Besides, the consecution of the above objectives would help to attain measurable results such as: (i) Inventory reduction; (ii) Reduction in the amount of plant space taken up by the inventories; (iii) Reduction in logistic costs (Gudehus and Kotzab 2012); (iv) Product availability and wait time; (v) Reduction in the number of stock-outs (due to the synchronization between supplier and automaker); (vi) Flexibility of the production process; (vii) Flexibility for new product launch.

Given the above requirements, a tangible outcome of this project should be an innovative model to sequence supplies such as a management system focused on achieving the desired synchronicity objectives to meet customer requirements by means of a certain organizational structure; sets of policies, procedures and processes; and human, material and financial resources needed to deploy supplies management.

4 Defining a conceptual model and a decision making tool

A task force made up of academics and Nissan's area managers, visited Nissan's plants in Barcelona and also visited suppliers A, B and C. For the aim of our project, suppliers are classified depending on their capability to manufacture and deliver part in synchronicity with the car manufacturer:

1. Suppliers such as company A, which is devoted since 1980 to manufacturing complete seats, which are manufactured in synchronicity with the automaker and delivered in synchronicity. Company A, a subsidiary of an American company, has more than 250 employees and is located 5 km away from Nissan's plant.

2. Suppliers that deliver parts in synchronicity although they do no manufacture in synchronicity with the automaker's schedule. Company B, performs "synchro" deliveries of plastic parts from a warehouse that keeps a couple of days in inventory. The warehouse is replenished from the supplier's plant, where parts are manufactured in batches. Company B, a subsidiary of a North American company since 1999, is located 69 km away from Nissan. With 200 employees, Company B manufactures plastic parts for Seat and, mainly, for Nissan.

3. Suppliers that neither manufacture nor deliver in synchronicity. Company C is a company born in Barcelona in 1947. Since 1991 it has been stamping parts for Nissan (and other companies). Currently it delivers chassis from its facilities 27 km away from the Nissan factory. It has 500 employees.

Four different questions of practical interest seemed to be feasible:

- To compute the lot size that would yield a better synchronicity for a given demand and for a known production rate and setup time.

- To compute the transfer lot size taking into account the existing constraints about transportation from the supplier manufacturing plant to the buffer warehouse in order to improve synchronicity.

- To compute the transfer lot size (and the response time between call off and the delivery in place) taking into account the existing constraints about transportation from the buffer warehouse to the car assembly plant in order to improve synchronicity.

- To compute WIP in the manufacturing plant and in the buffer warehouse as a function of the degree of synchronization between the supplier and the carmaker.

The relationship between the automaker and any supplier can be modelled as the relationship between two systems (Figure 1).

The automaker is considered the Main system (M) while the supplier is considered the Supplier system (S). The Main system has several attributes such as a sequence of units that has been previously scheduled (*Sm*), a vector of time values (*tm*), including cycle time, process time, setup time. In turn, the Supplier system has a sequence of units (*Ss*) that can be similar or not to *Sm*; and their own time vector (*ts*). Between both systems, there is a flow of information and a flow of physical products. The Main system has to send information about *Sm* to the Supplier sufficiently in advance (*tms*), where *tms* is the response time of the Supplier. *tsm* is the transfer time vector from the Supplier to the Main system and *qsm* is a vector of transfer lots from Supplier to Main.

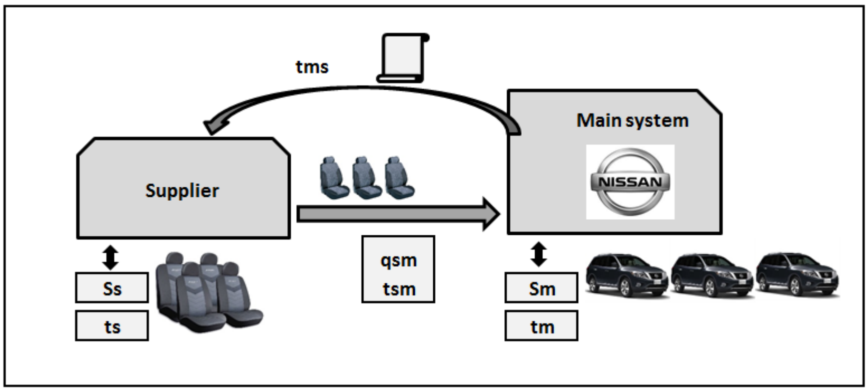

Fig.1
Conceptual model of the relationship between the automaker (Main system) and its suppliers (Supplier system). Relevant variables are shown.

This conceptual model is really practical: Company A is very close to Nissan's factory. Then, frequent deliveries are possible because *tsm* is small (a 10 minute trip). *tms* can be small too (every 15 minutes, a 15 minute-sequenced schedule for the following 15 minute time cube is available) and synchronization is possible. Short production runs and small delivery lots are possible too. However, Company B is further away. One hour is necessary to take parts to Barcelona. Besides, some processes have long setup times (*ts*). In consequence, the response time (*tms*) of this supplier is higher and thus the Main system has to send information enough in advance. This hinders synchronization. It is necessary to reduce the setup time in order to reduce lot size and response time. Meanwhile the information on *Sm* should be distributed sooner, because the required lead time, at the time of the study, was shorter than *tms*.

A final outcome of the research was a piece of software for company C. The aim of the program was to help company C take better decisions related to smooth-synchronized manufacturing problems. The program can accept a bill of materials (BOM) coming from any process in the system; display a multi-level BOM explosion; compute a manufacturing sequence of units that ensures a constant rate of consumption of all the necessary components using a variant of the Toyota Goal Chasing Method; compare the resulting sequence with a user defined sequence; compute when each component is needed; display the consumption of a component over time for a particular sequence; display the deviations from regular consumption in order to compute the necessary inventories of parts and the amount of inventories generated by regular manufacturing; compute the *SSAR* and *STAR* indexes of a sequence and compare them with another sequence.

5 Conclusions

Douki-Seisan aims at the total synchronicity between all the processes along the supply chain. Some internal processes make it difficult to keep the sequence because they are performed in batches. Besides, it is very complicated to keep the scheduled sequence beyond tier 2.

All the steps of the methodology described in this paper can be used by any company that wants to involve their suppliers in lean management. The conceptual model to study the degree of synchronicity between two companies is a first step in the definition of the necessary conditions to allow synchronicity between companies. The completion of the model requires a full list of conditions or constraints to be logically derived. Then, it would represent either an optimization problem or, at least, a constraint satisfaction problem (CSP), which asks whether there exists a feasible solution, or otherwise, gives clues on where the processes should be improved (time management, transportation means selection...).

6 References

Almomani MA, Abdelhadi A, Mumani A, et al (2014) A proposed integrated model of lean assessment and analytical hierarchy process for a dynamic road map of lean implementation Int J Adv Manuf Technol 72, 161–172, doi 10.1007/s00170-014-5648-3

Bautista J (2004) Modelo de gestión para la innovación de la secuencia de suministros. Resumen para la dirección de NMISA R-03/2010. Cátedra Nissan - UPC, Barcelona

David I, Eben-Chaime M (2003) How far should JIT vendor–buyer relationships go? Int J Prod Econ 81/82:361–368, doi: 10.1016/S0925-5273(02)00274-8

De Goldfiem F (2003) Nissan un cran de plus dans la modernisation. L'Usine Nouvelle 2888. Available via http://www.usinenouvelle.com/article/nissan-un-cran-de-plus-dans-la-modernisation.N36490 Cited 9 Feb 2015

Gudehus T, Kotzab H (2012) Chapter 6. Logistic Costs and Controlling In T. Gudehus and H. Kotzab (Ed.) Comprehensive Logistics 129-155 Springer Verlag, Berlin-Heildeberg, doi 10.1007/978-3-642-24367-7

MacDuffie JP, Helper S (1999) Creating lean suppliers: Diffusing lean production through the supply chain. In: Liker JK, Fruin WM, Adler PS, eds. Remade in America. Transplanting & transforming Japanese management systems. Oxford University Press. New York. 154-202

Ohno T (1988) Toyota Production System: Beyond large-scale production. Productivity Press, Cambridge, MA

Schwandt TA (2000) Three epistemological stances for qualitative inquiry: Interpretivism, hermeneutics, and social constructionism. In N. K. Denzin & Y. S. Lincoln (Eds), Handbook of qualitative research (2nd ed.) 189-213. Sage, Thousand Oaks, CA

Sugimori Y, Kusunoki K, Cho F, et al (1977) Toyota Production System and kanban system. Materialization of just-in-time and respect-for-human system. Int J Prod Res 15(6):553-564, doi: 10.1080/00207547708943149

Womack JP, Jones DT, Roos D (1990) The Machine That Changed the World. The Story of Lean Production. Rawson Associates, Macmillan Publishing Company, New York

Reverse Logistics of Agrochemical Pesticide Packaging and the Impacts to the Environment

Mello MF[1], Scapini R[2]

Abstract: Over time, agriculture has proven to be an important economic development factor for Brazil. The evolution and the need for productivity caused a large increase in the use of pesticides in agriculture and with it, the need to give proper treatment to packaging. With these agricultural activities in evidence, it is not possible to keep the crops without the use of pesticides. In 2000, it was created the 9,974 law as a decree Law 4,074/2002, which regulates the reverse logistics of empty containers of pesticides. This study intends to demonstrate that there are still producers who have difficulties in finding the correct destination to pesticide containers because of lack of knowledge of the law or because they acquire chemicals illegally, without a specific origin. The instruments for protecting the environment, such as licensing and environmental legislation stand out as high points, since it has the general objective of analysing and demonstrating how reverse logistics helps minimize the impact and the possible environmental and health problems caused by the incorrect disposal of pesticide containers of and along with a group of farmers.

Keywords: Reverse Logistics; Packages; Pesticides.

1 Introduction

Agriculture, in a country like Brazil, acts as an important development factor. However, it brings along a concern about the used packages of pesticides. The pesticide containers are hazardous to health and the environment when discarded improperly.

This study is justified to the extent that it aims to demonstrate the main problems of reverse logistics caused in the environment with improperly discarded pesticide containers along with the lack of knowledge that farmers have about the proper disposal of empty pesticide containers, where to take them after using and how to clean themselves before returning them to their suppliers.

According Razzolini Filho and Berté (2009), the distribution channels are responsible for providing reception facilities for the return of empty containers, that in accordance with the principles laid down by law, while the manufacturer is responsible for the collection and the disposal of used packages.

So the aim of this paper is to analyze and demonstrate how the Reverse Logistics helps minimize the impact and possible environmental and health problems caused by the incorrect disposal of pesticide containers of a group of farmers.

2 Theoretical Fundament

This chapter contains information of authors, institutions and laws that gave theoretical support to this article.

1 **Mario Fernando Mello** (mariofernandomello@yahoo.com.br)
2 **Rosangela Scapini**
Engineering Department, Universidade Luterana do Brasil,
ULBRA 99500-000 Carazinho, Rio Grande do Sul, Brasil.

2.1 Business Logistics

As Ballou said (2011), business logistics is the process of strategically managing the organization, from acquisition, handling and storage of raw materials to the final consumer. In addition to the information, flows that move the products, in order to provide differentiated services to customers, making it possible to reduce costs and thus increase profitability.

To Berkowitzet *et al* (2000), logistics encompasses all activities aiming to send the amount and the right products to the right places at the right time and at the lowest possible cost. The performance of these activities is called logistics management, which in turn corresponds to the practice of organizing the effective flow with respect to raw material costs, the product inventories in process, finished products, as well as related information from the point of origin to the point of consumption to meet the clients' requirements. From this definition, three elements can be emphasized: First, logistics handles the necessary decisions to move a product from the source of raw materials to consumption or the product flow. Second, these decisions need to be taken efficiently in costs. While it is important to reduce logistics costs, there is a limit, and this is the third point of emphasis.

According to Ballou (2011), business logistics is responsible for studying how management can, in the best way, provide the level of profitability in distribution services to customers and consumers, making planning, organizing and controlling an effective staff for handling activities and store device to facilitate the flow of producers.

2.2 Reverse Logistics

Established by Law # 12,305, of August 2nd, 2010, the National Policy on Solid Waste (PNRS), regulated by the decree # 7404 of 23 December, 2010, brings the shared responsibility for the life cycle of products, reverse logistics and the sectorial agreement.

Paragraph XII of the law defines as Reverse Logistics: economic and social development tool characterized by a set of actions, procedures and means to enable the collection and the recovery of solid waste for the business sector to reuse in its cycle or other production cycles, or other environmentally disposal. (Brazil, 2010).

This definition takes into account that the flow of goods in a supply chain does not end with the final consumer or the industrial user because "[...] companies now realize that a supply chain can work the other way." (Berkowitz et al, 2000).

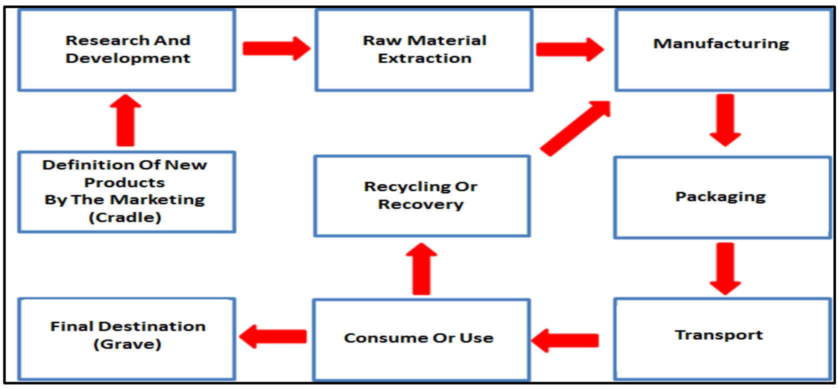

Fig.1
The life cycle of products 'from cradle to grave
Source: Razzolini Filho and Berté, 2009.
Adapted by the authors.

Thus, the same authors point out that reverse logistics is a process of recovery of reusable and recyclable materials, of returning and of reprocessed products from the point of consumption or use, for repair, repro-cessing or disposal.

According to Buchemann (2005), when a product is launched in the market, the company directors expect it to have a long and productive life, although they know that will not sell forever since it has a life cycle.

2.3 Reverse Logistics

People are concerned about what they consume and how they consume and therefore are changing their spending habits because they realize that it is necessary to preserve the planet. This means that individuals must rethink the way they consume as well as their behavior, such as the practice of reuse of products and/or packaging by the end of its useful life, taking care with the final destination of post-consumer waste. (Razzolini Filho; Berté, 2009)

The authors note that this will only be possible with the effective participation of business and public organizations, because only with the engagement of consumers, major changes in the environment as a whole will not happen.

In this scenario, changes occur related to various products, such as models of cars, lamps, clothes, papers, among others. It is essential, therefore, the commitment of organizations to reduce environmental impacts. If consumers change, organizations will react, giving them what they want.

There is greater entrepreneurial and individual awareness in order to change the patterns of consumption, there will be benefit for all involved and the organizations that precede these requirements will gain competitive advantages.

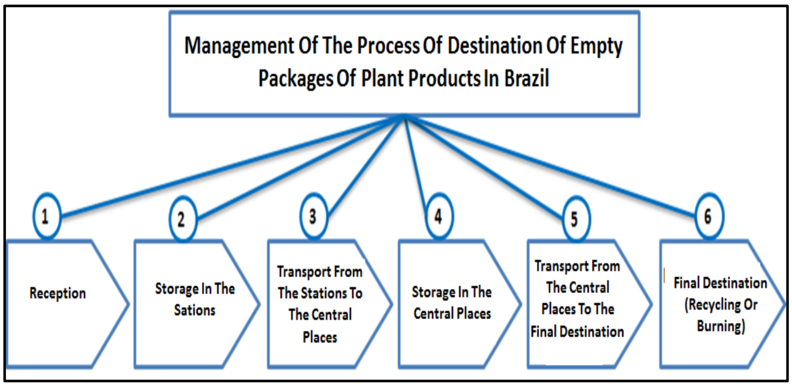

Fig.2
Destination processes of empty packages.
Source: Leite, 2009 – adapted by the author.

For Dias (2011), the environmental impact is defined as the change in the environment, caused by man. Thus, there are environmental impacts of all types, from the smallest one, which substantially modifies the natural environment, and even the one that affects nature deeply, causing problems for humans such as pollution of air, water and soil.

According to the National Association of Distributors of Agricultural and Veterinary Pesticides (2000), the disposal of empty pesticide containers is a complex procedure that requires the effective participation of all those involved in the manufacture, marketing, use, licensing, inspection and monitoring activities related to the handling, transportation, storage and processing of those packages.

Considering the great diversity of packaging and pesticide formulations with different physical characteristics and chemical compositions and the requirements established by Federal Law # 9,974 of 06/06/00 and the decree # 3550 of 07/27/00, it was prepared a manual containing the minimum and necessary procedures for the safe disposal of empty pesticide containers, with the concern that any risk from handling are minimized to levels consistent with the protection of human health and the environment (ANDAV 2000).

Thus, ANDAV (2000) says that the users' responsibilities are: preparing the empty containers to return them in the receiving units; performing cleaning of washable rigid packages which can be triple or under pressure; keeping non-washable rigid packaging properly capped and without leakage.

Moreover, it is necessary for users to carry and return the empty containers, with their lids, to the nearest receiving unit, seeking guidance from the dealers on where to return within up to one year from the date of their purchases. Also, we need to keep the proof of delivery of packaging and the receipts of purchases.

ANDAV also highlights the responsibilities of dealers: providing and managing receiving units (stations) for the return of empty containers by the users/farmers; upon the sale of the product, informing users/farmers about the washing procedures, packaging, storage, transport and return of empty containers; informing the address of the nearest receiving unit of empty packaging, setting forth this information in the Invoice of Sale of the product; to be included in the prescriptions issued, the final destination of information on the packaging; in cooperation with the government, educational programs and mechanisms of control and encouraging to WASH the packages/containers (triple or under pressure) and the return of empty containers by the users. (ANDAV, 2000)

Pesticides are classified by ANVISA (2011) in four classes of danger to health. Each class is represented by a color on the label and the product label. The class I, of extremely toxic products, is represented by the red color of the label; Class II is represented by the color yellow and refers to highly toxic products and Class III identified by blue indicates the moderate toxic ones. The green color is responsible for representing the little toxic ones, belonging to class IV.

For Gonçalves et al (2002), the contamination of surface waters, especially rivers and streams is fast and happens immediately after irrigation. There have been serious problems arising from the application of herbicides in flood irrigation; in furrow irrigation, water carries applied, and herbicides, fertilizers, pesticides and sediment.

Water contamination can also occur more slowly through a water table, which receives fertilizers, pesticides and herbicides dissolved in the applied water. Such contamination, according to Goncalves *et al* (2002), can be aggravated if there are soluble salts in the soil, therefore, when it infiltrates in the water containing the salts applied in the field, it will even dissolve the soil salts, becoming more harmful due to environmental contamination and pesticide residues in food, it can be estimated that the next resident populations in areas of cultivation and urban dwellers are also significantly exposed to the harmful effects of these chemical agents.

3 Methodology

As this study aims to examine the reverse logistics of empty pesticide containers, it has been based on the literature and research in the field, held in April 2014, from 1st to 22nd. There were 130 surveys via e-mails personally, of which 98 of them returned.

Through these surveys, personal data and general knowledge data were collected, regarding to the return of empty pesticide containers, used in the properties of those people surveyed, located in some cities of Rio Grande do Sul state, Brazil. The objective of covering several cities was to assess the knowledge and the culture of many farmers in relation to the return of used packaging of pesticides.

Thus, this research is measured and the farmers' knowledge about the proper disposal of empty pesticide containers and the protection of the environment is analyzed in accordance with current legislation.

4 Results

The survey results showed that females who remain in the field are only 10%. This can be justified because women are more sensitive and prefer to go to town in search of other professions which do not require much physical effort or even to take care of household chores. The males who stay in agriculture are 90%. This percentage is justified because men learn in their early ages to take part in the farm work watching the father figure, driving machinery and taking care of animals, actively participating in the crops and in the results so that they can keep the production processes in their properties.

Asked about the law of pesticide containers only 4% reported that they know it, but also only 8% said they fully know the law. It is a small percentage of farmers who know the legislation and it is worrying. Along with these data, it can be noticed that most farmers have information of the pesticide legislation. In this case, they will only dispose the packages improperly if there is no interest of preserving the environment and people's health.

As for the supplier of pesticide products require, at the time of sale, the return of empty containers, 56% of respondents answered that the supplier requires the return. This is about a breach of legislation that requires that suppliers require the return of used packaging.

It was asked what kind of packages can be washed and 43% of the farmers responded that they do no know what these packages are. However, 57% of them do not know or know little about the process of package washing. This lack of knowledge might be the cause of serious damage to the environment.

In relation to the behavior of farmers in return the used packaging, 76% of respondents answered that return the used packaging to their suppliers. Yet, another concern given: 8% of farmers burn their packaging, which creates serious damage to the environment.

Whereas the pesticide containers have hazardous waste to the environment and health of those working in agricultural practices, it was asked if they have knowledge about proper disposal of the packaging. A positive fact is that only 6% said they did not know it. Although, the vast majority, 94% of them do know about the proper disposal of packaging.

Finally, it was asked if farmers have some degree of difficulty in giving the correct destination to used pesticide containers. The significant percentage of 39% of respondents told that they have mean (average) and much difficulty in giving correct destination to packaging. This item was shown that only 7% have a hard time in giving correct destination of pesticide containers, likely the farmers have no knowledge of the law or acquire chemicals illegally without origin, making it difficult to deliver to the supplier because in return the farmer must present the purchase invoice from the supplier, it receives proof of delivery which should keep filed in their properties to show in the event of a possible inspection. So it is important to facilitate the return with new methods, so the authorities could review the current system.

5 Final considerations

It was shown in this research what can be done for the legislation of empty pesticide containers to be fully met, once it is still short of the desired, because there is a strict supervision of government agencies towards manufacturers and distributors of agrochemical pesticides.

The survey of 98 farmers showed that 90% are males while 10% are females. This is due to the fact that work on the farms is more practiced by men. In terms of age, it was noticed that people who remain working in agriculture are in the range from 21 to 40 years old. Regarding to the area of the property, most have properties from 51 to 200 hectare.

Pesticides providers do not require the return of packaging, but inform in the observations, of the invoice, where they must be returned. The percentages related to farmers who know the law and return properly packaging, belong to the group that have ecological awareness, care about the environment and make the purchase at the authorized locations. But those who do not know and do not make any return, probably acquire them in the clandestine mode, so it can not be assessed.

Thus, the overall objective was achieved through the demonstrated results and the analysis of this important issue which is the Reverse Logistics of agrochemical packaging.

Finally, because of the importance and the relevance of the topic, researches and incursions on this subject should be carried out in order to seek knowledge and assist farmers in the proper disposal of pesticide containers.

6 References

Associação Nacional dos Distribuidores de Defensivos Agrícolas e Veterinários – Andav –(2000). Destinação final de embalagens vazias de agrotóxicos. Disponível em: http://www.andav.com.br/repositorio/36.pdf. Accessed 06 april 2014

Agência Nacional de Vigilância Sanitária – Anvisa – (2011). Cartilha sobre Agrotóxicos. Série Trilhas do Campo. Elaborada em 19 de setembro de 2011. Disponível em: http://www.prt21.mpt.gov.br/feceagro/AnvisaCartilha.pdf. Accessed 06 april 2014

Assunção, J.F.M. (2012) Direito Ambiental Empresarial. Disponível em: http://www.aedmoodle.ufpa.br/mod/forum/discuss.php?d=26507&parent=80349. Accessed 06 april 2014

Ballou, R. H. (2011). Logística empresarial: transporte, administração de materiais e distribuição física. São Paulo: Atlas

Berkowitz, E. et al. (2000). Marketing. vol. 2, 6.ed. Rio de Janeiro: LTC Editora

Brasil, Lei nº 12.305, (2010) Institui a Política Nacional de Resíduos Sólidos; altera a Lei no 9.605, de 12 de fevereiro de 1998; e dá outras providências. Disponível em: http://www.planalto.gov.br/ccivil_03/_ato2007-2010/2010/lei/l12305.htm. Accessed 13 march 2014

Brasil, Lei nº 7.802, (1989). Dispõe sobre a pesquisa, a experimentação, a produção, a embalagem e rotulagem, o transporte, o armazenamento, a comercialização, a propaganda comercial, a utilização, a importação, a exportação, o destino final dos resíduos e embalagens, o registro, a classificação, o controle, a inspeção e a fiscalização de agrotóxicos, seus componentes e afins, e dá outras providências. Disponível em: http://www.planalto.gov.br/ccivil_03/leis/L7802.htm. Accessed 06 april 2014

Brasil, Ministério do Meio Ambiente. (1999) Conselho Nacional de Meio Ambiente. Resolução CONAMA Nº 258 de 26 de agosto de 1999. Publicação Diário Oficial da União 02/12/1999. Brasília. Disponível em: http://www.mma.gov.br/port/conama/res/res99/res25899.html. Accessed 27 march 2014

Buchemann, D. (2005) O ciclo de vida dos produtos. Disponível em: http://www.administradores.com.br/artigos/administracao-e-negocios/o-ciclo-de-vida-de-um-produto/11009/. Accessed 27 march 2014

Dias, R. (2011) Gestão Ambiental. Responsabilidade Social e Sustentabilidade. 2. ed. São Paulo: Atlas

Gonçalves, R.A.B et al. (2002) Avaliação da uniformidade de aplicação de ARS em cafeeiros irrigados por aspersã0o e gotejamento nas regiões do triângulo mineiro e Alto Parnaíba – MG. In: Simposio Brasileiro de Pesquisa em Cafeicultura Irrigada, 5, Anais, Araguari, MG

Leite, P.R. (2009) Logística reversa: meio ambiente e competitividade. 2. ed. São Paulo: Pearson Prentice Hall

Razzolini Filho, E. e R. Berté (2009) O reverso da logística e as questões ambientais no Brasil. Curitiba: Ibpex

Impacts of a tracking and tracing system for containers in a port-based supply chain

Muñuzuri J[1], Escudero-Santana A, Onieva L, Cortés P

Abstract: The visibility of containers throughout the entire supply chain provides multiple benefits for shippers, terminals and transport providers. Nevertheless, intermodal transport chains often appear as "black boxes" to the cargo owners and their clients, who lose track of the container until it arrives at the final end of the chain. We describe here the configuration and features of a novel low-cost system to track and trace containers in an intermodal supply chain, provide information to shippers regarding delays and other unexpected events, and assist terminal operation accordingly. We then analyze the positive impacts of such a system over the entire supply chain, identifying the requirements of the main chain actors regarding the availability of information and how the proposed system contributes to the fulfilment of those requirements.

Keywords: Containers; tracking and tracing; supply chain; logistics; port.

1 Introduction: supply chain visibility

The evolution of supply chain management (SCM) over the last half century can be described through an increase in integration and information sharing (Muzumdar and Balachandran, 2001). The first phase, encompassing from World War II until the late 1980s, witnessed the development of the departmentalised or functional SCM, with areas or departments operating in an isolated environment and decisions being made by managers within each area. The second phase covered from the late 1980s to the late 1990s and gave birth to the concept of integrated SCM, incorporating tools like advanced planning and scheduling systems (APS), enterprise resource planning (ERP) and business process reengineering (BPR). Finally, the third phase corresponds to the transformation of supply chains into value networks, with integrated and centralised planning, focusing on increased availability and sharing of information and thus aiming for higher customer service levels and lower supply chain costs.

Vernon (2008) examines the most important attributes of supply chain visibility and proposes a more precise definition, i.e., "Supply chain visibility is the identity, location and status of entities transiting the supply chain, captured in timely messages about events, along with the planned and actual dates/times for these events". According to a study which was conducted among 524 companies in North America and Europe (Aberdeen Group, 2006), nearly 80% of the respondents pointed to a lack of critical supply chain process visibility and had started or were planning to take actions to enhance their visibility-related technology both for domestic shipments and global supply chains. Furthermore, Muzumdar and Balachandran (2001) identified four key elements as essential for achieving operational success when supply chains migrate from push to pull models:

- Visibility across the entire supply chain
- Flexibility of supply and sourcing options
- Responsiveness to changes in customer demand and product lead times
- Rapid new product introductions based on market trends and new designs.

1 **Jesús Muñuzuri Sanz** (munuzuri@us.es)
Grupo de Ingeniería de Organización. Universidad de Sevilla.
ETS Ingeniería. Avd. Descubrimientos s/n, 41092 Sevilla.

If companies are strongly focusing on these elements, all the different links participating in the supply chain should be equally prepared to facilitate them, and this is one of the reasons why tracking and tracing systems for containers have evolved so notably over the last few years (Ahn, 2005; Schmidt et al, 2008), so that companies can track their shipments throughout the long-haul operations. The same can be said of terminals, where tracking and tracing facilitates the monitoring of loading, unloading and moving cargo (Shi et al, 2011), but also enables the terminal to share all that valuable information with shippers and logistics operators. Seo et al (2014) describe information sharing as one of the main components of supply chain collaboration, which in turn helps to create reciprocal benefits by also satisfying shippers' requirements.

We present here a novel low-cost tracking and tracing system which, in combination with a series of planning tools and automatic devices, provides visibility throughout the entire containerised transport link of the supply chain. Our aim is to demonstrate how this type of system covers all the visibility-related requirements of the supply chain.

2 Supply chain requirements

The main drivers that force companies to implement visibility solutions in order to remain competitive in today's business environment or even better distinguish themselves among competitors by offering premium services to customers include the following (Aberdeen Group, 2006):

- Improve on-time delivery performance
- Proactively alert customers of late shipments
- Reduce lead times and lead time variability
- Just-in-time and lean programs causing shorter delivery windows
- Ability to make midcourse corrections

The achievement of these customer-related goals can be translated into a series of requirements addressing critical parameters that technology solutions should provide in all the links of the supply chain for a successful overall performance. These visibility requirements can be grouped into six categories (Boile and Sdoukopoulos, 2014):

1. *Transparency*: this implies the availability of accurate information regarding the location of the shipment, which is expected to enable exception management while improving container utilisation and availability. Improved visibility of containers will also assist in the better organization of receipt and last mile delivery leading to more efficient management of local fleets.

2. *Security*: improved visibility across the extended supply chain is expected to reduce the number of pilferages and damages while alert notifications regarding unexpected events (e.g., unauthorised opening of the containers' door) can ensure secure container transport leading to significant benefits for several involved actors (e.g., reduced waiting time for customs clearance due to enhanced container profile in terms of security issues).

3. *Reliability*: visibility enables logistics operators to enhance customer satisfaction and strengthen their company profile by providing highly reliable services.

4. *Timeliness*: accurate information regarding the containers' estimated time of arrival may have a positive impact on supply chain processes (e.g., better arrangement of terminal operations, faster customs clearance, etc.) thus reducing lead time, achieving faster delivery of products and ultimately reducing the door-to-door lead time.

5. *Costs*: since reducing container transport costs is within the goals of all supply chain actors, supply chain visibility can lead to:

    - Reduced administration costs due to less customs physical inspections and requirements
    - Reduced communication costs due to improved access of all involved actors to supply chain data

• Savings in customs' business organisations and processes.

6. *Effort/efficiency*: Better management/arrangement of the whole supply chain is expected to be realised by improving supply chain visibility leading also to better organisation of intermodal connections (e.g., better management of truck and rail operations) as well as better arrangement of terminal procedures (e.g., yard planning).

3 System description

Our proposed system (see Fig. 1) covers the transport link of a road-train-vessel port-based container supply chain. Its main elements are:

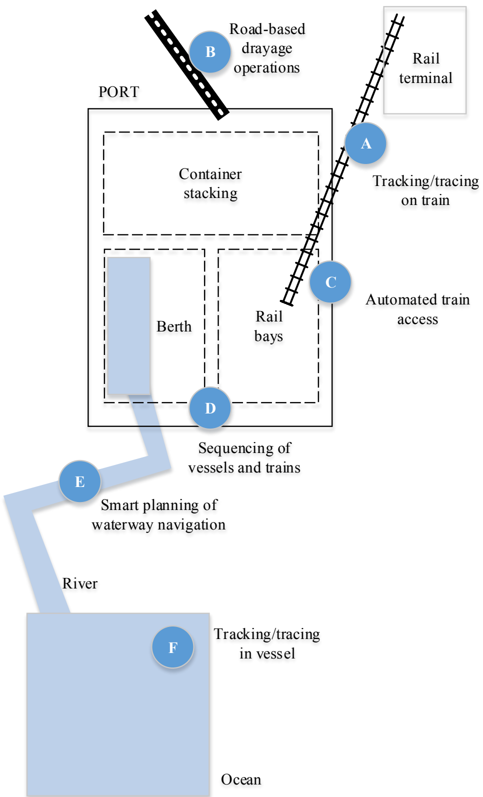

Fig.1
Schematic representation of the proposed system.

A. The tracking/tracing of containers on trains is achieved with specifically designed sensors that communicate with a concentrating unit located in the locomotive, instead of using individual GPS con-nections for each container, which enormously reduces cost and energy consumption. Besides, additional sensors detect any unexpected event in the container, like its opening or an anomalous temperature raise.
B. The availability of real-time information can provide valuable input for the planning of drayage fleets used for the collection and delivery of containers.
C. The access of the train to the port terminal is facilitated with automatic signal boxes, and planned with a specifically built planning unit.
D. The sequence of vessels and trains entering the port is planned in order to minimize lead times.
E. The inland waterway that gives access to the port is also equipped with a smart navigation system, to guide vessels, plan crossings and any other events, regulate light buoys and detect timing deviations.
F. Finally, the container loaded onto the vessel is also tracked by means of a concentrator similar to the ones installed on trains.

Another advantage of this system is that it functions on a common database which brings shippers and carriers together by providing a single interface. For shippers, they do not need to log into the different carriers' system in order to know a specific consignment's status. They can gain uniform visibility of all the shipments regardless of which carrier physically delivers them. For carriers, they do not need to log into different shippers' system in order to keep them updated of the shipment status. This removes the replication and saves them time and efforts (Wang and Potter, 2008).

4 Expected impacts

Our objective here is to determine the expected supply chain impacts of the system described above. Table 1, adapted from Boile and Sdoukopoulos (2014), contains a list of requirements linked to the six categories described in Section 2, together with the stakeholder groups (L for logistics operators and carriers, T for the terminal and S for the shipper) that would be positively affected by the fulfilment of each requirement. Then, for each requirement, the last column of the table contains the expected outcome of our system as described in Section 3: "**" indicates that the system, as it is currently defined, will have an impact on the fulfilment of this requirement, whereas "*" indicates that the system does not directly provide the fulfilment of the requirement, but provides the basis for the development of tools which may fulfil it in the medium term.

It is interesting to note that logistics operators and carriers (including here rail operators, naval operators, and – in case of a further extension of the system – drayage haulers) would be positively affected by the fulfilment of almost any of the requirements in Table 1. On the other hand, the terminal would be mostly interested in those functionalities affecting its internal operations, in order to improve the smoothness and efficiency of container flows through the facility. Finally, the shipper is mainly concerned with supply chain issues, including the management of delays or anomalies, container security, transport reliability and cost.

With respect to the proposed system, it does not fulfil completely any of the six categories of requirements, but does have an effect on all of them, except for cost. Nevertheless, the system constitutes a first step towards the fulfilment of the unaddressed requirements, allowing for the development of additional tools and services focused on them. Even in the case of cost reduction, the availability of real-time data on the location and status of containers provides invaluable input to inventory, routing and planning systems, which in turn help reduce supply chain costs and inefficiencies.

Table 1
Supply chain requirements related to the provision of a container tracking and tracing service.

Category	Requirement Description	Stakeholder	System
Visibility	Transparency and visibility on terminal shipping processes	L, T	**
	Earlier information on hinterland transport	T	**
	Visibility during recovery processes from anomalies (reactive)	L, T, S	**
	Traceability of empty containers for better repositioning strategies	L	*
	Enablers of exception management	L, T, S	**
	Accuracy of position of container in terminal area	T	*
Security	Opening of container only once/as less as possible	L, T, S	*
	Fight counterfeiting	L, T, S	*
	Reduce theft	L, T, S	**
	Avoid cargo damage (liability issue) by knowing the sensitivity of the commodity	L, T	**
Reliability	Decrease lead time variability and capture deviations within margins	L, S	**
Timeliness	Reducing total door-to-door time, minimise idle time	L, S	**
	Reduce dwell time at terminals by improved availability of information to different actors thus contributing to better process planning	L, T	**
	For some users, waiting time can be functional	L, T, S	*
	Enabling companies to go intermodal by reducing complexity	L	*

	and solving interoperability issues		
	Contribution to e-freight and internet of things vision becoming a reality	L, T, S	*
Cost	Reducing total door-to-door cost	L, T, S	*
Efficiency	Reducing administrative burden/single window offering one stop-shop-service	L, T, S	*
	Pre-announcement of hinterland operators to improve terminal efficiency	L, T, S	**
	Value added services from platform: automatic document generation from users	L, T, S	*

5 Conclusions: potential supply chain benefits

We have shown that the proposed system impacts the supply chain from multiple points of view and with respect to multiple actors. We conclude our work discussing the potential benefits provided for shippers whose supply chain incorporates the described system in its intermodal link. These benefits constitute a significant increase of the service level offered by the terminal to the industrial actors, with the corresponding impact on their business processes. The potential benefits include the following:

- Better supply chain visibility through real-time information regarding the containers' location and integrity status
- Potential lead time reduction
- Enhanced supply chain cooperation through information sharing between partners along the supply chain
- Better arrangement of pickup and delivery procedures in terminals due to information on the exact time of vessels' arrival
- Competitive advantage resulting from the ability to create premium services through the real-time tracking of containers, making companies unique in the market.
- Reduction of communication costs
- Container fleet capacity reduction and better decision making as a result of the real-time management of containers and accurate data on container movements
- Easier communication with customs authorities – early notification of container ETA and integrity
- Better organization of intermodal connections. Alerts regarding the availability of the cargo (when and where it is available) can assist in better managing truck and rail or other mode operations.
- Improved container safety and security through alarms and alerts regarding any unexpected events (exception management)
- Savings in customs' business organization and processes
- Delayed deadlines for decision making with respect to the final destination of the cargo
- Better management/arrangement of the whole supply chain

As an example, Table 2 (adapted form Arendt et al, 2011) shows some disruptive situations that may arise in the intermodal chain and how the proposed system could help to alleviate or overcome them.

Table 2
Possible benefits provided by the proposed system to the supply chain in case of different disruptive situations.

Scope	Disruptive situation	Benefit provided by the system
Punctuality	Container misses ship at port of departure	Alerts and information exchange avoid a cascade of disruptions in the supply chain
Transshipment	Unscheduled transshipment	Communication regarding new vessel and time and place of departure avoids disruptions
ETA/ATA	Labor capacity peaks	Reporting of ETA during sea/rail voyages result in opportunities to adjust inbound logistics planning
Cargo quality/reliability monitoring	Cargo damaged upon reception	Monitoring of cargo quality may help to determine liability
Lead time analysis	Shipment exceeds time windows	Alerts and information exchange avoid a cascade of disruptions in the supply chain

6 Acknowlegements

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7 References

Aberdeen Group (2006) The Supply Chain Visibility Roadmap – Moving from Vision to True Business Value, Boston, MA

Ahn SB (2005) Container tracking and tracing system to enhance global visibility. Proceedings of the Eastern Asia Society for Transportation Studies, 5: 1719 – 1727.

Arendt F, Hintsa J, Meyer-Larsen N, Müller R, van Oosterhout M, Veenstra A, Urciouli L, Zuidwijk R (2011) Impact of Supply Chain Visibility and Security on International Container Transport. In Maritime Logistics in the Global Economy. T. Blecker, C. Jahn and W. Kersten eds. Josef Eul Verlag. 133-144.

Boile M, Sdoukopoulos L (2014) Supply chain visibility and security – the SMART-CM project solution. Int. J. Shipping and Transport Logistics, 6(3): 280-292

Muzumdar M, Balachandran N. (2001) The supply chain evolution: roles, responsibilities and implications for management. The Performance Advantage, APICS, 11(10): 57–61.

Schmidt R, Gagnon A, Allcock D (2008) Trial results of a new low-cost and covert technology to trace the path of maritime containers worldwide. ICCST 2008. 42nd Annual IEEE International Carnahan Conference on Security Technology, Prague.

Seo YJ, Dinwoodie J, Roe, M (2015) Measures of supply chain collaboration in container logistics. Maritime Economics & Logistics, in press.

Application of the tools of Production Engineering for the reduction of dead time in an assembly line

Mello M F[1], Fassini G M[2]

Abstract: The constant changes in the agricultural equipment market have brought many challenges to the productive sectors inside the organizations. Once the market is increasingly competitive, the industries lack of efficient working methods and companies seek intensely to adapt themselves to a methodology to assist in the standardization of production processes. The main objective of this work is the application of some tools of Production Engineering to improve the operating times in an assembly sector of a metal mechanical industry. The focus is to establish and to define the guidelines of the used methodology, the so-called 'Just in time', to seek the reduction of dead time in the process of the assembly line according to the reality of the companies. Change processes are very conditioned to the environment, the culture of who receives them and leads them. Thus, this project also aims to aid in the maturation of the staff in this cultural aspect, seeking the development of operators in a new operating process.

Keywords: Dead times; Methodology; Culture.

1 Introduction

Once Brazil is a developing country, agriculture acts as an important development factor. However, it brings with it some concerns in the industrial area where high costs can often derail the industrial development. Along with the advancement of mechanical metal industry, technologies and an increasingly competitive market, it is clear that large companies should not differentiate only on the innovation and performance of their products in the countryside. When it comes to continuous improvement in machinery and equipment usage, optimization has significance to generate results to industry. However, analyzing the perspective of Production Engineering focused on assembly processes, the emphasis happens because of the importance of improving the physical arrangements in order to achieve cost reduction, standardization of processes, operations and, as a result, an increased productivity.

The company researched is an agricultural implement industry located in the northern region of Rio Grande do Sul state, Brazil. It has a great position in the domestic market and is a sale leader. The company has around 2,200 employees and its constant evolution is a challenge to remain competitive in the market.

Thus, this study aims to demonstrate the application of the concepts of Production Engineering seeking to increase the uptime rate in an assembly line that currently is lacking of a working method. It aims to achieve the development of processes to reduce costs and lead time, in order to increase the company's profitability and serve customers more quickly, thus becoming more competitive in the market.

1 **Mario Fernando Mello** (mariofernandomello@yahoo.com.br)
2 **Gabriel Mino Fassini**
Escola de Engenharia. Universidade Luterana do Brasil – ULBRA.
99500-000 Carazinho, Rio Grande do Sul, Brasil.

2 Concepts of physical setting

The physical arrangement, also known as layout, is the way of how the resources used for the manufacture of a product are placed. The layout of the study is not restricted to the positioning of the equipment in the factory plant, it also covers issues such as productive material flow, consumption of components, manufacturing methods, support services and time available for manufacturing.

For Shingo (1996), the production is a process network and operations. In order to achieve improvements in the production process one must distinguish the product flow (process) from the workflow (operation). Therefore, a suitable layout contributes to the improvement of processes and operations According to Peinaldo and Graemi (2007), there are five basic types of layout:
Physical Arrangement by Product; Physical Arrangement by Process; Cellular Physical Arrangement; Physical Arrangement by Fixed Position; Physical Arrangement Mixed.

3 Philosophy Just in Time

According to Correa and Gianesi (1996), the system 'Just in Time' (JIT) originated in Japan in the mid-1970s, and its basic idea and its development credited to the Toyota Motor Company, which was looking for a management system that could coordinate production with the specific demands of different models and vehicle colors with minimal delay. For Shingo (1996), however, JIT is more of a technique or a combination of the production management techniques being considered as a complete "philosophy", which includes aspects of the material management, quality management, physical arrangement, product design, work organization and human resource management.

To Antunes (2008) although the success of JIT delivery system is trampled in the cultural characteristics of the Japanese people, more and more managers have become convinced that this philosophy is composed of management practices that can be applied anywhere in the world. According to Shingo (1996), JIT system has as its fundamental objective the continuous improvement of the production process. The pursuit of this objective occurs through a mechanism of reduction of stocks. High volume of stocks tend to mask the problems. The objectives of stock reduction, manufacturing reduction, working force involvement, the continuous production flow and improvement, present in JIT philosophy, require some changes in order to get productive resources in a manufacturing company. The traditional layout for companies that produce certain variety of products has been the layout of process or the functional one.

4 Stages of the layout planning

For Lobo (2010), time in the layout planning is important because the implementation of a new layout is usually costly. This is why a good planning must be done to avoid relocations or replacements of machines and spaces. In Table 1, the stages of the layout planning are shown.

Table 1
Stages of the layout planning.
Source: Lobo, 2010 – adapted by the authors.

STAGES	DESCRIPTION
Stage 1 **Location**	It specified the location of the area to which the layout is planned. This may be an existing area or a new one. It is important to determine whether the rearrangement or new layout will be in an area in use, in a storage area to be disabled, in a new building or reused elsewhere.
Stage II **General Physical Arrangement**	In this stage, it is specified the relative position among the various areas. The flow models are worked and the areas are worked in sets, so the interrelationships and the general settings of the areas are established in a crude form. These layout sketches are called coarse layout, block layout, the relative location of areas.
Stage III **Detailed Physical Arrangement**	In the detailed physical arrangement, the position of each machine and equipment is exposed. This stage specifies each physical characteristic of the area including the supplies and services.
Stage IV **Implementation**	In this phase, the movement of machines and equipment is carried out according to what was detailed and approved in the stage III, it is also made a survey of the financial resources necessary for the implementation.

5 Methodology

As this study aims to suggest improvements in the production process in order to reduce the dead time, it is based on the concepts of Production Engineering. Through a research, the process data were collected for the initial analysis of the critical points. Data were collected and analyzed in the months of April, May and June 2014. The company researched is an industrial company of agricultural equipment located in northern of Rio Grande do Sul state, Brazil, and has approximately 2,200 employees.

It was carried out the evaluation of the current working system of the assembly line of the company above mentioned. The assembly line department has 102 employees operating in approximately 5,000 m², running the processes of the assembly line in this company. The results are described based on observations in the aspect of the assembly process; in the cultural aspect; in the ergonomic aspect; and in the logistical aspect.

6 Results

Initially, it was made an analysis of the current process. The surveys were divided into three distinct main areas. They are:

– Working logic: based on the concepts of ergonomics, short manufacturing, 5S, 'milk run', the technical characteristics of the assembly line as well as the analysis of the current logic of work is raised.

– Functional Table: survey of ergonomic issues, requirements of filling the functions of employees, training, skills and segregation of this information to the profile designed by the company.

– Working environment: survey of environmental safety conditions and auxiliary devices, survey of the layout conditions, survey of the environment among operators.

The analysis of the current situation is made by assessing the applied physical arrangement, composition of flowcharts work on the macro level and study of time and motion of assembly processes.

6.1 Working logic aspect

We note the following points about the aspect of working logic, according to the survey data conducted on the current situation:

– Lifting structures as well as assembly and transportation devices are working properly.
– The current logic of supply logistics is deficient in some points making the assembly not possible at the planned time.
– There is no definite supply flow.
– The assembly line does not follow a 'takt-time' in an orderly manner, thereby managing the run-in time according to good or bad conducts of the assembly processes.
– The parts with production problems are not assessed before the assembly process and the machine inspection is carried out after the whole assembly of the product.

The assemblers face some ergonomic problems due to the machine position in the assembly line. The same is assembled from the start to the end of the process at a height of 1.80 meters making the arms of operators get extremely tired at the end of the working day.

Currently, the process of pre-assembly is held in a separate pavilion of the main line with about 2,000 m² and distant eighty (80) feet. This distance creates a very high logistics costs and consequently a vulnerability in a very large system, in the transport, because of the disability of some packages, the parts are damaged affecting the quality of the final product as the assembly line does not evaluate the visual quality of them before the union of the sets.

6.2 Staff aspect

It was noticed a serious lack of a working method in the staff, therefore, one of the most difficult obstacles to work is the culture of operational base. It can be seen in this analysis that the operating base cannot follow some basic concepts of an organization. The rules are set aside and turned into exception at work. Nowadays, the company works with 102 employees focused on the assembly process.

6.3 Working environment aspect

It was perceived in this analysis that, because the company is not given a modern working method, various problems occur in the workplace hindering a better productivity. They are:

– Corridors (hall): blocked by assemblies, clogged by parts packed around awaiting for the assembly process and obstructed by devices and/or tools or objects in general. The lack of space in corridors are caused by obstructions and the disruption of the flow of parts and raw materials.
– Temperature ranges: Ventilation systems are not efficient resulting in a hot work environment during the Summer and the structure does not have a heating system with heating function in the Winter.
– Culture: Organizational culture, which imposes accelerated rhythm of production, and the personal culture of employees still struggling to assimilate, produce at minimum cost with quality and in a clean and organized environment.

6.4 Description of the intervention

By having these data about the current process, the development focused on reducing the in-process and the optimization of its logistics process and the physical arrangement was started, making the operator work with footage of the suitable working area. The stock was previously accumulated in 6 machines now works with only the machine that will be used by the main line, without any floor space for accumulation of unnecessary stock. The pre-assembly line supplies the main line laterally. This new concept has reduced the cost of transportation of pre-assembled components to numbers close to zero. The whole process was based by using an action plane f the model 5W2H for the transition.

Along with the defined action plan, the physical arrangement started changing. Walking corridors were created, a demarcation located next to the main hall where the assembly operators should move not to interfere in the space that belongs to the flow of the logistics department. This intervention was successful and today all operators only move around in the area allocated to them. In order to eliminate one of the major problems already highlighted in the analysis before the intervention, the main corridors were clear. The logistics and the assembly departments were involved in this stage. So, it was defined a team that initially would be responsible for monitoring and for the cultural development of the operators. It can be concluded that the goal was achieved and today the corridors are free.

In this scenario, it was performed a time measure on April 23rd 2014, analyzing the operative and inoperative times of the production assembly process. After the interventions already described, a new time measure was performed on June 10th 2014 and it was perceived an improvement in the daily performance indicator of operators. Table 2 shows the time measures before and after the improvement actions. It should be noted that Table 2 refers to the production in the assembly process. The percentages do not match and the assembly process show that the operator is performing other tasks that do not correspond to their main functions.

Table 2
Functions and percentage data of the measured times.

FUNCTION	PERCENTAGE OF OPERATING TIME 23.04.14	PERCENTAGE OF OPERATING TIME 10.06.14	IMPROVEMENT INDEX
Assembly	49.3%	62.1%	12.8%
Verifying parts	28.5%	10.4%	
Others	15.2%	24.4%	
Tools	4.3%	2,4%	
Maintenance	1.5%	0	
Movement	1.2%	0.7%	
Total	100%	100%	

It is clear in Table 2, at the time measure of April 23rd 2014, that analyzing the operative and inoperative times, operators have on average, on a day's work, 50.7% of their time as dead time, that is, making tasks other than the mounting (assembly). On the other hand, on June 10th 2014, after the improvement actions, we can see an improvement in the indicator that shows the daily performance index of operators. In the survey data before the intervention, we note that operators reached less than 50% of their workday acting in their assigned roles. Comparing the two measurements of time, there is an increase of 12.8% in the operating time, that means, the operator who spent less than half of his day being productive in his role for the company now reaches numbers above 60%. This is the result of measures taken in relation to production.

7 Conclusion

It became clear in this research, the importance of using methodologies of Production Engineering in search of better competitiveness in companies. It is known that the reduction of waste and the improvement of the operational performance enhances the financial performance of organizations. This paper proposed, through the use of production engineering tools, to identify and to improve operative time within an assembly line in an industrial production process. Thus, the overall objective was achieved through the demonstrated results and the analysis of this important issue which is the constant pursuit of continuous improvement.

Regarding the cultural aspect, it was achieved in a short space of time, making the leadership and the operational base understand the new concepts to transform them allies in the change process at work.

Regarding the working environment aspect, the improvement of the ergonomic aspect comes as a consequence of an entire work performed, as mentioned in the analysis previous to the intervention. The operators used to work for hours standing and with theirs arms raised. Because it is heavy work, operators sometimes ended up extremely tired, reducing their productivity. After the intervention, the operators started working with proper ergonomics positions.

So with the application of Production Engineering tools, it was decided that each department carries out its real function without interfering in the responsibilities of other areas, working with low stock production, product quality and maximum organization in the industry. These features are great allies in reducing dead times, since they help assemblers in the daily process and add much in the cultural development of each worker.

Finally, because of the importance and relevance of the topic, new incursions of research in this area should be made, increasingly seeking knowledge on the subject and assisting in the search for better productivity and profitability for organizations.

8 References

Antunes, J. (2008) Sistemas de Produção: conceitos e práticas para projeto e gestão da produção enxuta / Junico Antunes ...[et al.]. - Porto Alegre: Bookman.

Casarotto Filho, N. (2011) Elaboração de projetos empresariais: análise estratégica, estudo de viabilidade e plano de negócio. 1. ed. – 3. reimpr.- São Paulo: Atlas.

Corrêa, H.L., Gianesi, I.G.N. (1996) Just in time, MRP II e OPT: Um enfoque estratégico.2ª Edição. São Paulo:Atlas.

Lobo, R.N. (2010) Gestão da Produção. São Paulo: Erica.

Paladini, E.P. (2011) Gstão da Qualidade: teoria e prática. – 2. ed.- 11. reimpr. – São Paulo: Atlas.

Peinaldo, J. GRAEML, A.R. (2007) Administração da Produção: Operações Industriais e Serviços. Curitiba: Unicenp.

Shingo, S. (1996) O Sistema Toyota de Produção do ponto de vista da Engenharia de Produção – 2.ed. – Porto Alegre: Bookman.

Ten Years of Supply Chain Management Research in Brazil

Machado M C[1], Macau F[2], Santos C E[3]

Abstract: This paper explores the supply chain management (SCM) research in Brazil from 2004 to 2014, identifying research opportunities in this domain. A literature review was performed, comprehending articles from Brazilan scholars, collected in two major academic data bases. An established framework to categorize this literature is applied to identify: (i) current status of high level supply management research in Brazil; and (ii) main streams, both theoretically and methodologically. A thematic analysis is done on the content, positioning Brazil's recent publications related to SCM context, emphasizing research drivers and opportunities for future work.

Keywords: Supply Chain Management; Thematic Analysis; Literature Review; Brazil.

1 Introduction

The study of supply chain management (SCM) in Brazil in recent years had a considerable increase. As seminars and journals, especially in the business and production engineering fields, demand for abstracts and full papers in English, comparison along what is published there and mainstream SCM content is increasingly possible. As discussed in Bortollossi & Sampaio (2012), logistics and SCM are popular, well developed themes, calling attention to both academics and practitioners. This is aligned to international developments in the field, where SCM has received more and more attention through the years, given phenomena like the Globalization and IT developments.

The international scientific community carried out different studies on literature review in SCM. Some developed frameworks for future analysis (Alfalla-Luque et al. 2013; Croom et al. 2000; Almuiet & Salim 2014; Gunasekaran & Ngai 2005; Seuring & Müller 2008). Other categorized researches given their particular approach to SCM, such as: humanitarian issues, sustainability, strategic planning, knowledge management and governance (Abidi et al. 2014; Gold et al. 2010; Lambiase et al. 2013; Martin et al. 2006; Rajurkar & Jain 2011; Shukla & Jharkharia 2013; Torres Valdivieso & García Cáceres 2008). This article presents a systematic literature review on papers selected in two major academic databases, which present both (i) SCM as a central topic; (ii) a Brazilian journal as host for the material; (iii) at least abstracts and keywords published in English. The objective is to perform a systematic literature review of the Brazilian context, analyzing information and methodologies to identify well-developed themes, and overlooked ones to be prioritized for a more complete research in the area in Brazil.

2 Supply Chain Management in Brazil

The study of supply chains gained momentum in the last decade (**Fig.** 1). It is established as an important area of business management, being one of the main topics in the domain statement of the Operations Management division of the Academy of Management. Respected academic journals, such as the *Journal of Supply Chain Management* and *Management Science* are devoted to studies in the field.

1 **Marcio Cardoso Machado** (marciocmachado@uol.com.br)
2 **Flavio Macau** (professor@flaviomacau.com)
3 **Carlos Eduardo Santos** (carlos.santos@ifmt.edu.br)
PGA. UNIP. Rua Dr. Bacelar, 1212 - Vila Clementino - São Paulo – SP, CEP 04026-002. FEA, PUC-SP. Rua Monte Alegre, 984, Perdizes - São Paulo - SP, CEP: 05014-901

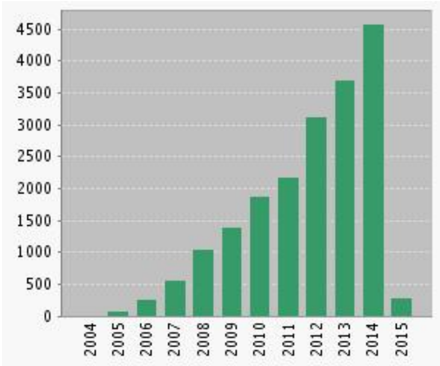

Fig.1
Citations of Supply Chain Management in Web of Knowledge.
Source: Authors.

In Brazil SCM is in the domain statement of the Operations and Logistics Group of the ENANPAD congress (main academic event in the country), and is represented in academic journals such as the *Journal of Operations and Supply Chain Management*. To grasp which topics are presented in Brazilian studies, we did a systematic review of papers published from 2008 to 2014.

2.1 Systematic review

In a systematic review the most relevant information for a given topic is selected, following a logical sequence that reduce bias and guarantees an adequate coverage (Abidi et al. 2014). Researches following the same steps should be able to replicate the process, resulting in robust and transparent results. A logical and exhaustive process of data mining is done in the literature review, involving published materials in a systematic way, which allow for peer reviewers a better position to audit assignments. This article conducts such systematic review, following Tranfield et al. (2003) steps:

- *Planning:* to evaluate the status of high level supply management research in Brazil, and to establish its research streams both theoretically and methodologically, an assessment of representative academic publications on supply chain management in Brazil was performed. After consulting with expert Brazilian scholars two databases were selected (Scopus and SciELO), both containing journals that, since 2008, are involved in an effort to publish in English language. Instead of developing new classifications, the categories suggested by Croom et al. (2000) (see **Table** 2) were chosen to support comparisons with other studies.

- *Searching:* supported by the experts, the keywords chosen to capture SCM publishing in Brazil were "supply chain" OR “supply chain management” OR “logistic”. Literature review was performed in the end of December 2014, involving a ten-year period of data collection (although the next session focus on the 2008 - 2014 period). Journals were res-tricted to those related explicitly to business management, decision science, engineering, and social sciences. A relevant amount of related articles was found (**Table** 1).

Table 1
Protocol for database search.
Source: Authors.

Database	Scope	Number of publications
Scopus	Title, abstract and keyword	1799
SciELO	Title, abstract and keyword	452
Total		2251

- *Screening:* to guarantee replication, a criteria was established to exclude articles from the original 2.251 list. Articles had to be empirical or theoretical, blind reviewed, published from January 2004 to December 2014, in Brazilian journals that take part of the CAPES-Qualis list (a local rank for academic journals). Papers that were duplicated, that did not contain at least one Brazilian author, and that were submitted to conferences only, were excluded (except for Souza et al. (2014) literature review on SCM). Abstracts from the 71 remaining articles were read to eliminate those where SCM was not a central topic, e.g. when the unit of analysis was an aspect of a firm inserted in a supply chain (not SCM *per si*). This resulted in a list of 53 articles clearly related to SCM studies in Brazil, conducted with Brazilian scholars (**Fig.** 2).

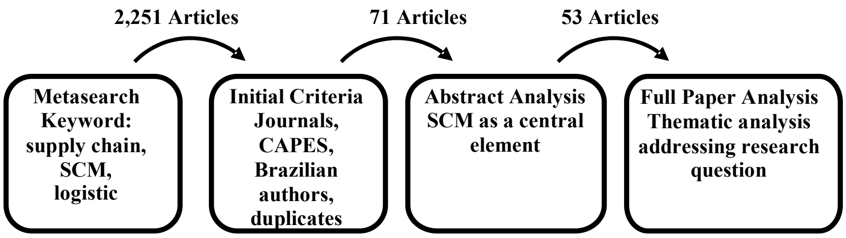

Fig.2
Paper screening methodology based on Abidi et al. (2014) & Wilding et al. (2012).
Source: Authors.

- *Extraction, synthesis and reporting:* the remaining 53 articles were classified according to Croom et al. (2000) categories, considering the level of analysis (dyadic, chain, network), and the elements of exchange (assets, information, knowledge, relationship).

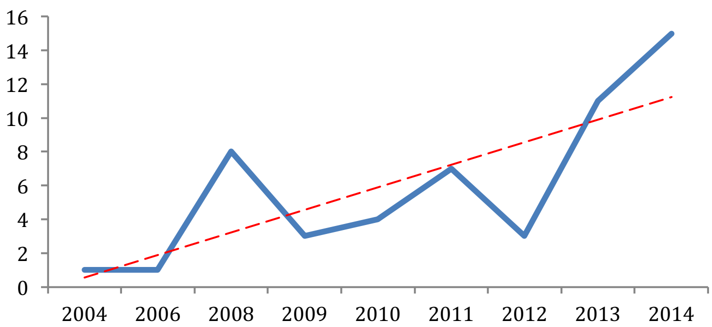

Fig.3
Number of selected articles in SCM published in Brazil from 2004 to 2014.
Source: Authors.

Also, an epistemological classification was performed, involving methods of analysis (theoretical and empirical), and paradigms (prescriptive and descriptive). The distribution of the 53 selected articles, per year of publication, can be found in **Fig.** 3.

2.2 Literature Review – thematic analysis

Croom et al. (2000) two dimensional approach to literature thematic analysis enables to address both the level of analysis (dyadic, chain and network) and the element of exchange (assets, information, knowledge or relationship). The level of dyad analysis is divided into relationships between supplier and manufacturer, and between manufacturer and distributors. In the chain level there is no division. In the network analysis level divisions occur depending on the nature of the operation (downstream or upstream), or take the network as a whole.

Table 2
Number of papers classified in each supply chain thematic matrix cell.
Source Adapted from Croom et al. (2000)

Level of analysis	Elements of exchange			
	Assets	Information	Knowledge	Relationship
Dyadic				
- Suppl. Manuf.	4	2	3	4
- Manufa. Dist.	4	1		2
Chain				
- Suppl. Manuf. Dist.	14	1	2	2
Network				
- Up Stream	4	1		
- Down stream	3			
- Whole	4			2

Each matrix cell represents the level analysis and the element of exchange (Table 2). The 53 articles were meticulously read and categorized, resulting in extensive notes (available upon request for comparison and discussion) as to which categories they fit best. A recurrent situation was the possibility to place a given article in more than one category. To ensure that a given paper did not result in multiple contributions, therefore with a heavier weight than others to determine actual trends, each article was allowed to occupy only one category - that which represented best its central characteristic. As a consequence, the sum of all cells result in the 53 analyzed articles.

However, analyzing it vertically, 33 articles involved asset examination, while 5 involved information, 5 involved knowledge, and 10 involved relationships. Therefore, there was a clear trend into the more explicit, economic trait of SCM.

2.3 Literature Review – method analysis

Again Croom et al. (2000) structure was applied to categorize the methods employed in each of the 53 articles. The epistemological dimensions ranged from theoretical to empirical in one axe, and from prescriptive to descriptive in the other. **Fig.** 4 presents the results. Each quadrant represents the amount of crossing perspectives found in the body of articles.

	Prescriptive	Descriptive
Theoretical	13 % 7 articles	17 % 9 articles
Empirical	17 % 9 articles	53 % 28 articles

Fig.4
Literature classification according to the method analysis.

There is a trend toward descriptive theoretical papers (53%), similar to that observed in Croom et al. (2000) (56%). Descriptive, theoretical papers are a bit far of (17% against 11%), as well as prescriptive theoretical (13% against 6%), and prescriptive empirical (17% against 27%).

Therefore, descriptive papers predominate in Brazil (70%), aligned to the 67% found by Croom et al. (2000) in international literature. This suggests a strong focus in understanding what happened in the past in SCM, rather than suggesting what to do in the future. One may see a clear trend into explaining (a scholar activity) rather than acting (a practitioner activity).

	Prescriptive	Descriptive
Theoretical	13 % 7 articles	17 % 9 articles
Empirical	17 % 9 articles	53 % 28 articles

Fig.4
Literature classification according to the method analysis.

However, in Brazil the percentage of empirical papers (70%) is lesser than that observed in the international literature (83%). This may suggest an earlier stage in the study of SCM, where concept dissemination and understanding is still necessary to solidify the area's foundation within the country. Before comparing even more extensively, what is going on in the field, it is necessary to align and share definitions and models, adapting them to the local reality.

3 Research agenda for SCM in Brazil

Research on SCM in Brazil is increasingly seeking for visibility in the international community, as shown in the indexation of Brazilian journals in international databases, and also in the insertion of Brazilian authors in international journals of greater visibility. The typical Brazilian author in the last 10 years directed his/her research in SCM to the dyadic or chain level of analysis, working with assets as exchange elements, with empirical, descriptive analysis. To achieve parity with the SCM community more research in the network level of analysis should be conducted, applying structures such as those proposed by Harland et al. (2004). In addition, mixing academic and practitioner perspectives might enhance the development of the area, contributing for more opportunities of international insertion.

4 Conclusion

Research on SCM increased in Brazil in the last 10 years, with a growing number of academics and journals aiming for more international relevance, inserting research done in the country in the international arena. This article studied published papers from 2004 to 2014, observing the remarkable jump started in 2008, which aggregated a number of local publications to the international mainstream. Through systematic literature analysis, it was possible to identify actual trends and future opportunities of research in SCM in Brazil. The current status of high-level supply management research in the country point to empirical, descriptive material, analyzing the dyad or the chain, focusing on its assets (an economic perspective). Chains should receive more attention as unit of analysis, and an effort to extend research in less prominent areas - such as information, knowledge, and relationship aspects of SCM - might contribute to a greater participation of Brazilian authors and journals worldwide. Today's status reflect the current need to translate concepts and ideas to local conditions. To achieve greater relevance, a shift is needed toward innovative, practitioner based applications.

References

Abidi, H., De Leeuw, S. & Klumpp, M (2014). Humanitarian supply chain performance management: A systematic literature review. *Supply Chain Management*, 19, pp.592–608.

Alfalla-Luque, R., Medina-Lopez, C. & Dey, P.K (2013). Supply chain integration framework using literature review. *Production Planning and Control*, 24(8-9), pp.800–817.

Almuiet, M.Z. & Salim, J (2014). From a literature review to a conceptual framework for automation knowledge acquisition in supply chain management. *Journal of Theoretical and Applied Information Technology*, 64(3), pp.730–745.

Bortollossi, L.N. & Sampaio, M (2012). Academic research published in the management & production journal (G&P, 1999-2010): Trends and future research directions. *Gestao e Producao*, 19(1), pp.189–201.

Croom, S., Romano, P. & Giannakis, M (2000). Supply chain management: An analytical framework for critical literature review. *European Journal of Purchasing and Supply Management*, 6(1), pp.67–83.

Gold, S., Seuring, S. & Beske, P (2010). Sustainable supply chain management and inter-organizational resources: A literature review. *Corporate Social Responsibility and Environmental Management*, 17(4), pp.230–245.

Gunasekaran, A. & Ngai, E.W.T (2005). Build-to-order supply chain management: A literature review and framework for development. *Journal of Operations Management*, 23(5), pp.423–451.

Harland, C et al (2004). A Conceptual Model for Researching the Creation and Operation of Supply Networks. *British Journal of Management*, 15(1), pp.1–21.

Lambiase, A et al (2013). Strategic planning and design of supply chains: A literature review. *International Journal of Engineering Business Management*, 5(1), pp.1–11.

Martin, V et al (2006). Knowledge management for the sustainable supply chain: A literature review. *Proceedings of the European Conference on Knowledge Management, ECKM*, pp.302–309.

Rajurkar, S.W. & Jain, R (2011). Food supply chain management: Review, classification and analysis of literature. *International Journal of Integrated Supply Management*, 6(1), pp.33–72.

Seuring, S. & Müller, M (2008). From a literature review to a conceptual framework for sustainable supply chain management. *Journal of Cleaner Production*, 16(15), pp.1699–1710. Available at:

Shukla, M. & Jharkharia, S (2013). Agri-fresh produce supply chain management: A state-of-the-art literature review. *International Journal of Operations and Production Management*, 33(2), pp.114–158.

Souza, D.L. de, Mesquita, D.L. & Antonialli, L.M (2014). O campo de estudos sobre Supply Chain Management no Brasil sob a ótica da bibliometria : Uma abordagem exploratória em periódicos nacionais. In *XVII SEMEAD Seminários em Administração*. São Paulo, p. 17.

Torres Valdivieso, S. & García Cáceres, R.G (2008). Supply chain governance forms: A literature review and a research model proposal . *Cuadernos de Administracion*, 21(35), pp.65–91.

Tranfield, D., Denyer, D. & Smart, P (2003). Towards a methodology for developing evidence-informed management knowledge by means of systematic review. *BRITISH JOURNAL OF MANAGEMENT*, 14(3), pp.207–222.

Wilding, R et al (2012). Extending sustainability to suppliers: a systematic literature review. *Supply Chain Management: An International Journal*, 17(5), pp.531–543.

Environmental management in companies in the food sector: the state of the art

Viles E[1], Santos J[2], Ormazabal M[3], Jaca MC[4]

Abstract: The food sector, given its size and impact, should be one of the principal focus of the environmental management progress. This article aims to analyze the scientific advances in the field of environmental management in food companies through a literature review of the last 10 years. Trends in research linked to the environmental management of food and/or beverage companies are analyzed by classifying the literature into five themes: culture/models, environment, logistics, materials and process.

Keywords: State of the art, food sector, environmental management.

1 Introduction

In recent decades, all types of organizations have incorporated within the workplace different tools in order to promote awareness of environmental impact and to comply with legislative requirements and requirements for protecting the environment (Claver et al., 2007). These environmental tools range from techniques from Life Cycle Analysis (LCA) or product and service eco-design to the implementation of environmental management systems in accordance with different standards and norms or environmental performance evaluations (Emilsson and Hjelm, 2002).

However, many companies remain reluctant to incorporate environmental improvements or do not exploit the potential of environmental management. Many companies are satisfied with simply having an environmental management system through a certification such as ISO 14001.

The European food industry is the largest industrial sector in the EU (14.9% of annual turnover) but it is heavily fragmented (out of 287,000 companies, over 99% are SMEs). The sector, in Europe, contributes to 23% of global resource consumption and 18% of global greenhouse gas emissions, it represents 5.3% of the worldwide industrial energy consumption, and it is considered one of the largest producers of wastewater. These data warrant the need to know in depth what the state of the sector is in terms of environmental management and what scientific advances are taking place in this field.

Specifically, this paper analyzes the scientific advances in the field of environmental management in the food sector by reviewing the scientific literature of the last 10 years. This study focuses mainly on analyzing trends in the research linked to the environmental management of food and/or beverage companies.

The article first details how the literature review was carried out and the criteria for article selection. Then it analyzes and classifies the selected articles, and finally it presents the conclusions of the study.

2 Literature review

In the scientific domain, the database of reference is, undoubtedly, the *ISI Web of Knowledge*. It allows users to conduct structured studies, to know what citations appear in each article, to filter results by topic, and to access any summary; hence, any article can be classified according to the subject or keywords.

1 **Elisabeth Viles** (eviles@tecnun.es)
Po Manuel Lardizabal, 13. 20018 San Sebastián.
2 **Javier Santos** (jsantos@tecnun.es)
3 **Marta Ormazábal** (mormazabal@tecnun.es)
4 **Carmen Jaca** (cjaca@tecnun.es)
Dpto. de Organización Industrial. Tecnun. Universidad de Navarra.

For this study, during November 2014, we consulted for articles and reviews for the period 2004-2014, using a combined subject search with the key words "food industry" and "environmental management". The initial search areas were environmental sciences; ecology; food science technology; agriculture; public, environmental, and occupational health; engineering or operations research management science; and water resources.

The query returned 352 articles, which are shown distributed by year in Figure 1. There is a slight increase in the number of articles published each year, although the year 2014 is not representative as all the publications have not yet been incorporated and indexed on the web.

The first noteworthy aspect of the query results is the diversity of scientific journals in which articles have been published, for a total of 203 journals. Just one article was found in 154 journals and 1, 2 or 3 articles were found in 185 journals. The three journals that have published more articles are: Journal of Cleaner Production (20 articles), British Food Journal (14 articles) and Journal of the Science of Food and Agriculture (10 articles).

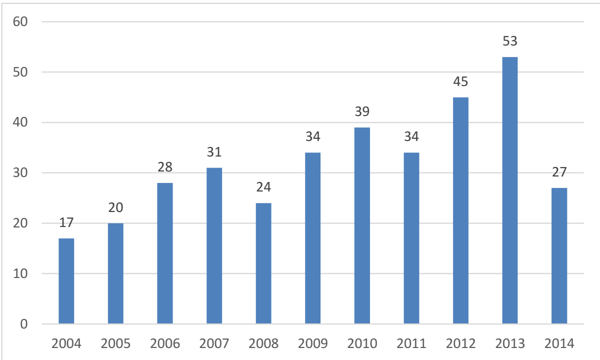

Fig.1
Distribution of articles by year.

A diverse set of topics were found in the articles, so we proceeded to classify them by first looking at the title and abstract and the following content criteria stablished beforehand for the analysis:

- **Climate**. Of the 352 articles, 19 articles focus on aspects related to the impact that food manufacturing has on climate change.

- **Ecosystems**. This topic covers 41 articles that address how to defend certain marine ecosystems, flora or fauna, or how to encourage the captive breeding of certain species.

- **Management**. 115 articles address issues of business management, and these are the ones that will be analyzed in depth and reclassified in the next section.

- **Chemical/Biological**. 50 articles explain the effect that chemical or biological agents have on water quality or on manufactured products. This group also covers the effects of pesticides on production.

- **Natural Resources**. 29 articles explain the problems of natural resource scarcity and how to encourage their proper use with policies and actions that can be implemented in companies, especially on livestock farms.

- **Health**. 62 articles analyze the effects that the production of food, pesticides or bacteria have on people's health. Articles covering food safety in food production companies are also in this section.

- **Technology**. 36 articles deal with applying technology to non-productive sectors such as perishable goods, crops, water treatment plants or genetic modification.

Table 1 shows this classification by year of publication for the 352 articles. The total number of articles for each category is also provided.

Table 1
Initial classification of the articles.

Category / Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	**Total**
Climate	1	0	1	1	0	2	2	2	4	1	5	**19**
Ecosystems	3	0	4	6	3	6	6	1	4	4	4	**41**
Management	5	10	14	6	8	11	10	6	16	18	11	**115**
Chemical/Biological	4	1	3	5	5	1	7	5	7	7	5	**50**
Natural Resources	1	3	1	4	0	3	5	4	2	6	0	**29**
Health	3	4	1	4	8	9	6	11	6	10	0	**62**
Technology	0	2	4	5	0	2	3	5	6	7	2	**36**
Total / Year	**17**	**20**	**28**	**31**	**24**	**34**	**39**	**34**	**45**	**53**	**27**	**352**

3 Research on environmental management in the food sector

As described above, after the initial classification, 115 articles were identified as having content directly related to aspects of environmental management in companies in the food sector. Although articles related to environmental management in any company of the sector were considered, this study will be focused on the productive sector and consequently two groups of articles are going to be eliminated:

- **Other sectors**. 30 articles cover issues of environmental management in retail companies, supermarket chains, fish farms, water treatment companies or intensive agriculture.

- **Other studies**. 10 of the 115 articles focus on environmental problems from the perspective of consumers, stakeholders or marketing strategies and company communication.

As a result, the final list of scientific publications that cover environmental management in food production companies is comprised of 75 articles. Figure 2 shows the distribution of these articles by year, where no trends are observed.

The distribution of articles across journals remains highly fragmented (36 different journals), although a third of the articles are from three journals: Journal of Cleaner Production (15 articles), British Food Journal (6 articles) and International Journal of Production Economics (5 articles).

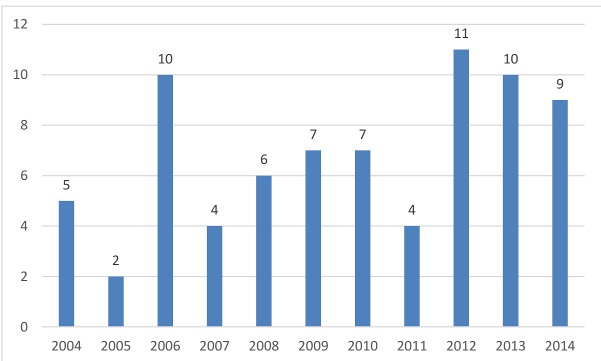

Fig.1
Distribution of the final set of articles by year.

3.1 Selection criteria. Final classification

Once the publications that did not respond to the objectives of the present article were removed from the study, a detailed reading of the abstract, objectives and keywords of the 75 articles was undertaken. Below a thematic grouping is proposed, taking into consideration 5 areas or aspects that affect the environmental management of a company in the food sector:

- **Culture/Models**. Articles in this area present environmental management models, barriers to the adoption of environmental policies or models of environmental sustainability for companies.

- **Environment**. A company's environmental requirements depend largely on the conditions established in the environment where it is located. On the one hand, environmental legislation sets requirements that affect the way the company carries out certain processes. On the other hand, the environmental culture of the people sets the level of the workers' environmental commitment. Ten of the articles are part of this area and they focus principally on legal aspects.

- **Logistics**. In addition to the company itself, a company's customers and suppliers make up the company's environmental efficiency, setting new restrictions concerning packaging, transportation, etc. In this sense, most of the 12 articles included in this area focus on the sustainability of food companies' supply chains.

- **Material**. The efficient use of raw materials should be dealt with separately from the production process. One reason for this is that an environmental impact has already been generated due to their production. Another reason is that maximum use of raw materials should be undertaken wherever it is possible to reuse them. The 20 articles in this area make proposals for reducing waste in or recovering it for further use.

- **Process**. The area where a company can better manage its environmental impact is its own transformation process, which often has the greatest impact. Out of the 26 articles that address issues related to process, 9 deal with technical aspects, 3 propose process management indicators, 8 use tools to analyze environmental impact, and 6 present proposals to reduce water consumption in the process of transformation.

Table 2
Year of publication for the final set of articles.

Aspect / Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	**Total**
Culture/models	0	0	0	0	0	1	2	0	2	2	0	**7**
Environment	0	0	2	1	1	0	1	1	2	0	2	**10**
Logistics	1	0	0	0	0	2	1	0	1	1	6	**12**
Material	3	0	2	2	4	2	0	0	3	3	1	**20**
Process	1	2	6	1	1	2	3	3	3	4	0	**26**
Total	**5**	**2**	**10**	**4**	**6**	**7**	**7**	**4**	**11**	**10**	**9**	**75**

Table 3
Citations received per year.

Aspect / Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	**Total**
Culture/models	0	0	0	0	0	0	2	5	13	14	24	**58**
Environment	0	0	0	11	4	3	2	7	7	3	6	**43**
Logistics	0	1	2	2	10	3	13	4	17	31	33	**116**
Material	0	0	0	8	22	38	43	63	79	90	50	**393**
Process	0	0	4	15	37	47	50	68	114	142	136	**613**
Total	**0**	**1**	**6**	**36**	**73**	**91**	**110**	**147**	**230**	**280**	**249**	**1223**

Tables 2 shows the number of articles published in each category and Table 3 shows the number of citations received by those articles in the period under study. It is important to highlight that only 3 articles out of the 75 have no citations and that only 8 have fewer than 5 citations.

3.2 Most cited articles

Due to space constraints it is not possible to analyze the 75 articles and their references in detail. We will therefore analyze the most cited articles in each category, with the aim of covering the scientific community's interest in the topics tackled in those articles. We will therefore analyze the ten most cited articles across all categories that account for more than 50% of the citations (720 of a total of 1223), which means that they can be thought of as the base of the scientific literature on environmental management in companies in the food sector.

Generic models facilitate the adoption of successful environmental strategies. Because some of them are adjusted to comply with the requirements set by standards such as ISO 14000, it is possible to identify barriers or incentives for the implementation of environmental regulations, especially in developing countries (Masood et al. 2010). The models also rely on tools such as life cycle analysis to assess the environmental impact that different types aspects of the food industry have (Notarnicola et al., 2009).

It is clear that the environment surrounding a company establishes the framework for action and the requirements that the company has to fulfill on environmental issues. On the one hand, it is necessary to comply with the law and avoid polluting, which can be more demanding in some countries (Murty et al., 2006). The culture of the company also facilitates or hinders the adoption of the proposed general models. For example, it is possible to identify proposals that align environmental management models with quality assurance models (Seymour et al., 2007).

Companies are not isolated and if they want to reduce the environmental impact of their products, they should be aware of the supply chain and make it more sustainable, even in the area of bottle and container reverse logistics (Gonzalez-Torre et al., 2004). It is a complex problem that also supports integration with sustainability and food security, even through simulation models (van der Vorst et al., 2009).

The raw material used in the production processes of the food industry has a limited use and the concern about waste revalue is particularly important in this sector, whether it involves olives (Roig et al., 2006) or fish (Arvanitoyannis et al., 2008). In this way it is essential to reduce and manage the environmental impact caused by raw materials.

Finally, the most obvious point of control at a company is its own transformation process, and scientific publications in this field focus on technological implementations, such as wireless sensors (Wang et al., 2006) or new systems to reduce water consumption (Oelmez et al., 2009).

4 Conclusion

Although the number of publications in the food sector area is growing, there is no correspondence between scientific interest and the interest shown by companies and governments about the environmental impact generated by this sector. Therefore, in light of the present study on the state of the art, it is clear that much work remains to be done to improve the environmental management of companies in the food sector. The number of citations associated with the articles analyzed is still low and corresponds to a research area of with development potential. The main aspects that this line of research should focus on could be framed in the five presented areas: Culture/models, Environment, Logistics, Material and Process.

5 References

Arvanitoyannis, IS.; Kassaveti, A. (2008). “Fish industry waste: treatments, environmental impacts, current and potential uses”. International Journal of Food Science And Technology, Vol 43 (4), pp. 726-745.

Claver E., López M.D., Molina J.F., & Tarí J.J. (2007), "Environmental management and firm performance: a case study", Journal of Environmental Management, vol. 84 (4), pp.606-619.

Emilsson S., & Hjelm O. (2002), "Implementation of standardised environmental management systems in Swedish local authorities: reasons, expectations and some outcomes", Environmental Science & Policy, vol. 5 (6), pp.443-448.

Gonzalez-Torre, PL., Adenso-Diaz, B., Artiba, H. (2004). “Environmental and reverse logistics policies in European bottling and packaging firms”. International Journal of Production Economics, vol. 88 (1), pp. 95-104.

Massoud, MA., Fayad, R., El-Fadel, M., Kamleh, R. (2010). “Drivers, barriers and incentives to implementing environmental management systems in the food industry: A case of Lebanon”, Journal of Cleaner Production, vol. 18 (3), pp. 200-209.

Murty, MN., Kumar, S., Paul, M. (2006), “Environmental regulation, productive efficiency and cost of pollution abatement: a case study of the sugar industry in India”, Journal of Environmental Management, Vol. 79 (1), pp.1-9.

Notarnicola, B., Hayashi, K., Curran, MA., Huisingh, D. (2012). “Progress in working towards a more sustainable agri-food industry”. Journal of Cleaner Production, Vol. 28, pp. 1-8.

Oelmez, H., Kretzschmar, U. (2009). “Potential alternative disinfection methods for organic fresh-cut industry for minimizing water consumption and environmental impact”. LWT-Food Science and Technology, Vol. 42 (3), pp. 686-693.

Roig, A., Cayuela, ML., Sanchez-Monedero, MA. (2006). “An overview on olive mill wastes and their valorisation methods”. Waste Management, vol. 26 (9), pp. 960-969.

Seymour, EJ., Ridley, AM., Noonan, J. (2007). “Assessing the role of a four-stage approach for improving the compatibility of Environmental Management Systems and Quality Assurance”. Australian Journal of Experimental Agriculture, Vol. 47 (3), pp. 333-345.

Van der Vorst, JGAJ., Tromp, SO., van der Zee, DJ. (2009). “Simulation modelling for food supply chain redesign; integrated decision making on product quality, sustainability and logistics”. International Journal of Production Research, Vol. 47 (23), pp. 6611-6631.

Wang, N., Zhang, NQ., Wang, MH. (2006). “Wireless sensors in agriculture and food industry - Recent development and future perspective”. Computer and Electronics in Agriculture, Vol. 50 (1), pp. 1-14.

The impact of Supply Chain Management on the innovation process: systematic literature review

Zimmermann RA[1], Ferreira LM[2], Moreira AC[3]

Abstract: Innovation generation is increasingly seen as a collaborative process carried out with the participation of different actors within or outside the organizations. In this context, the influence of the supply chains over innovation process is a current topic of great interest. This paper aims at contribute to the improvement of the knowledge about the relationship between supply chains and the innovation process by means of a systematic literature review. The identification and analysis of sixty relevant papers on the field showed the complexity, the topicality, and the broad character of the theme as well as indicated opportunities for future researches.

Keywords: supply chain management, innovation management, organizational performance, systematic literature review.

1 Introduction

The complexity of the business environments, as a result of the globalization, elevates the impact of external factors over the organizations' overall performance. Innovation management is increasingly seen as a collaborative process carried out with the participation of different actors within or outside the organizations (Berghman, Matthyssens, & Vandenbempt, 2012; Chesbrough, 2010).

Among external aspects that exert such influence are drivers and barriers derived from the relation whit external actors, economic uncertainty, government policies, legislation, market technological intensity, and competition. The influence of the supply chains over innovation process is a current topic of great interest (Golgeci & Ponomarov, 2013; Narasimhan & Narayanan, 2013; Oke, Prajogo, & Jayaram, 2013; Roy, Sivakumar, & Wilkinson, 2004). This relationship was explored in recent Special Issues in journals as Decision Sciences and Journal of Supply Chain Management.

Supply chains are networks where suppliers and clients share the common objective of provide products and services to the final clients and enterprises rely on their partners to have innovative inputs (Narasimhan & Narayanan, 2013; Oke et al., 2013). Being historically vital for organizations for its strategic and financial impact, supply chain management has become more relevant as society becomes more and more concerned with knowledge. As a result knowledge and information flows are added to the traditional monetary and physical flows what increases its management complexity as well as its importance for processes undergoing little impact before, such as innovation management.

Thus, this paper aims at contribute to the improvement of the knowledge about the relationship between supply chains and the innovation process. For this, we conducted a systematic literature review, which analysed published papers about the topic, in order to know what has been studied in the literature and identify gaps and possible areas for future research. The question that the paper aims to answer is: considering that the innovation process is impacted by external factors, how the supply chains impact the innovation process and performance?

1 **Ricardo Augusto Zimmermann** (ricardoaz@ua.pt)
2 **Luís Miguel Domingues Fernandes Ferreira** (lmferreira@ua.pt)
3 **António Carrizo Moreira** (amoreira@ua.pt)
Economics, Management and Industrial Engineering Department,
University of Aveiro, Aveiro, 3810-193, Portugal.

In the next section, we present the methodology used, including the research question formulation, definition of papers selection and exclusion criteria, and analysis criteria. Then we present the results in two parts: (1) context of the literature on the topic – predominantly quantitative analysis; (2) qualitative analysis aims to answer the research question. Finally, we present the research conclusions.

2 Methodology

The paper uses the Systematic Literature Review (SLR) method as presented by Denyer and Tranfield (2009). SLR is the identification, selection, analysis, and synthesis of existents studies on a given topic and their clearly presentation in order to know what is known and what is not known about the subject (Denyer & Tranfield, 2009). The five steps proposed by the authors are used: (1) research question definition; (2) location of studies; (3) selection and evaluation of studies; (4) analyses and synthesis and; (5) presentation and use of the results. This method aims to ensure that the review is transparent, auditable and your repetition is possible.

The first step is the definition of the research question, which has to be clear to ensure the focus of the study. The defined question is: considering that the innovation process is impacted by external factors, how the supply chains impact the innovation process and performance?

The next step is the location of relevant studies to answer the research question. The ISI Web of Science database was used once it comprises the main works on the field. This strategy is used in many literature reviews on this field. We defined three categories of key words: (1) term related to innovation: innovation, innovate, innovativeness. We decided to use the term innovate* to include all the possibilities; (2) the terms supply chain and SCM; (3) and the terms align*, partner*, coordinat*, collaborat*, relation*. The search considered all the possible combinations of the three categories of key words. Only Journals were surveyed, limited to the areas of management, economics and engineering. There were no restrictions to the date of publication. The first search showed 627 articles.

Thereafter, the abstracts and keywords were read and the following question had to be positively answered so that the paper was selected: the paper has the relationship between supply chain and the innovation process as a clear objective? Using this criterion, 98 articles were selected. Finally, the entire articles were read to verify their contribution to answer the research question. After that, 60 papers were selected. Doubts and disagreements were discussed until a consensus was reached.

Following other authors' suggestion and as a mean to improve the confidence of the selection, three researchers simultaneously analysed the articles. Doubts and disagreements were discussed until a consensus was reached. At last, the articles were analysed in two stages: (1) quantitative stage to know the literature context of the topic; (2) qualitative stage to identify and describe the main contributions of the articles to the topic.

3 Literature context – quantitative analysis

The analysis criteria used in this stage were year of publication, journals published, authors' location (country), and theoretical perspective of the papers. The relationship between SC and innovation is a relatively new topic in the literature. Most of the articles are quite recent, and sixteen of the sixty papers were published in 2013 (Fig. 1). Eleven papers were published in 2014, and six in 2011 and 2012, totalling more than 60% of the articles in the last four years. The recent interest on the subject is justified for the growing importance of innovation as a competitive advantage factor, as well as the importance of collaboration between organizations.

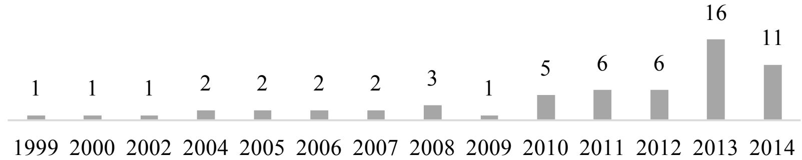

Fig.1
Number of articles per year.

Regarding to the source of the publications, the analysed papers were published in twenty-three different Journals, what evidence the relevance and the broad character of the topic. The Journals with more papers published were the *International Journal of Production Economics* with nine articles, the *Journal of Supply Chain Management* and the *Journal of Operations Management* with seven papers each and the *Supply Chain Management – An International Journal* with six. The main Journals present high Impact Factors according to the *Journal Citation Report* and the first three are in the first quartile in their categories.

Table 1
Main Journals.

	Journal	Number of articles
1	International Journal of Production Economics	9
2	Journal of Supply Chain Management	7
3	Journal of Operations Management	7
4	Supply Chain Management-An International Journal	6

In what refers to location of the authors, the papers have a considerable dispersion, showing that the topic has a global interest. Although there is a predominance of papers held in the United States of America (about 50%), the number of articles of Europe and Asia are relevant. Regarding to the authors, once again there is a great dispersion. Twelve authors have two articles published and no author has more than two. Finally, between the institutions with the largest number of publications, we can highlight the *Michigan State University*, with seven papers and the *Hong Kong Politechnic Univesrsity* with five.

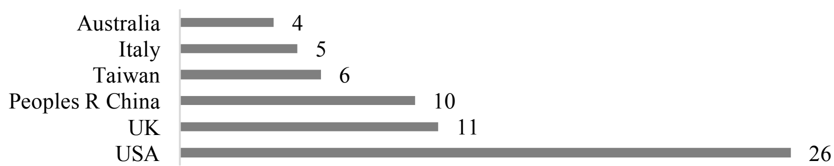

Fig.2
Countries with more published papers.

The analysis of the articles also showed the inexistence of a predominant theory in this topic. In the sixty analysed papers, we identified more than ten theories as basis of the studies. The theories most cited were the *Transaction cost economics*, with seven papers, the *Knowledge-based view*, with six, *Resource-based view*, with five, *Network theory*, *Contingency theory* and *Relational view theory*, with four papers each. Sixteen papers do not refer the theory used.

4 Impact of the SC over the innovation process – qualitative analysis

Innovation is seen as a collaborative process carried out with the participation of different actors within or outside the organizations. Great innovators depend on external actors to assure great part of the advantage in what refers innovation (Fawcett, Jones, & Fawcett, 2012). Ozman (2009) and Radas & Bozic (2009) state that innovation is more effective when seen as a collective process and that collaboration with other enterprises is an important part of enterprise efforts toward innovation. Hieh & Tidd (2012), claim that the higher the degree of novelty of innovation, the greater should be the intensity of knowledge sharing.

Jarayam & Pathak (2013) argue that the knowledge integration is an effective strategy to obtain better performance in the product and process development process. In this sense, Radas & Bozic (2009) highlight the alliances with research centres and universities, beside clients and suppliers, as facilitators to the innovation process.

Few companies have the set of skills or have the necessary resources for the development of all components of their final products (Yeniyurt, Henke, & Yalcinkaya, 2014). Fitjar & Rodriguez-Pose (2013), argue that companies engaged in external collaboration tend to be more innovative than companies that depend exclusively on its own resources and knowledge. Among the external partners, SC actors are recognized as potential contributors to the innovation process (Jean, Kim, & Sinkovics, 2012; Yeniyurt et al., 2014). Roy et al. (2004), claim that innovation is not only influenced by relationships with suppliers, but is largely a result of these interactions.

Typically SC are designed to harmonize routine activities between partners, not including the innovation process (Bouncken, 2011). Considering the growing market competitiveness, however, is noticeable that companies, in most cases, do not have all the necessary resources internally, and try to build relationships with partners who own these resources, especially with other SC actors (Ettlie & Pavlou, 2006; Oke et al., 2013). Partners located upstream in the SC provide updated information on the preferences of consumers and on new trends. Partners located downstream, in turn, tend to provide current knowledge of new technologies (Bouncken, 2011). The level of participation of the partners in the innovation process also depends on their position in the chain. The farther the partner is located in the chain, upstream or downstream, the lower the level of participation in the innovation process (Wynstra, von Corswant, & Wetzels, 2010).

As companies become more specialized, increases the importance of engaging the SC partners in the innovation process. Becomes crucial that companies align their internal research and development strategies with the knowledge available in the chain in order to achieve better performance with regard to innovation (Narasimhan & Narayanan, 2013). Soosay, Hyland and Ferrer (2008) claim that the ability to work in partnership with other SC actors allows companies to integrate their operations, generating greater efficiency and facilitating innovation, both radical as incremental.

Petersen et al. (2005), argue that there are different levels of liability of suppliers in the process of develop-ping new products of its customers. When the supplier is involved in an informal and superficial way and the client makes all decisions, the relationship is called White Box. When there is a formalized integration and decisions and product development are conducted jointly, we call a Grey Box. Finally, when the development is coordinated and carried out primarily by the supplier, according to customer specifications, it is called Black Box (Petersen et al., 2005).

Golgeci & Ponomarov (2013) claim that the ability and the magnitude of the innovations of the companies are related to the resilience of the SC. Considering the growing importance of the SC to the organizations performance and the impact of disruptions, increased resilience can be seen as an improvement in the performance since it reduces the risk of ruptures. According to these authors, companies must invest in their innovative capacity not only to be competitive and improve its performance, but also to respond to the risks and disruptions in uncertain environments.

Narasimhan & Narayanan (2013) reinforce the hypothesis that innovation should be seen as a collaborative process, where the SC has a fundamental role. They define innovation as "the process of generating changes in products, processes and services that results in the creation of value for the company and its customers by leveraging the company's own knowledge and / or its SC partners."

Thus, considering the analysed studies, the relationship between the SC actors is a potential facilitator of the innovation process. The main features described as facilitators in the articles analysed are: trust between partners, ease and frequency of information sharing, shared decision-making, integration of information systems and efficient management of the chains. Some features of the supply chains, however, can act as barriers to the innovation process. One of these barriers is the difference of the technology used by the actors, particularly between customer and supplier (Peitz & Shin, 2013). Another important barrier is the difficulty of establishing trust relationships between actors of SC (Fawcett et al., 2012).

Finally, it is clear that there are different characteristics of the SC able to positively influence the organizations performance with regard to innovation. Given this influence, companies adopt different strategies in order to involve the other SC actors in their innovation process. Among the articles analysed, the following main strategies have been identified: (1) partnerships for specific purposes - development of a new product or process; (2) coordination of projects by the client company; (3) Integration of the product development process between actors of the SC; (4) Strategic alignment between actors in SC; (5) Strategy of open innovation.

5 Conclusions

The increasing complexity of business environments, which increases the impact of external factors to the overall performance of organizations and the perception that innovation is a collaborative process involving external actors, explains the growing number of published studies on the relationship of innovation and SC.

Using the methodology of systematic literature review, we identified and analysed articles that explore the relationship between SC and the innovation process. The analysis showed the complexity of the topic, its relevance and its broad character. Companies, in general, do not have the necessary resources or skills internally necessary for the success of the innovation process. The main reason to collaborate with other organizations, therefore, is the access to these resources, especially to knowledge. Thus, collaboration with external actors becomes relevant to the innovation process of organizations.

Therefore, the SC affects the innovation process and their performance in many ways as facilitators or barriers to the process. The way organizations manage the innovation process relatively to the SC is addressed in different ways in the literature. Among the sixty analysed articles, we identified five main action strategies. From the articles, we also conclude that little has been studied about the influence of SC on the different types of innovation and the different stages of the innovation process, as well as the reality of services and SME. Another gap identified is the study of alignment of Supply Chain Management Strategies and Innovation Management Strategies to improve organizational performance.

Finally, the main recommendation for future research is the in-depth empirical studies on the use of different strategies for innovation applied to the SC. Also, it is recommended to carry out empirical studies on facilitating factors and barriers to the innovation process. Although, as shown in this article, some factors have been identified, there are no studies that explore this subject in depth.

6 References

Berghman, L., Matthyssens, P., & Vandenbempt, K. (2012). Value innovation, deliberate learning mechanisms and information from supply chain partners. *Industrial Marketing Management, 41*(1), 27-39. doi: 10.1016/j.indmarman.2011.11.014.

Bouncken, R. B. (2011). Supply Chain Contingencies: The Effects of Up-Stream Directives on Supplier's Innovation Performance. *Emj-Engineering Management Journal, 23*(4), 36-46.

Chesbrough, H. (2010). Business Model Innovation: Opportunities and Barriers. *Long Range Planning, 43*(2-3), 354-363. doi: 10.1016/j.lrp.2009.07.010.

Denyer, D., & Tranfield, T. (2009). Producing a systematic review. In D. A. Buchanan & A. Bryman (Eds.), *The Sage Handbook of Organizational Research Methods*. London: Sage.

Ettlie, J. E., & Pavlou, P. A. (2006). Technology-based new product development partnerships. *Decision Sciences, 37*(2), 117-147. doi: 10.1111/j.1540-5915.2006.00119.x.

Fawcett, S. E., Jones, S. L., & Fawcett, A. M. (2012). Supply chain trust: The catalyst for collaborative innovation. *Business Horizons, 55*(2), 163-178. doi: 10.1016/j.bushor.2011.11.004.

Fitjar, R. D., & Rodriguez-Pose, A. (2013). Firm collaboration and modes of innovation in Norway. *Research Policy, 42*(1), 128-138. doi: 10.1016/j.respol.2012.05.009.

Golgeci, I., & Ponomarov, S. Y. (2013). Does firm innovativeness enable effective responses to supply chain disruptions? An empirical study. *Supply Chain Management-an International Journal, 18*(6), 604-617. doi: 10.1108/scm-10-2012-0331.

Hsieh, K.-N., & Tidd, J. (2012). Open versus closed new service development: The influences of project novelty. *Technovation, 32*(11), 600-608. doi: 10.1016/j.technovation.2012.07.002.

Jayaram, J., & Pathak, S. (2013). A holistic view of knowledge integration in collaborative supply chains. *International Journal of Production Research, 51*(7), 1958-1972.

Jean, R.-J. B., Kim, D., & Sinkovics, R. R. (2012). Drivers and Performance Outcomes of Supplier Innovation Generation in Customer-Supplier Relationships: The Role of Power-Dependence. *Decision Sciences, 43*(6), 1003-1038. doi: 10.1111/j.1540-5915.2012.00380.x.

Narasimhan, R., & Narayanan, S. (2013). Perspectives on supply network-enabled innovations. *Journal of Supply Chain Management, 49*(4), 27-42. doi: 10.1111/jscm.12026.

Oke, A., Prajogo, D. I., & Jayaram, J. (2013). Strengthening the innovation chain: the role of internal innovation climate and strategic relationship with supply chain partners. *Journal of Supply Chain Management, 49*(4), 43-58. doi: 10.1111/jscm.12031.

Ozman, M. (2009). Inter-firm networks and innovation: a survey of literature *18*(1), 39-67. doi: 10.1080/10438590701660095.

Peitz, M., & Shin, D. (2013). Innovation and waste in supply chain management. *Journal of Economic Behavior & Organization, 86*, 191-199. doi: 10.1016/j.jebo.2012.11.013.

Petersen, K. J., Handfield, R. B., & Ragatz, G. L. (2005). Supplier integration into new product development: coordinating product, process and supply chain design. *Journal of Operations Management, 23*(3-4), 371-388. doi: 10.1016/j.jom.2004.07.009.

Radas, S., & Bozic, L. (2009). The antecedents of SME innovativeness in an emerging transition economy. *Technovation, 29*(6-7), 438-450. doi: 10.1016/j.technovation.2008.12.002.

Roy, S., Sivakumar, K., & Wilkinson, I. F. (2004). Innovation generation in supply chain relationships: A conceptual model and research propositions. *Journal of the Academy of Marketing Science, 32*(1), 61-79. doi: 10.1177/0092070303255470.

Soosay, C. A., Hyland, P. W., & Ferrer, M. (2008). Supply chain collaboration: capabilities for continuous innovation. *Supply Chain Management-an International Journal, 13*(2), 160-169. doi: 10.1108/13598540810860994.

Wynstra, F., von Corswant, F., & Wetzels, M. (2010). In Chains? An Empirical Study of Antecedents of Supplier Product Development Activity in the Automotive Industry. *Journal of Product Innovation Management, 27*(5), 625-639.

Yeniyurt, S., Henke, J. W., & Yalcinkaya, G. (2014). A longitudinal analysis of supplier involvement in buyers' new product development: working relations, inter-dependence, co-innovation, and performance outcomes. *Journal of the Academy of Marketing Science, 42*(3), 291-308.

Planning routes and shifts driving for a small business of road passenger transport

Aparicio P[1], Muñuzuri J[2], Escudero A[3], Grosso R[4]

Abstract: The presented work is done for a company that currently operates twenty lines of passenger transport in the metropolitan area of Seville. The planning of these was originally carried out manually, building routes and shifts in an Excel spreadsheet. In order to automate the process as much as possible. It was designed and implemented by a scheduling algorithm that would be much simpler than other algorithms in the literature and that, in addition, would make it possible to allow mixing vehicles and drivers between the lines. The objective was, firstly, to employ the minimum number of drivers; then, it is trying to use the least possible number of vehicles; finally, the study tries to reduce as much as possible the amount of split shifts. In addition, restrictions on the design of routes and shifts were added. At all times the service frequencies remained above the set limit. To allow the possibility of unexpected demand peaks, was established in the capacity of each route some slack.

Keywords: planning routes; shifts driving; bus; passenger transport; algorithm

1 Introduction

Planning passengers' bus services is a complex optimization problem, because the conditions and restrictions that often occurring in them, they are usually specific to each case. This necessitates the use of simplified or partial approaches to reach good enough designs. Thus, the global problem of planning a bus service is broken down into basic modules, in a total of five, according to the original description of (Ceder, 1986), shown in Table 1. Many scientific papers focus on each of the steps shown in Table 1, sometimes considering several stages at once. Ceder and Wilson propose a two-step algorithmic procedure to establish the network design and service frequencies, whereas (Guihaire, 2008) carried out an extensive collection of articles focusing on the planning of schedules in the network. Finally, regarding planning on driving schedules, (Ernst, 2004) collected studies about heuristic approaches (e.g., Martello, 1986), column generation methods (Desrochers, 1989) metaheuristics (Wren, 1995), or even multi-objective approaches (Lourenço, 2001).

This paper focuses on the last three stages of the planning process associated with the establishment of schedules of buses and shifts driving. These problems, which are based on prior knowledge of the network and the minimum frequency step and the demand divided time slots and all data cost and time constraints can be addressed in multiple ways. The most advanced approach is to solve the three problems together (Ball, 1983; Rodrigues, 2006; Mesquita, 2008). However, this approach has the disadvantage that it requires solving a linear optimization problem at some point in the execution of the algorithm.

An approach is taken in this case because it is a small company with few lines, is a heuristic approach that seeks a reasonably good solution in a time interval reduced to provide guidance to the company in planning schedules and shifts driving. Thus, we decouple both problems, using the result of the first as input for solving the second. The goal of the algorithm is: first, it expects to employ as few conductors as possible; then, will seek to use the least possible number of vehicles; eventually pursue reduce as much as possible the amount of split shifts that are required.

1 **Pablo Aparicio Ruiz** (pabloaparicio@us.es)
2 **Jesús Muñuzuri Sanz** (munuzuri@us.es)
3 **Alejandro Escudero Santana** (alejandroescudero@us.es)
4 **Rafael Grosso de la Vega** (rgrosso@us.es)
Grupo de Ingeniería de Organización,
Escuela Superior de Inge- niería, Universidad de Sevilla,
Camino de los Descubrimientos S/N, 41092 Sevilla, Spain.

Table 1
Bus services planning process (Ceder, 1986).

Inputs required	Planning activity	Outputs
Demand data Supply data Route performance indices	Network Design	Route changes New routes Operating strategies
Budget or subsidy available Buses available Service policies	Establishment frequency	Service frequencies
Demand for time slots Start and end time of service Travel time	Timetable development	Trip departure time Trip arrival time
Deadhead times Break or rest periods Time restrictions Structure of operating costs	Bus schedules	Bus schedules
Driver work rules Staff costs or structure cost	Drivers scheduling	Driver shifts schedules

The problem consists in the planning of a company that operates twenty lines in the metropolitan area of Seville. The lines have radial character, operating from a terminal in the city of Seville and another located in the metropolitan area. Three different terminals in Seville, with approximately equal numbers in each line. The lines need two planning processes per year (winter and summer). At the beginning of our work, this process was done manually for each of the lines separately, using a spreadsheet. Automating the process, attached to the possibility of combining lines between vehicles and drivers that have the same terminal. Thus, this work presents great opportunities for increased efficiency.

2 Problem definition

From the files of the company, it was known the following information for each of the lines: the round trip time (*rt*), the number of daily services (*ns*), the start and end of the journey, the first hour (h_f) and last hour (h_l) of departure, the demand for each slots in each line (*D*). If a line has several variants (*i*), the number of daily services (ns_i) and the round trip time (rt_i). As is reflected in Table 1, the complete planning, scheduling and shifts driving also required information on the costs involved and the time constraints applicable to each line. This information is detailed below:

- Structure cost. The cost applicable to the service depends on the type of activity, basically, drivers can perform three types of functions:

  – Time of presence (TP): It is the time spend next to the vehicle without driving. There is an obligatory time presence of 10 minutes at the beginning of each day to prepare the vehicle, and a similar end for the liquidation of the cash box.

  – Time driver-no-receiver (TDNR): The driver is driving the vehicle without carrying passengers. Such times are for the routes from the garage to the header line and vice versa, or fictitious route which are placed on service planning.

  – Time driver-receiver (TDR): The driver is driving the vehicle carrying passengers. It corresponds to the regular bus services.

The time costs associated with these three types of functions have the next relation: cost per hour (*TDR*) > cost per hour (*TDNR*) > cost per hour (*TP*)

- Temporal restrictions. There is a restriction on driving times and rest periods of drivers. This restriction is described by the following four principles:

  – Driving shift: There are two types of shifts: full and split shifts (morning, evening).

  – Length shift: normal shifts are 8 hours, and maximum an extra additional hour a day.

  – Start and end of shifts: morning shifts often end before 15h, and often start later than 12h.

  – Rest periods: Maximum period of continuous driving is 6h. If the shift is longer, it is obligatory to introduce a break period of at least 15 minutes, if it is higher, is recorded at the present time. However, in split shifts that break is at least 1 hour, but time will not be considered presence if the break is longer.

3 The proposed solution

The proposed solution is presented in Figure 1. The solution consists of an initial analysis and a heuristic calculation.

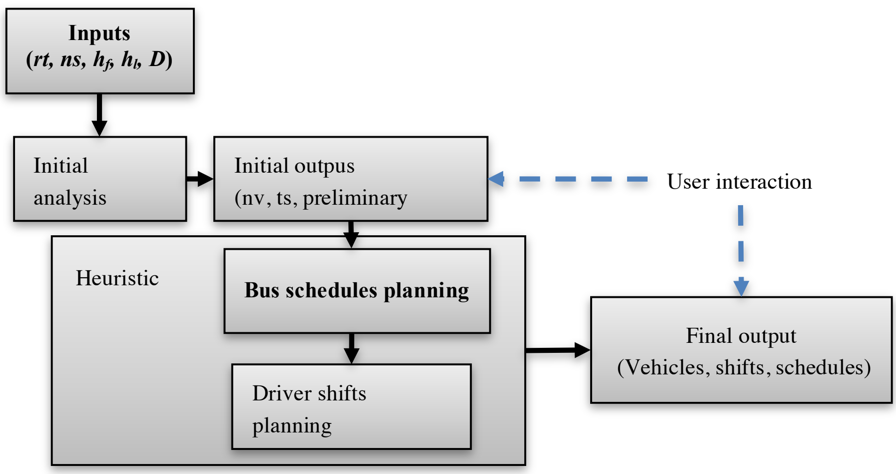

Fig.1
The planning algorithm.

3.1 Initial analysis

The initial calculation, which is initially determined, the number of buses to be used in each line and a first approximation to the schedules of them, the lines of the company are classified into different groups, and this consists of several steps:

- The calculation of the number of buses needed for each line, estimated from:

$$tv = \sum_i ns_i \cdot rt_i / \sum_i ns_i \qquad (4.1)$$

Also, is calculated: the travel time in one direction ($ttd = rt / 2$), hours of service ($h_s = h_l - h_f + ttd$) or the number of buses needed ($nb = ns \cdot rt / h_s$).

- Grouping and closing of the lines. If the decimal part of *the nb* is greater than 0.85 (modifiable parameter) will be considered closed lines. For the remaining lines, to

identify those lines that are coincident, that is, they share the same terminal point in Seville. Then:
– All possible groups of matched lines are tested, in order to maximize the number of closed groups.
– Afterwards, groups of lines that are mismatched and not closed are tested, to building all possible closed groups.
Accordingly, four cases are defined:
– Type A: Individual lines closed with one vehicle
– Type B: Lines individual closed with two or more vehicles
– Type C: Groups with two or more vehicles
– Type D: Lines with various routes with different times. These lines are treated as belon-ging to type C.

Thus, the total number of buses is obtained, rounded to the next whole number needed for each line and closed group buses.

3.2 Heuristic

After preliminary analysis, the heuristic calculation performs the final planning, the heuristic is divided into two modules: the bus schedules and the driver shifts planning.

3.2.1 Bus schedules

The planning module of bus schedules, is based on a historical demand of each line and travel times according to the time of day. Route designs are done by determining the number of vehicles required and departure times.

To understand the heuristic, an operation of a bus, with four services (two departures and two arrivals, between two terminals) is shown in Figure 2. For each service, it has shown time in each terminal, departure time in one terminal and arrival time in the other, in the line, the slope defines speed and distance between both terminals.

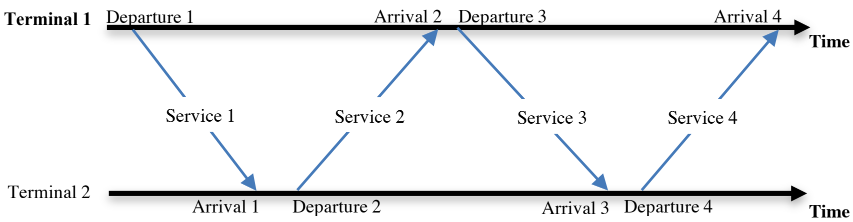

Fig.2
Description of the operation of a bus line with two services.

The operation of the heuristic for determining bus schedules depend on the type of line, according to the definition in the preliminary analysis. The procedure for each type of possible lines are described:

- **Type A**: lines that only need a single vehicle for all services, the process is as follows:

  – The only vehicle defines their services beginning at the start time of service (h_f). As in Figure 2, outward journeys are defined at (h_f + rt, h_f + 2 *rt*, h_f + 3 *rt*,...) and return journeys at (h_f + *ts*, h_f + rt + *ts*, h_f + 2 *rt* + *ts*,…) to meet the demand or minimum service associated with each slot time. When all services in the time slot have been performed, the bus is waiting for the next service. The process continues in this way until the end of the day (h_l).

- **Type B**: lines with two or more vehicles for all services, the process is as follows:

  – Times are determined for the first vehicle in the same way as in the type A.

  – For the second vehicle, the backward process is performed. Defined the routes backwards from the time of the last arrival (h_l - *rt*, h_l - 2 *rt*, h_l - 3 *rt*,…) and from the opposite terminal (h_l - *ts*, h_l - *rt* - *ts*, h_l - 2 *rt* - *ts*,…), until the start of the day.

  – If it is necessary a third vehicle, there is reintroduced forward, like the first. The departure time of the first service will be the midpoint between the first and the second vehicle departure time (h_m). From there, we proceed identifying services until the end of the day.

  – The process continues in this way until the number of vehicles needed is completed.

- **Type C**: The situation is more complex when are line groups with two or more vehicles, in which is known amount of vehicles, and are shared the services assigned to them all. In such lines, the heuristic operates in a greedy way, following a similar procedure to the previous cases. This preliminary estimation about time schedules is built on the classification of lines made above. Thus:

  – Allocate to each group enough buses as indicated by the integer part of *bn*.

  – Allocate these bus schedules following the same pattern than in type A and B.

  – For other buses: if it is only a single, is considered shared between all lines of the group. If they are *m* buses to be distributed in *n* lines of the group (with $m<n$), take the *m* lines with decimal part upper to *bn*, and combine with remaining *nm* lines trying than the sum of lines in all combinations is as small as possible.

  – If the bus has to serve *p* lines, in each line is proceeded with the calculation *D*/*bn*, for the morning and afternoon. These bus travel is sequentially allocated to bus lines based on that calculation.

3.2.2 The driver shifts planning

Driving shifts are constructed taking into account the break times, lunch times if there are split shifts, time constraints driving and the associated costs. It allows multi-shift worker allocation along the lines, that allowing a single worker is allocated to different lines on the same day, depending on the needs of the service and trying to optimize break times.

For a line or group of lines with *bn* necessary vehicles and *dn* drivers needed. Two possible cases may occur: First, if $n = 1$, all the time will be assigned to a single conductor. Second, if $n>1$, further fulfilling that $n = 2 \cdot bn$, we will focus on this case. Finally, if $n> 1$ and $n> 2 \cdot bn$.

In the second case, each vehicle was initially allocated two drivers, one at the opening and one at the end of the day. The number of services *tn* that are assigned at the beginning (end) of the journey. That number can only be such that $tn \cdot rt$ is between 35% and 65% of the number of daily driving hours. This will give *x* total possible values of *v*. After (before) to make that number of trips, the driver can enjoy a short break (less than 1 hour) or long break (not less than 1 hour), and after (before) this break, the driver may rejoin to either *bn* vehicles of the line, performing all trips that still have to do the bus.

To show the complexity of the problem, for example, a line or group of lines with 4 buses and 8 drivers who could make 2 or 3 trips (two possibilities) before break, the number of possibilities before the break will be: VR (2,8) = 2^8 = 256, and the breaks can be short and long we will have 65,536 possibilities (256 • 256). After the break, we should combine each driver with each of the possibilities of each bus. Thus, the four drivers who started the day could end their turn in each of the four buses, resulting V (4,4) = 24 variants. Likewise, each conductor used to close the bus line, can start your day in each of the four buses, taking another 24 possibilities, and giving a total of 37,748,736 variants (65,536 • 24 • 24). This number would be increased by a factor that depends on the number of possible variations caused by the long or short break in each case.

In the evaluation of each alternative, should be penalized with p_{lb} hours long break over an hour, with p_x hours extra, and with p_{sb} hours of short break over 15 minutes, where: $p_{lb} < p_x < p_{sb}$. The goal is to minimize the total cost.

The procedure for allocating drivers to the services is carried out by greedy heuristic. For each group, the journey of one of the *nc* drivers needed is allocated to one of the initial services in a line. At the end of that service, is assigned the new service that is closer to start of the whole group (which will usually be in the same line, however, this is not necessarily the case).

This is the process until you have covered 50% of their workday. If there is a sufficient gap between services for a short break, is assigned and the driver continues to allocate services to the end of their journey. If there is no space, the allocation of the bus drivers stop.

The following drivers are also assigned to services, but this time from back to front, assigning the last line services, until the moment of break. We proceed in the same way with all *nc* drivers until some of them are completed, and others have covered only up to their break, backwards or forwards.

Then are allocated the breaks to drivers, initially all short, to try to maximize the number of consecutive shifts and assigning services continues until completely covered. If the service earlier than can be assigned to a driver has an excessively large slack after the short break, this is replaced by a long break and the allocation is continued.

4 Result and conclusions

In this paper, we have presented a simple algorithm to schedule work shifts from driving in a metropolitan company with a small size of passenger transport and bus services. While it does not guarantee the optimal solution, it does allow the company to achieve a good solution in a small space of time, avoiding having to resort to commercial optimization software packages or modelled complexes.

The application of this methodology to the Seville company under study allowed to achieve a reduction of 12.5% in the number of buses required to meet all the daily services, 8% in the number of drivers and 7.5% in the total cost of operation. It is therefore a tool effectively, susceptible as well as being applicable in any company with similar characteristics, in which the manual planning and lack of validation of procedures tend to hide great opportunities for improving efficiency and reducing costs.

5 References

Ball M, Bodin L, Dial R (1983) A matching based heuristic for scheduling mass transit crews and vehicles. Transportation Science, 17(1):4-31.

Ceder A, Wilson N (1986) Bus network design.
Transportation Research B, 20B(4): 331-344.

Desrochers M, Soumis F (1989) A Column Generation Approach to the Urban Transit Crew Scheduling Problem. Transportation Science, 23(1):1-13.

Guihaire V, Hao J (2008) Transit network design and scheduling: a global review. Transportation Research A, 42:1251-1273.

Lourenço H, Paixao J, Portugal R (2001) Multiobjective metaheuristics for the bus–driver scheduling problem. Transportation Science, 35(3):331–341.

Martello S, Toth P (1986) A heuristic approach to the bus driver scheduling problem. European Journal of Operational Research, 24:106-117.

Mesquita M, Paias A (2008) Set partitioning/covering-based approaches for the integrated vehicle and crew scheduling problem. Computers and Operations Research, 35:1562 – 1575.

Rodrigues M, de Souza C, Moura, A (2006) Vehicle and crew scheduling for urban bus lines. European Journal of Operational Research, 170:844–862.

Wren A, Wren D (1995) A genetic algorithm for public transport driver scheduling. Computers and Operations Research, 22(1):101-110.

A Two Stage Heuristic to Good Feasible Solutions for the Fuel Cost Transmission Gas Pipeline Networks Problem

Mothé E[1], Arica J[2]

Abstract: The pressure, which drives the natural gas (NG) in pipeline networks, is lost to the extent the NG flows. To keep the NG flow, the pressure is restored to each certain stretch of the pipeline by Compressor Stations (CSs). A CS is formed by several compressors, which returns the NG pressure, consuming part of the transported gas, causing the transmission cost. Therefore, it is necessary to determine the operation of the CSs to minimize their fuel cost. This problem is known as the problem of the fuel cost minimization of gas pipeline networks, which results an NP-complete problem. Heuristics working this problem must generate feasible solutions and compute their cost. This problem is addressed here with a two-stage approach, which sequentially generates feasible solutions and computes their costs, depending on a parameter. The first stage deals with feasibility and the second with cost minimization. The pipeline (cyclic or not) is associated to a network and decomposed in subnetworks connected by CSs. Given the mass flow rate at CSs as a parameter, a solution is found for a first given subnetwork using the feasibility stage, then, using the cost stage, are computed the minima costs to pass to the subnetworks connected with the given subnetwork. Using repeatedly these two stages, feasible solutions and minima costs to connect each subnetwork with other sub-networks are calculated sequentially, until the whole network is covered. Computational tests were carried out in Matlab, obtaining satisfactory results.

Keywords: Natural Gas, Transmission, Pipeline.

1 Introduction

The transmission of natural gas (NG) is the gas transportation over long distances by land. It is carried out by pipeline networks, where NG is driven by pressure differences, which is lost to the extent that gas flows, due, mainly, to friction with the inner walls of the pipe and the heat exchange with the environment (Wu et al., 2000; Iamashita et al, 2008; Woldeyohannes and Majid, 2011). To keep the NG flow, the pressure is restored to each certain stretch of the pipeline by devices called Compressor Stations (CSs), which are formed by batteries of (centrifugal) compressors, returning the NG pressure and consuming part of the transported gas, causing this way the fuel transportation cost (between 25% and 50% of total operating costs of the pipeline). This leads to the problem of finding a distribution of NG flow rate and pressures through the pipeline network and an operating configuration of compressors at each CSs to transport the NG at the minimum fuel cost. This problem is known as the fuel cost minimization of gas pipeline networks. Here the problem is based on steady-state gas pipeline networks, which can be cyclic.

To model the problem, a pipeline network can be identified with a network, where edges represent pipes or CSs and nodes their physical connections. The variables associated to the problem are the flow rate through the edges and the pressures at nodes. The cost function is the NG consumed at CSs, which depends on the suction and discharge pressures at each CSs. If the CSs are assumed composed by identical unit compressors, the mathematical model results nonlinear, non-convex and non-differentiable (c.f., Wu et al, 2000; Ríos-Mercado et al 2002; Borraz-Sánchez and Ríos-Mercado, 2009). If the CSs are

1 **Eduardo Machado Mothé** (edumothe@gmail.com)
2 **José Arica** (jose.arica.chavez@gmail.com)
Lab. Engenharia de Produção.
Universidade Estadual do Norte Fluminense Darcy Ribeiro.
Av. Alberto Lamego, 2000. Campos dos Goytacazes, RJ.

considered composed by non-necessarily identical compressors, the problem results in a more general (more complex) model: non-differentiable quadratic mixed-integer model (c.f., Iamashita et al, 2008). Anyway, as known the result problem is NP-Complete (which means, *grosso modo*, that the number of arithmetic operations for solving the problem raises exponentially with the problem size).

In the last years this problem has been addressed by several researchers on different perspectives: to model the problem for apply mathematical programming techniques (c.f., Wu et al, 2000; Ríos-Mercado et al, 2002) and to model the problem considering a more complex model, applying (meta-)heuristic techniques (c.f., Chung et al, 2003; Iamashita et al, 2008; Borraz-Sánchez and Ríos-Mercado, 2009; Woldeyohannes and Majid, 2011). Typically, the last approach considers a two stage problem, where the first stage leads with the feasibility of solutions and the second stage with the cost solution.

In this study it is addressed the efficiency to construct *good* feasible solutions for the problem. In the sense that, since a feasible solution is determined by flow rates and node pressures, where the flow rates through pipes have no cost and can be dispatched at different pressure levels, the cost generated at CSs, depends on the suction (inlet) or discharge (outlet) pressures is not unique. Therefore, it is worth studying which would be the suction and discharge pressures at each CS to dispatch the NG at minimum cost, where the flow rate through the CSs is known.

Given a flow rates set through the CSs, satisfying network mass balance, a two stage procedure is proposed to iteratively construct a good solution: the first deals with feasibility and the second with cost minimization. The pipeline network is decomposed in subnetworks connected by CSs (subnetworks not containing CSs). Beginning with a particular subnetwork, the feasibility stage is applied to find flow rates and pressures to dispatch the NG at this subnetwork. The set of flow rates results unique, but the pressures not, each node pressure can be range on a defined interval, depending on an initial given pressure. A procedure, based on the Newton-Raphson method, finds the flow rates and the range interval of pressure on each pipe and node of the subnetwork, respectively.

Then, the cost minimization stage is applied. A greedy searching procedure, based on bisection of the range interval of pressure at each suction (discharge) node of the last subnetwork, which connects trough a CS with another subnetwork, finds the discharge (suction) pressure, with minimum cost for the given flow rate at the CS. This way, by applying the first stage to the new subnetwork and then the second stage, the entire network is covered at a minimum cost, parametrized by the given flow rates through the CSs (at this point, some (meta-)heuristic technique can be used to pick another set of flow rates through the CSs).

This procedure was implemented in Matlab and computational tests were carried out in Matlab, obtaining satisfactory results.

2 The Model for the Fuel Cost Minimization of Gas Pipeline Networks

The CSs are usually formed by multiple centrifugal compressors. Differently of other authors (c.f., Wu et al, 2000; Ríos-Mercado et al 2002; Chung et al, 2003; Borraz-Sánchez and Ríos-Mercado, 2009; Woldeyo-hannes and Majid, 2011), in this work are considered CSs not necessarily formed by identical compressors, which are called generalized CSs (GCSs). Following Iamashita et al (2008), it is described the generalized model for the problem.

Consider the pipeline network as a directed graph $G=(N,L\cup M)$, where N is the nodes set and $L\cup M\subset N\times N$ is the arcs set, whit L the pipes set and M the CSs set (Wu et al, 2000). Fig. 1 illustrates a pipeline network, with $|N|=48$ ($N=\{1,...,48\}$), $|L|=43$ ($L=\{(1,2),(3,4),...,(46,45),(45,47)\}$), $|M|=8$, showing a partition in subnetworks (these ones without CSs, in dashed lines).

Considered the following notation: s_a, net mass flow rate at node $a\in N$ ($s_a>0$, if the node is a supply node; $s_a<0$, if the node is a delivery node; and $s_a=0$, if the node is a transshipment node); p_a, gas pressure at node $a\in N$ (there exists lower and upper bounds for the pressure denoted by p_a^L and p_a^U, respectively); K_{ab}, compressors number of CS $(a,b)\in M$; v_{abk}, mass flow rate through compressor k at CS $(a,b)\in M$; $x_{abk}\in\{0,1\}$, decision variable to operate compressors at CS $(a,b)\in M$ ($x_{abk}=1$, if compressor k is activated; $x_{abk}=0$, otherwise); D_{abk}^{unit}, domain of compressor k at CS

$(a,b)\in M$; $g_{abk}^{unit}(v_{abk}, p_{ab}^S, p_{ab}^D)$, fuel cost function for compressor k at CS $(a,b)\in M$, for $(v_{abk}, p_{ab}^S, p_{ab}^D)\in D_{abk}^{unit}$, where p_{ab}^S and p_{ab}^D are suction pressure and discharge pressure, respectively (this function is implicitly known, see Paula et al (2011) for details); u_{ab} or v_{ab}, mass flow rate through pipe $(a,b)\in L$ or through CS $(a,b)\in M$, respectively.

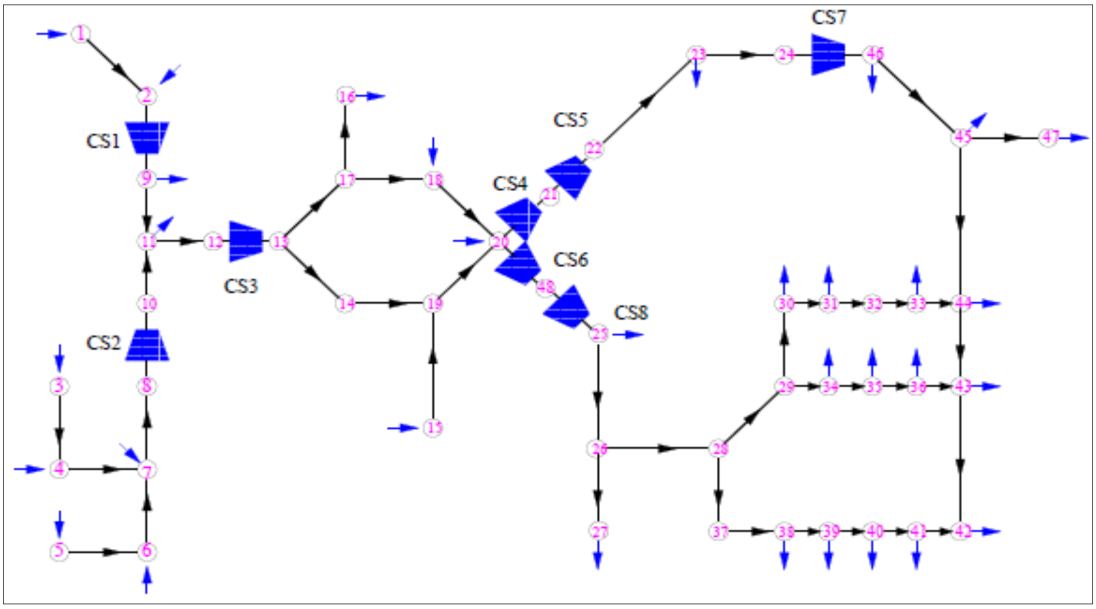

Fig.1
Illustration of a pipeline network as a directed graph, where dash lines show subnetworks without CSs (adapted from Wu et al., 2000).

A CS $(a,b)\in M$ has its operational cost measured by the sum of the fuel cost of each unit compressor, $g_{ab}(v_{ab}, p_{ab}^S, p_{ab}^D) = \sum_k g_{abk}^{unit}(v_{abk}, p_{ab}^S, p_{ab}^D)$. Then, the fuel cost of the pipeline is given by

$$\sum_{(a,b)\in M} g_{ab}(v_{ab}, p_{ab}^S, p_{ab}^D) = \sum_{(a,b)\in M} \sum_{k=1}^{K_{ab}} g_{abk}^{unit}(v_{abk}, p_{ab}^S, p_{ab}^D) \quad (1)$$

Therefore, the considered model is:

$$\text{minimize} \quad \sum_{(a,b)\in M} \sum_{k=1}^{K_{ab}} g_{abk}^{unit}(v_{abk}, p_{ab}^S, p_{ab}^D) \quad (1.1)$$

$$\text{s.t.} \quad \sum_{b:(a,b)\in L} u_{ab} - \sum_{b:(b,a)\in L} u_{ba} = s_a, a\in N \quad (1.2)$$

$$v_{ab} - \sum_{k=1}^{K_{ab}} x_{abk} v_{abk} = 0, (a,b)\in M \quad (1.3)$$

$$p_a^2 - p_b^2 = t_{ab} u_{ab} |u_{ab}|, (a,b)\in L \quad (1.4)$$

$$x_{abk} \in \{0,1\}, k = 1,\dots, K_{ab}, (a,b)\in M \quad (1.5)$$

$$p_a \in [p_a^L, p_a^U], a\in N \quad (1.6)$$

$$(v_a, p_{ab}^S, p_{ab}^D)\in D_{ab}, (a,b)\in M \quad (1.7)$$

where D_{ab} is the feasible domain CS $(a,b) \in M$, defined according to (2), the domains of unit compressors that compose it, D^{unit} (see (7)). Additionally, the meanings of the constraints are: (1.2), mass balance at each node; (1.3), mass balance at each CS; (1.4), mass flow rate and pressures dynamic at each pipe; (1.6), pressure bounds at each node; (1,7), feasibility of points for CSs.

The domain of a compressor unit, D^{unit}, is given by

$$D^{unit} = \left\{ (v, p_s, p_d) : p_s^L \le p_s \le p_s^U, V^L \le \frac{v}{p_s} \le V^U, G^L\left(\frac{v}{p_s}\right) \le \frac{p_d}{p_s} \le G^U\left(\frac{v}{p_s}\right) \right\}, \tag{2}$$

where functions $G^L(\cdot)$ and $G^U(\cdot)$ are implicitly known (see Wu et al, 2000). D^{unit} is a truncated conic. Fig. 2 and Fig. 3 show the horizontal and vertical profiles of D^{unit}, for fixed values of p_s and p_d, respectively.

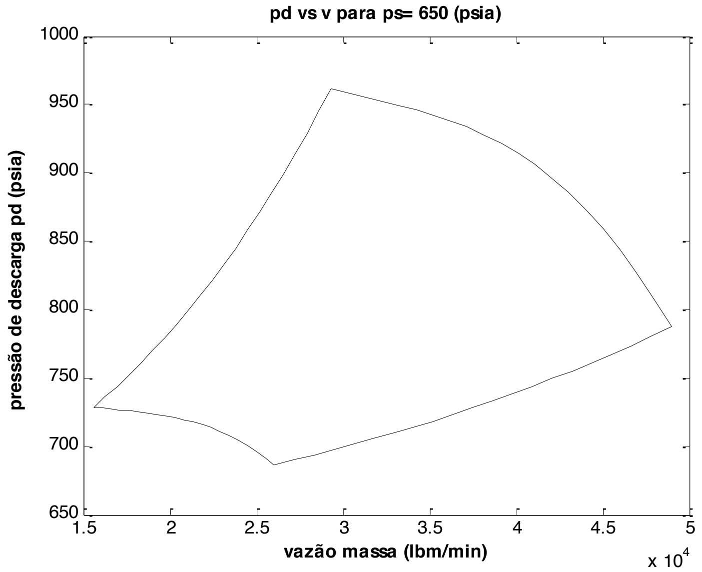

Fig.2 Feasible range interval of discharge pressure for given v and p_s

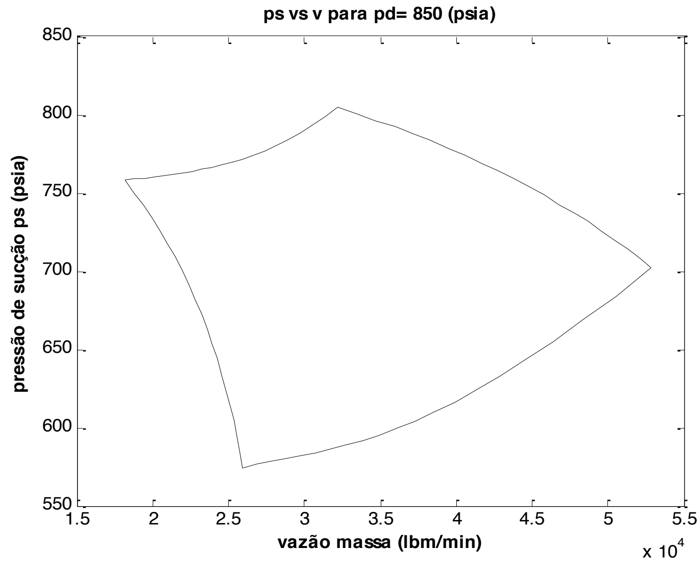

Fig.3 Feasible range interval of suction pressure for given v and p_d

3 The Two-stage approach

The feasible stage deals with the feasibility of mass flow rates and pressures at subnetworks (SNs). As in Ríos-Mercado et al (2000), assume $|N| = n$, $|L| = l$, $|M| = m$ and define the incidence matrix associated to G by $A = (A_l \mid A_m)$, where A_l is the $(n \times l)$ node-pipe incidence matrix and A_m is the $(n \times m)$ node-station incidence matrix. This allows writing the model (1.1)-(1.7) in matrix notation.

Considering the mass flow rate vector decomposed as $w^T = (u^T, v^T) \in \Re^{l+m}$, where u is the flow rate mass through the pipes L and v the mass flow rate through the CSs M, the balance mass equations and mass flow rate and pressures dynamic at pipes in model (2.1)-(2.7) can be written as

$$Aw = A_l u + A_m v = s \tag{3}$$

$$A_l^T p^2 = \varphi(u) \tag{4}$$

where $(p^2)^T = (p_1^2, \ldots, p_l^2)$ and $\varphi(u)^T = (t_1 u_1 |u_1|, \cdots, t_l u_l |u_l|)$. Note that if (v, p_s, p_d) is a feasible point for the domain of compressor stations of the pipeline, a solution (u, p) for system (3)-(4) determines a distribution of mass flow rates among pipes and pressures at pipeline network nodes, if vector p is between required bounds. As noted by Rios-Mercado et al (2000), finding such (u, p) requires fixing a pressure in one of the nodes. This node is called *reference node* and its value, called *reference pressure*, is denoted by p_{ref}. The subnetwork to which p_{ref} belongs is called *reference subnetwork.*

Consider that there exist m_{SN} SNs associated to the pipeline network ($m_{SN} = 8$ in Fig. 1). Assume that the given mass flow rate $v \in \Re^m$ satisfies the mass flow rate balance and let be A_l^i, A_m^i, u_{SNi}, p_{SNi} and s_{SNi} the node-pipe incidence matrix, the $(n \times m)$ node-station incidence matrix, the mass flow rate at pipes, the pressures at nodes and net mass flow rate at nodes of subnetwork SN_i, $i = 1,\ldots,m_{SN}$, respectively. Form (3)-(4), finding (u_{SNi}, p_{SNi}) feasible for SN_i, is equivalent to solve the system

$$A_l^i u_{SNi} = s_{SNi} - A_m^i v \tag{5}$$

$$(A_l^i)^T p_{SNi}^2 = \phi(u_{SNi}) \tag{6}$$

It is known that, choosing a reference node and fixing p_{ref} (between the known bounds), it can be found (u_{SNi}, p_{SNi}) by using Newton-Raphson method (Wu et al (2000), Iamashita et al (2008) and Paula et al (2011)). Thus a greedy procedure is developed considering bisection applied on bounds pressure interval at reference node. This way are found feasible points (u_{SNi}, p_{SNi}), $p_{SNi} \in [p_{SNi}^L, p_{SNi}^U]$, for i-th SN. Note that, from a greedy point of view, (u_{SNi}, p_{SNi}^U) should be considered to operate the i-th SN, but others points, with $p_{SNi} \in [p_{SNi}^L, p_{SNi}^U)$ could be considered if necessary. The feasible stage, in this way, is formulated.

The minimization cost stage is based on considering that a vector (v, u, p), satisfying (3)-(4), is feasible for model (1.1)-(1.7), if $p_j \in [p_j^L, p_j^U]$, $j = 1,\ldots,n$, and $(v_i, p_i^S, p_i^D) \in D_i$, $i = 1,\ldots,m$, where D_i is the feasible domain of the i-th CS (Paula et al, 2011):

$$D_i = \left\{(v, p_{SD}, p_D) : v = x_1 v_1 + \ldots + x_K v_K, (v_k, p_{SD}, p_D) \in D_k^{unit}, x_k \in \{0,1\}, k = 1,\ldots,K\right\} \tag{7}$$

where $(v_1,\ldots,v_K)$ is a possible partition of the inlet mass flow rate v at the respective CS, among its K not necessarily identical compressors.

See Fig. 2 (Fig. 3), to note that if they are given the suction (discharge) pressure p_S (p_D) and the respective v_{CSj} mass flow rate to be operated at the j-th CS, the point $(v_{CSj}, p_S, p_D) \in D_j$, if $p_D \in [\bar{p}_D^L, \bar{p}_D^U]$ ($p_s \in [\bar{p}_s^L, \bar{p}_s^U]$), where the minimum cost operation is given by $(v_{CSj}, p_S, \bar{p}_D^L)$ ($(v_{CSj}, \bar{p}_S^U, p_D)$). This way, the cost stage determines minimum cost operations at each CS.

3.1 The two stage algorithm

Consider that feasible stage was applied to the i-th actual subnetwork, from a given reference node a given p_{ref}, finding the unique feasible mass flow rate vector u_{SNi} at pipes and the interval of feasible pressures $p_{SNi} \in [p_{SNi}^L, p_{SNi}^U]$ at subnetwork nodes. Some nodes of this subnetwork are incidents to some CSs, connecting it to other subnetworks. Choose one of these nodes, say node j, with $p_j \in [(p_{SNi}^L)_j, (p_{SNi}^U)_j]$, which is a suction (discharge) node for another subnetwork, say through k-th CS, where is given the mass flow rate v_{CSk}. Then, the minimum cost stage finds the feasible interval $p_D \in I_1 := [\bar{p}_D^L, \bar{p}_D^U]$ ($p_s \in I_1 := [\bar{p}_s^L, \bar{p}_s^U]$), for which $(v_{CSk}, (p_{SNi}^U)_j, p_D) \in D_k$ ($(v_{CSk}, p_S, (p_{SNi}^L)_j) \in D_k$), if $p_D \in I_1$ ($p_s \in I_1$). Note that, the minimum cost stage works greedy, finding the greedy cost solution is given by $(v_{CSk}, (p_{SNi}^U)_j, \bar{p}_D^L)$ ($(v_{CSk}, \bar{p}_S^U, (p_{SNi}^L)_j)$).

The last found interval I_1 corresponds to a discharge (suction) node of the next subnetwork, say node *r*, which have feasible pressure bounds $I_2 := [p_r^L, p_r^U]$, given by the application of feasible stage to the respective subnetwork, with reference node *r*.

Thus, if $I_1 \cap I_2 = [\bar{p}_D^L, \bar{p}_D^U] \cap [p_r^L, p_r^U] = [\bar{p}_r^L, \bar{p}_r^U] \neq \phi$ ($I_1 \cap I_2 = [\bar{p}_s^L, \bar{p}_s^U] \cap [p_r^L, p_r^U] = [\bar{p}_r^L, \bar{p}_r^U] \neq \phi$), then the new greedy cost solution for the *k*-th CS is given by $(v_{CSk}, (p_{SNi}^U)_j, \bar{p}_r^L)$ ($(v_{CSk}, \bar{p}_r^U, (p_{SNi}^L)_j)$), and node *r* can be took as reference node, with $p_{ref} = \bar{p}_r^L$ ($p_{ref} = \bar{p}_r^U$) for the new subnetwork, to find the mass flow rates and pressure nodes for this. Note that as necessary, the value of p_{ref} must be increased (decreased) in $[\bar{p}_r^L, \bar{p}_r^U]$ to get feasibility of mass flow rates and pressure nodes at the new subnetwork.

If, in the other hand, $[\bar{p}_D^L, \bar{p}_D^U] \cap [p_r^L, p_r^U] = \phi$ ($[\bar{p}_s^L, \bar{p}_s^U] \cap [p_r^L, p_r^U] = \phi$), this indicates that the interval $p_D \in [\bar{p}_D^L, \bar{p}_D^U]$ ($p_s \in [\bar{p}_s^L, \bar{p}_s^U]$) found by the greedy pressure $p_j = (p_{SNi}^U)_j$, when the application of the minimum cost stage at *k*-th CS, generates no feasible pressures at node *r* of the next subnetwork. Therefore, it must be chosse another value for p_j, in the application of minimum cost stage at *k*-th CS, such that $(p_{SNi}^L)_j \leq p_j < (p_{SNi}^U)_j$ and the new interval generated to by this stage, $[\bar{p}_D^L, \bar{p}_D^U]$ ($[\bar{p}_s^L, \bar{p}_s^U]$), satisfies $[\bar{p}_D^L, \bar{p}_D^U] \cap [p_r^L, p_r^U] = [\bar{p}_r^L, \bar{p}_r^U] \neq \phi$ ($[\bar{p}_s^L, \bar{p}_s^U] \cap [p_r^L, p_r^U] = [\bar{p}_r^L, \bar{p}_r^U] \neq \phi$).(It may also need a back to previous subnets to achieve feasibility).

Then, as in the above paragraph, could be found mass flow rates and pressure nodes at the new subnetwork. If, at last, there is not exist $(p_{SNi}^L)_j \leq p_j \leq (p_{SNi}^U)_j$, such that the respective $[\bar{p}_D^L, \bar{p}_D^U]$ ($[\bar{p}_s^L, \bar{p}_s^U]$), satisfies $I_1 \cap I_2 \neq \phi$, then the given mass flow rate v, through CSs, is not feasible for the network. The flowchart in Fig. 4 describes the two stage algorithm.

Additional used notation is used: $Seq := \{SN_1, SN_2, ..., SN_T\}$, denotes a given sequence to travel along all the network going from one subnetwork to another through a CS, indicating the respective nodes of suction and discharge; $CS_{i,i+1}$ denotes the CS connecting SN_i and SN_{i+1} (with the known outlet and inlet nodes); FS_1 denotes the feasible stage; FS_2 denotes the minimum cost stage.

4 Numerical results

To test the two stage algorithm, it was used an adaptation of an existing case in the literature (Example 3, Wu et al, 2000), which is shown in Fig. 1. The adaptation consists on considering generalized CSs, formed by five compressors of two types: Type A, formed by the three identical original compressors of the example; Type B, formed by two identical compressors, different of Type A compressors. The correspondent data can be found in Rodrigues (2010).

A summary of results obtained, for $v = (600,1000,1100,850,850,850,650,850)$, can be found in Table 1 and Table 2. The total cost found was 1.042759360812377e+07.

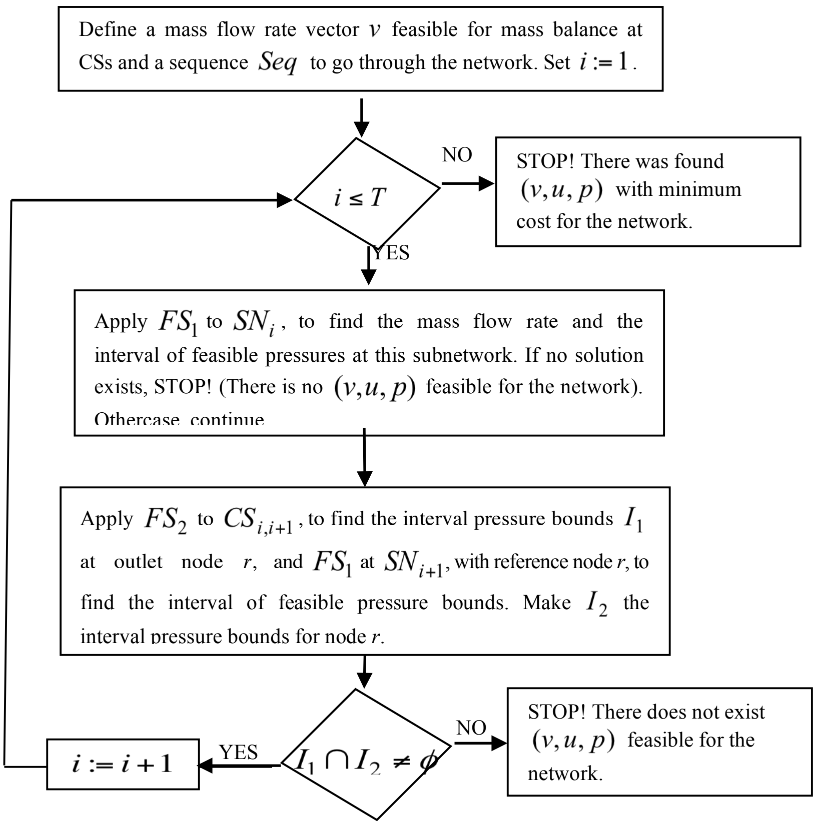

Fig.4 The two stage algorithm to find (u, p) with minimum cost for the network, given v

Table 1
Summary of pipe mass flow rates found for $v = (600,1000,1100,850,850,850,650,850)$

Pipe	*u*	Pipe	*u*	Pipe	*u*	Pipe	*u*
(1,2)	600.0	(17,16)	50.0	(28,29)	140.9	(37,38)	109.1
(3,4)	200.0	(17,18)	729.7	(29,30)	55.7	(38,39)	79.1
(4,7)	400.0	(14,19)	320.3	(30,31)	25.7	(39,40)	49.1
(7,8)	1000.0	(15,19)	100.0	(31,32)	-4.3(*)	(40,41)	19.1
(6,7)	400.0	(19,20)	420.3	(32,33)	-4.3	(41,42)	-10.9
(5,6)	200.0	(18,20)	829.7	(33,44)	-34.3	(43,42)	50.9
(9,11)	200.0	(22,23)	850.0	(29,34)	85.2	(44,43)	95.7
(10,11)	1000.0	(23,24)	650.0	(34,35)	55.2	(45,44)	170.0
(11,12)	1100.0	(25,26)	300.0	(35,36)	25.2	(46,45)	450.0
(13,14)	320.3	(26,27)	50.0	(36,43)	-4.8	(45,47)	180.0
(13,17)	779.7	(26,28)	250.0	(28,37)	109.1		

(*)Negative mass flow rate means flowing in opposite direction that the arbitrarily one given at the respective pipe

5 Final Comments

Many metaheuristic methods work generating feasible solutions that are sequentially improved. This work, addressing to develop metaheuristic methods, introduces a two stage algorithm to find good feasible solutions for the problem of fuel cost minimization of gas pipeline networks. Associated to a distribution of mass flow rates among the pipes and CSs of a pipeline network, with mass balance, there exist different pressure levels to operate the CSs. Thus the strategy to find good feasible solutions consists in to partition the whole network into adjacent subnetworks connected by CSs, each subnetwork without CSs. Then, given a feasible vector of flow rates through the CSs, a feasible stage finds mass flow rates at pipes of an initial subnetwork and the interval ranges of pressure levels at each node associated to the respective pipes, from consider the range of a reference pressure at a given node as much as possible. This way, considering greedy the greater (lower) level at each suction (discharge) node incident to CSs at that subnetwork, a cost minimization stage finds an interval range of pressure level for the other incident node – a discharge (suction) node. If this interval intersects the feasible interval of pressures for the new subnetwork, with the discharge (suction) node as reference, taking the lower (greater) level, a cost minimization solution for the CS is found. Otherwise, the respective suction (discharge) pressure of the CS must be changed, in its interval range pressure, for finding a feasible discharge (suction) pressure for the new subnetwork. Going from one subnetwork to another, the whole network is crossed. This two stage algorithm was codified in Matlab and tested in several literature examples, with very good results.

Table 2
Summary of pressures found for $v = (600,1000,1100,850,850,850,650,850)$

Node	Pressure	Node	Pressure	Node	Pressure	Node	Pressure
1	1242.7	13	1175.3	25	848.2	37	478.7
2	831.4	14	1066.9	26	711.4	38	316.7
3	1150.0	15	958.6	27	708.5	39	180.4
4	1131.4	16	1036.7	28	598.4	40	80.3
5	1312.2	17	1039.5	29	378.2	41	50.0
6	1131.4	18	904.0	30	336.1	42	61.6
7	1042.5	19	946.2	31	325.3	43	170.0
8	920.8	20	690.5	32	325.6	44	324.9
9	932.2	21	731.1	33	325.9	45	417.2
10	1006.5	22	889.8	34	253.7	46	477.2
11	879.9	23	637.0	35	186.6	47	395.9
12	838.9	24	426.3	36	169.3	48	779.5

6 References

Chung, T.S., K.K. Li, K.K.; , Chen, G.J.; Xie, J.D.; G.Q. Tang, G.Q. (2003), Multi-objective transmission network planning by a hybrid GA approach with fuzzy decision analysis. Electrical Power and Energy Systems, 25, 187–192.

Iamashita, E. K.; Galaxe, F.; Arica, J. (2008), A Planning Model for Offshore Natural Gas Transmission. Pesquisa Operacional, v.28, n.1, 29-44 (Janeiro - Abril de 2008).

Paula, C.P.; Arica, J.; Vieira, M.C.B. (2011), Minimização de Custos de Combustível em Transporte de Gás Natural por gasodutos. Anais do XXXI ENEGEP. Belo Horizonte, MG, Brasil.

Ríos-Mercado, R. Z.; Wu, S.; Scott , L. R.; Boyd E. A. (2002) A Reduction Technique for Natural Gas Transmission Network Optimization Problems. Annals of Operations Research, 217-234.

Rodrigues, P. F. C. (2010), Uma Metaheurística GRASP para Minimização do Custo de Combustível no Transporte de Gás Natural por Gasoduto. Masters thesis, Universidade Estadual do Norte Fluminense Darcy Ribeiro, Campos dos Goytacazes, RJ, Brasil.

Woldeyohannes, A.D. and Majid, M.A.A. (2011), Simulation model for natural gas transmission pipeline network system. Simulation Modelling Practice and Theory, Vol. 19, No. 1, 196-212.

Wu, S.; Ríos-Mercado, R. Z.; Boyd E. A.; Scott , L. R. (2000) Model Relaxations for the Fuel Cost Minimization of Steady-State Gas Pipeline Networks. Mathematical and Computer Modelling, 31, 197-220.

On the on-hand stock estimation in a lost sales context and periodic review policy

Guijarro E[1], Babiloni E, Cardós M

Abstract: Traditionally, inventory literature assumes that unfilled demand can be backordered for the next replenishment cycle. However, there are a lot of practical situations where, if an item is out of stock, backordering assumption is not applicable and unfilled demand is lost. The main problem of the lost sales case is the mathematical difficulty of its treatment. This paper focuses on the estimation of on hand stock levels just after the order arrives, i.e. at the beginning of the cycle. On one hand, this paper presents a review of the existing literature on the on hand stock estimation in lost sales case. On the other hand, a new close-form approach to compute the probability vector associated to the on hand stock levels at the beginning of the cycle for periodic review systems and discrete demands is proposed. Numerical results show that our approximation presents low deviations and overcomes other estimation methods**.**

Keywords: on hand stock; lost sales; periodic review; discrete demand.

1 Introduction

There are two possible customer's responses when an item is temporarily out of stock: (i) unfilled demand is backordered and filled as soon as the replenishment order arrives or (ii) unfilled demand is lost. Although there are many real life situations where backordering assumption is not applicable, only a handful of inventory papers study optimal policies for systems with lost sales. This is mainly because backordering models are easier to formulate and simpler to analyze [(Hadley and Whitin 1963), (Zipkin 2008), (Bijvank and Vis 2012)]. However, the assumption of excess demand being lost is of practical importance in sectors such as retailing (Gruen et al. 2002), service sector (Diels and Wiebach 2011) or on-line commerce (Breugelmans et al. 2006).

Recently, lost sales models have received more attention in inventory research and there is a proliferation of publications under this context [(Bijvank and Vis 2011), (Bijvank et al. 2014)]. Lost sales problem was formulated long time ago by (Karlin and Scarf 1958) but it is still very hard to formulate and deal with. In inventory systems the demand is satisfied with the available stock at the beginning of the cycle, i.e. just after the order arrives. At this point, if backordering is assumed, the probability associated to each stock state can be easily computed as the difference between the inventory position at the replenishment moment (which is equal to the base stock, *S*) and the demand during the lead time. However, applying the same reasoning in a lost sales context could lead to negative net stocks, so that finding the on hand stock probability vector becomes a challenge. Therefore, the key question in lost sales models is to know accurately the on hand steady probability vector at the beginning of the cycle ($\overline{P(OH_R)}$) because not only service measures but also performance metrics must be computed based on them.

To the best of our knowledge, only (Cardós et al. 2006) propose an exact expression to compute $\overline{P(OH_R)}$ for lost sales context, periodic review policy and discrete demand. This expression applies only when there is just one outstanding replenishment order at every time, however it is not a close formula what complicates its implementation in practical environments. The main goal of this paper is to propose a new close-form approximation to compute the probability of on hand stock levels for lost sales context

1 **Ester Guijarro** (esguitar@doe.upv.es)
Dpto. de Organización de Empresas.
Universitat Politècnica de València.
Camino de Vera, S/N, 46022 Valencia (Spain).

and periodic review (*R, S*). Furthermore, we present a thorough review of current existing methods and analyze their performance.

The rest of the paper is organized as follows. Section 2 introduces the notation and basic assumptions of this paper. Section 3 describes current methods to compute the on hand stock probability vector and proposes a new approximation. Numerical results are presented in Section 4. Finally, Section 5 highlights the most relevant conclusions of this work and presents further studies.

2 Basic Notation and Assumptions

In general, the periodic review, base stock (*R*, *S*) system places replenishment orders every *R* fixed time periods to raise the inventory position to the base stock *S*. The replenishment order arrives after a constant lead time *L*. Figure 1 shows an example of the evolution of the on hand stock and the inventory position for the lost sales case. Notation used in it and in the rest of the paper is as follows:

S	=	base stock (units),
R	=	review period and replenishment cycle corresponding to the time between two consecutive deliveries (time units),
L	=	lead time for the replenishment order (time units),
OH_t	=	on hand stock in time t from the first reception (units),
IP_t	=	inventory position in time t from the first reception (units),
NS_t	=	net stock in time t from the first reception (units),
D_t	=	accumulated demand during t consecutive periods (units),
$f_t(\cdot)$	=	probability mass function of D_t,
$F_t(\cdot)$	=	cumulative distribution function of D_t,
X^+	=	maximum {X, 0} for any expression X,
$E[X]$	=	expected value of expression X.

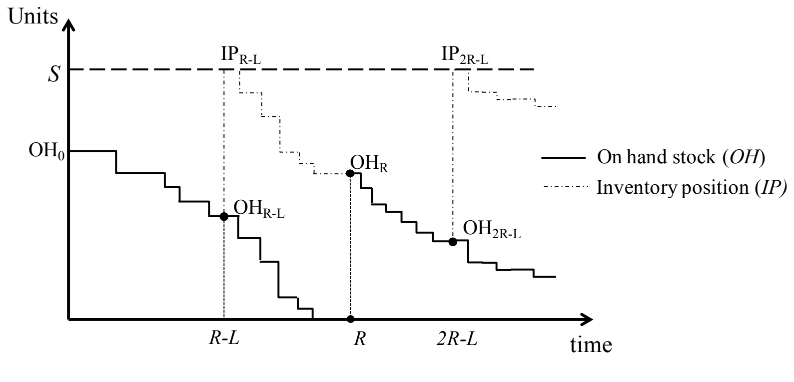

Fig.1
On hand stock and inventory position evolution in a periodic review and lost sales system.

This paper considers the following assumptions: (i) time is discrete and is organized in a numerable and infinite succession of equi-spaced instants; (ii) the lead time, *L*, is known and constant; (iii) the replenishment order is added to the inventory at the end of the period in which it is received, hence these products are available for the next period; (iv) demand during a period is fulfilled with the on hand stock at the beginning of that period; (v) only one outstanding replenishment order is launched within any period, which means that $L<R$, (vi) backordering is not allowed and (vii) demand process is stationary with a known, discrete, and i.i.d. distribution function.

3 Methods to compute the on hand state probability vector at the beginning of the cycle

As known, the on hand stock varies from 0 to S so that if the probability of each stock level were known we could easily compute the fill rate or the cycle service level for that probability. However in a lost sales context, finding the probability associated to each stock value becomes a challenge. In the literature, there are only several papers that deal with it. This section presents these methods and proposes a new approximation.

3.1 Exact calculation

(Cardós, Miralles, & Ros 2006) derive and inductive expression to compute $\overline{P(OH_R)}$, based on modelling the on hand inventory as an ergodic Markov chain with a set of states {0, 1,..., S}. This probability vector is computed by means of calculating the probability transition matrixes of the on hand stock levels between: (i) the beginning of the cycle and the review moment (times 0 and R-L), $\overline{\overline{M_{R-L}}} = \left[m_{ji}\right]$, and (ii) the review and the beginning of the next replenishment cycle (times R-L and R), $\overline{\overline{M_L}} = \left[s_{kj}\right]$.

Hence, $\overline{\overline{M_R}} = \overline{\overline{M_{R-L}}} \cdot \overline{\overline{M_L}}$ is the transition matrix between two consecutive replenishment cycles. Considering the case where the Markov chain is regular, $\lim_{n\to\infty} \overline{\overline{M_R}}^n = \overline{\overline{M}}$ where all rows of $\overline{\overline{M}}$ are the same vector $\bar{v}$, which is the principal left eigenvector and their components are positive, add up to one, and represents the state probabilities of every feasible value of the on hand stock at the beginning of any cycle, i.e. $\bar{v} = \overline{P(OH_R)}$.

Note that the convergence process required to find $\overline{\overline{M}}$ requires a huge computational effort and may be time consuming, mainly for large values of S, which complicates its implementation in practical environments. However it is very useful for reference purposes.

3.2 Non Stock Out Approximation

A close form approximation to compute $\overline{P(OH_R)}$ can be derived based on the assumption that there is no stockout during the lead time. In this case, the stock balance at R can be easily computed as

$$OH_R = \left[OH_{R-L} - D_L\right]^+ + S - OH_{R-L} \approx OH_{R-L} - D_L + S - OH_{R-L} = S - D_L$$

Then, we can define

$$P(OH_R = i) \approx \begin{cases} f_L(S-i) & 0 < i \le S \\ 1 - F_L(S-1) & i = 0 \end{cases} \tag{1}$$

so that the vector of on hand stock probabilities is

$$\overline{P(OH_R)} \approx \left[\left(1 - F_L(S-1)\right) \quad f_L(S-1) \quad \cdots \quad f_L(0) \right] \tag{2}$$

Expression (2) is quite similar to the backlog case, obviously except for the zero stock probability.

3.3 Bijvank and Johansen Approach

(Bijvank and Johansen 2012) study optimal replenishment policies and suggest a close-form expression to approximate the average on hand stock level when demand follows a pure and compound Poisson distribution. To that end, authors develop an approximation to compute $\overline{P(OH_R)}$ as in backordering case but correcting the demand distribution with a factor C_s in order to avoid negative net stocks.

$$P(OH_R = i) \approx \begin{cases} C_S \cdot f_L(S-i) & 0 < i \leq S \\ 1 - C_S \cdot F_L(S) & i = 0 \end{cases} \tag{3}$$

In its derivation, authors assume that L can be any value, but following the assumption of $L<R$, the computation of C_s can be simplified by

$$C_s = \frac{S}{E\left[(S-D_L)^+\right] - E\left[(S-D_{L+R})^+\right] + E\left[(S-D_R)^+\right]} \tag{4}$$

3.4 Proposed Approximation

The Non Stock Out Approximation (Section 2.2) considers an extreme situation in inventory system, which is precisely the most favourable: there are no stock out situations during L, i.e. $OH_{R-L} \geq D_L$. On the contrary, the most unfavourable situation is being always out of stock during the replenishment period, which implies that $OH_{R-L} < D_L$. In this case, the on hand stock just after the order arrives is

$$OH_{R\_OOS} = \left[OH_{R-L} - D_L\right]^+ + S - OH_{R-L} = S - OH_{R-L} \tag{5}$$

where

$$OH_{R-L} = \left[OH_0 - D_{R-L}\right]^+ \tag{6}$$

then we need to know the value of OH_0. It is assumed that: (i) we initialize the system with a stock equal to the base stock, i.e. $OH_0 = S$ and (ii) the on hand stock at the review period is always positive, i.e. $OH_{R-L} > 0$. Under these assumptions

$$OH_{R\_OOS} \approx S - (S - D_{R-L}) = D_{R-L} \tag{7}$$

and therefore the probability vector in an out of stock situation is expressed as

$$\overline{P(OH_R)}_{OOS} \approx \left[f_{R-L}(0) \quad f_{R-L}(i) \quad (1 - F_{R-L}(S-1)) \right] \tag{8}$$

The new close-form approximation proposed in this paper combines both extreme situations, taking into account that the probability of a stock out situation occurs during L can be computed as $F_R(S)$. Then, the proposed approach to compute $\overline{P(OH_R)}$ is

$$\overline{P(OH_R)} \approx F_R(S) \cdot \overline{P(OH_R)}_{NOOS} + (1 - F_R(S)) \cdot \overline{P(OH_R)}_{OOS} \quad (9)$$

where $\overline{P(OH_R)}_{NOOS}$ represents the probability vector when there is no a stock out situation (expression (2)) and $\overline{P(OH_R)}_{OOS}$ the probability vector when the system is always out of stock during L (expression (8)).

4 Numerical results

This section illustrates deviations which arise from using approximations instead of the exact expression for $\overline{P(OH_R)}$ calculation. We assume that demand follows a Poisson distribution with λ = 0.01, 0.1, 0.5, 1, 2, 5 and 10. The inventory policy values considered are: L = 1, 2, 3, 4, 5; R = 5, 7 and S = 5, 7, 9. The total feasible combinations result in 189 cases. We quantify the deviations computing the module of the error vector with the following expression:

$$Deviation = \frac{|e - ap|}{|e|} \quad (10)$$

where e is the exact $\overline{P(OH_R)}$ vector and ap is the approximate vector obtained with the Non Stock Out Approximation vector (*NSO*), (Bijvank and Johansen 2012) approach (*B&J*) and the new approach proposed in this paper (*Prop.Appr.*). Table 1 presents the average and the standard deviation of each approximation for different values of D_{R+L}.

Table 1

Deviation between exact and approximate methods to compute $\overline{P(OH_R)}$

	Average			**Standard deviation**		
	NSO	*B&J*	*Prop.Appr.*	*NSO*	*B&J*	*Prop.Appr.*
[0-0.1]	0.000	0.000	0.000	0.000	0.000	0.000
]0.1-1]	0.000	0.000	0.000	0.000	0.000	0.000
]1-5]	0.059	0.068	0.101	0.084	0.102	0.177
]5-10]	0.421	0.653	0.406	0.273	0.545	0.235
]10-20]	1.098	2.874	0.474	0.352	1.995	0.377
]20-50]	1.485	9.160	0.159	0.371	7.720	0.268
>50	1.420	21.469	0.006	0.094	11.801	0.021
Total	**0.678**	**5.401**	**0.166**	**0.667**	**9.609**	**0.276**

As can be observed, the *B&J* estimation presents the highest average and standard deviations whereas the new approach presented in this paper shows the lowest. If we analyze the results for categories of D_{R+L} we observe that, when demand is low, all the approximations present a good performance. However, for high values of D_{R+L} both the average and the standard deviations of *NSO* and *B&J* are increasingly high.

5 Conclusions

We propose a new perspective to deal with lost sales systems. Most of the papers on inventory control focus on proposing cost models or service metrics in lost sales context, for which they need to know the on hand stock at the beginning of the cycle. However, this work focuses directly on the calculation of the on hand stock and proposes a close formula which can be applied to compute any other inventory metric. We consider periodic review, (R, S) system, and discrete demands.

We observe that when D_{R+L} is low, all approximations present low average and standard deviations corresponding to cases which most of the demand has been fulfilled. However, as numerical results point out, the proposed approximation presents the best performance even for high values of D_{R+L}.

Further researches should focus on analyzing the impact of these approximations when they are used to compute service measures. Furthermore, there is only one exact expression which assumes that $L<R$. One possible extension of this work is to assess the suitability of this proposed approach even when $L \geq R$.

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6 References

Bijvank, M., Huh, W.T., Janakiraman, G., & Kang, W. 2014. Robustness of Order-up-to Policies in Lost-Sales Inventory Systems. Operations Research, 62, (5) 1040-1047

Bijvank, M. & Johansen, S.G. 2012. Periodic review lost-sales inventory models with compound Poisson demand and constant lead times of any length. European Journal of Operational Research, 220, (1) 106-114 available from: ISI:000302448100011

Bijvank, M. & Vis, I.F.A. 2011. Lost-sales inventory theory: A review. European Journal of Operational Research, 215, (1) 1-13

Bijvank, M. & Vis, I.F.A. 2012. Lost-sales inventory systems with a service level criterion. European Journal of Operational Research, 220, (3) 610-618

Breugelmans, E., Campo, K., & Gijsbrechts, E. 2006. Opportunities for active stock-out management in online stores: The impact of the stock-out policy on online stock-out reactions. Journal of Retailing, 82, (3) 215-228

Cardós, M., Miralles, C., & Ros, L. 2006. An exact calculation of the cycle service level in a generalized periodic review system. Journal of the Operational Research Society, 57, (10) 1252-1255 available from: ISI:000241588300012

Diels, J.L. & Wiebach, N. 2011. Customer reactions in Out-of-Stock situations: Do promotion-induced phantom positions alleviate the similarity substitution hypothsis? Berlin, SFB 649 Discussion paper 2011-021.

Gruen, T.W., Corsten, D., & Bharadwaj, S. 2002. Retail Out-of-Stocks: A Worldwide Examination of Extent Causes, Rates and Consumer Responses Washington, D.C., Grocery Manufacturers of America.

Hadley, G. & Whitin, T. 1963. Analysis of Inventory Systems Englewood Cliffs, NJ, Prentice-Hall.

Karlin, S. & Scarf, H. 1958, "Inventory models of the Arrow-Harris-Marschak type with time lag," In Studies in the mathematical theory of inventory and production, Standford, Ca.: Standford University Press.

Zipkin, P. 2008. Old and New Methods for Lost-Sales Inventory Systems. Operations Research, 56, (5) 1256-1263 available from: ISI:000261236800016

Evolution of Term Productivity

Estelles-Miguel S, Andrés Romano C, Albarracín Guillem JM, Palmer Gato ME[1]

Abstract: Increasing productivity means increasing efficiency of labour, that is, both physical and human capital which exist in either a country or a company. One of the commonest ways of measuring efficiency gains is calculating increases in the overall productivity of the factor; that is, the efficiency with which the economy transforms its production factors into goods. As discussed in this paper, the productivity concept has evolved over time and has incorporated new concepts into its definition, while new ways to measure it have appeared.

Keywords: Productivity, Measuring productivity, Effectiveness, Efficiency.

1 Introduction

Productivity is defined as the efficiency of a production system: i.e., the ratio between productive system output and the amount of inputs used. So in a production system, there are as many productivity levels as there are resources. The equation becomes very complex when several input measurements or indices exist, and subjective weightings are often required. This is where the seemingly simple definition of output based on input becomes complex and confusing (Smith, 2001).

The importance of productivity is recognised internationally due to the changes in it being manifested in a country's living conditions, essentially as a large number of economic and social phenomena. It is fundamental to understand the importance of a country´s productivity because productivity affects inflation, living standards, employment, and so forth (Sumanth, 1999).

In the present-day, job destruction and an unprecedentedly high unemployment rate exist in the Spanish economy. Despite signs of recovery in productivity, Spain´s progress in this area is slow and static.

In this context, if the factors that affect productivity are correctly measured and identified, the likelihood of successfully analysing these factors, diagnosing the conditions of a company´s productivity, and fundamentally knowing which actions should be undertaken to improve productivity, will be greater.

This paper comprehensively reviews existing literature on productivity to define potential future research. This article is organised as follows: Section 2 offers a thorough review of productivity-related literature and various types of measurement in the literature. Section 3 provides the main conclusions. This paper forms part of a more comprehensive study carried out by the same authors.

2 Productivity Literature Review

In an environment characterised by strong competition, technological change, globalisation, market deregulation and fragmentation of demand, productivity has emerged as one of the main factors that contributes to determine competitiveness. Although the productivity concept is lengthily discussed by politicians, economists, managers and the media, it is often vaguely defined and poorly understood. In practice, lack of this knowledge results in productivity being ignored by those who influence production processes (Tangen, 2002).

1 **Sofía Estellés Miguel** (soesmi@omp.upv.es)
Carlos Andrés Romano (candres@omp.upv.es)
José Miguel Albarracín Guillem (jmalbarr@omp.upv.es)
Marta Elena Palmer Gato (marpalga@doe.upv.es)
Dpto. de Organización de Empresas. Universitat Politècnica de València.
Edificio 7D, Camino de Vera S/N, 46022 Valencia.

Table 1
Evolution of the productivity concept.
Source: The Authors

Author (year)	Definition, Measurement of the Method to Increase it
Quesnay (1766)	The productivity concept appeared for the first time.
Smith (1776)	Indicates only increasing in two ways: • Improving useful work. • Increasing the amount of work.
Marx (1867)	Indicates the factors that influence it: • The average worker´s level of skills. • State of development in science and its technological applications. • Social coordination of the production process. • Scale and effectiveness of production means. • Natural conditions.
Littré (1883)	Productivity as "the faculty to produce".
Weintraub (1937)	Develops measures of work productivity in manufacturing companies.
Timbergen (1940)	Productivity as "the ratio between real output and the use of real factor or inputs".
OEEC (1950)[1]	Productivity as the ratio obtained by dividing production by one of the production factors.
ILO (1951)	Total productivity as an average that remains unaltered when each individual productivity remains unaltered.
Siegel (1953)	Productivity as the ratio between inputs and products associated with productive activities, both measured in real terms.

[1]Taken from Sumanth (1999).

Table 1
Evolution of the productivity concept.
Source: The Authors (continued)

Davis (1955)	Productivity as the change in the product obtained from spent resources.
Solow (1957)	Incorporates "residual" into the productivity measure.
Japan Productivity Centre (1958)[2]	Productivity is what man can accomplish with materials, capital and technology. Productivity is mainly an issue of personal manner. It is an attitude that we must continuously improve ourselves, and the things around us.
Fabricant (1959)	Productivity as the ratio between production and input.
Denison (1962)	Introduces quality of the work done as part of the productivity concept.
Kendrick & Creamer (1965)	Functional definitions have been made for partial productivity, total factor productivity and total productivity.
Klein (1965)	Defines productivity as the technical aspect of exploiting resources, claimed that its tendency decides a company´s future.
Farag (1967)	Includes the input-output relationship in the measure of a company´s productivity.
Wolf (1969)	The concept of productivity is understood through the terms of function of production that specify the possibility to substitute between capital and work and other inputs.
ILO (1969)	Productivity is the ratio between output and the total input or factors required to produce output, and refers to productivity as total factor productivity.
Correa (1970)	Measures productivity by dividing total production by the value of inputs used.
Yoshihara et al (1971)	Analyses the repercussions of changes in productivity on the price index.
Elliot-Jones (1972)	Incorporates the input-output relationship in the companies´ productivity measurement.
Hernández-Laos (1973)	Productivity as the quantity of output obtained per unit of factor/factors used to achieve it, measured in physical terms.

Siegel (1976)	Revises its earlier definitions, defining productivity as the relationship between the quantity of goods produced and the quantity of resources used in production, and as the family of ratios between production and input.
Mundel (1976)	Develops indices of productivity for companies.
Gold (1976)	Proposes the focus of financial ratios in the productivity measurement
Taylor & Devis (1977)	Proposes a model to measure total factor productivity.
Hershauer & Ruch (1978)	Proposes a servosystem model for worker productivity and claims that productivity relates input to output by a conversion process.
Stewart (1978)	Defines productivity as the ratio of performance to organisational targets among the total input parameters and incorporates the utility concept to measure manufacturing productivity.
Agarwal (1979)	Proposes a compound index of productivity based on four financial ratios.

Table 1
Evolution of the productivity concept.
Source: The Authors (continued)

Denison (1979)	Defines productivity as the efficiency of products through resources used.
Sumanth (1979)	Total productivity as the ratio of tangible production divided by tangible inputs.
Adam et al. (1981)	An indirect form of measuring productivity is to determine and analyse "unit" costs.
Kurosawa (1983)	Productivity as the outcome of the complex social process, consisting of science, research and development, education, technology, business management, production methods and workers organisations.
Novelo (1985)	Defines productivity as the human phenomenon determined by three factors and one outcome: aptitudes and attitudes of man; efforts invested in work; evolution of the input-output relationship; quality of work and labour.
Prokopenko (1987)	Productivity as the relationship between the production yielded by a production or services system and the resources used to obtain this production.
Chew (1988)	Productivity is the ratio between units of outputs and units of inputs.
Sink & Tuttle (1989)	Productivity is the ratio between actual output and expected resources used.
Fisher (1990)	Productivity is the ratio between total income and cost plus goal profit.
Aspén et al. (1991)[2]	Productivity is the ratio between added value and input of production factors.
Hill (1993)	Productivity is defined as the ratio of what is produced to what is required to produce it. Productivity measures the relationship between output such as goods and services produced, and inputs including labour, capital, material and other resources.
Grossman (1993)	"Companies need to realise that gains in productivity are one of their major weapons to achieve cost and quality advantages over their competition.
Thurow (1993)	Productivity (output per hour of work) is the central long-run factor to determine any population´s average living.
Koss and Lewis (1993)	Productivity is the quality or state of bringing forth, of generating, of causing to exist, of yielding large results or yielding abundantly.
Mercado (1997)	Productivity as the final output of effort and the combination of all the human, material and financial resources that make up the company.
Bernolak (1997)	Productivity means how much and how well we produce with the resources used. If we produce more or better goods from the same resources, we increase productivity. If we produce the same goods from lesser resources, we also increase productivity. By "resources", we mean all human and physical resources, i.e., people who produce goods or provide services, and the assets with which the people can produce goods or provide services.

Kaplan & Cooper (1998)	Productivity is a comparison of the physical inputs to a factory with the physical outputs from the factory.

[2] Taken from Tangen (2005)

Table 1
Evolution of the productivity concept.
Source: The Authors (continued)

Jackson & Peterson (1999)	Productivity is the product of efficiency by effectiveness and, at the same time, is equal to value adding time divided by quality.
Al-Darrab (2000)	Productivity is the product of efficiency by utilising quality and, at the same time, is equal to the output divided by input, and all multiplied by quality.
Smith (2001)	Productivity generally expresses the relationship between the quantity of goods and services produced (output) and the quantity of labour, capital, land, energy and other resources used to produce it (input).
Moseng & Rolstadås (2001)	Productivity is the ability to satisfy the market´s need for goods and services with minimum total resource consumption.
Asian Productivity Organization (2006)	Productivity is the belief in human progress. It is a state of mind that aims at perpetual improvement. It is ceaseless effort to apply new technology and new methods for the welfare and happiness of humankind.
Lucey (2007)	Productivity is an expression of how efficiently goods and services are being produced. Productivity is, therefore, expressed in physical or economic units, in quantities or in values (money).
Trade Unionists (2008)	Productivity is a process of continuous improvement in the production/supply of quality output/service through efficient, effective use of inputs, with emphasis placed on teamwork for the betterment of all.
European Productivity Agency (2008)	Productivity is an attitude that seeks the continuous improvement of what exists. It is a conviction that one can do better today than yesterday, and that tomorrow will be better than today. Furthermore, it requires constant efforts to adapt economic activities to ever-changing conditions, and the application of new theories and new methods.
Roger (1998) &Russell & Taylor (2009)	Productivity is the ratio of output to input for a specific production situation. Rising productivity implies either more output being produced with the same amount of inputs, or that fewer inputs are required to produce the same level of output.
Chinda (2010)	Productivity is the ratio of outputs to inputs. To improve this ratio, the organisation must implement processes of continuous improvement.
Makris et al. (2014)	Productivity is a measure of manufacturing system or process output per unit of input, over a specific period, used as a metric of production and engineering efficiency.

3 Conclusions

A relatively simple literature review has suggested that (Tangen, 2005):

- Those who use the term productivity rarely define it.
- There is lack of awareness of the multiple interpretations of the term, as well as the consequences to which this discrepancy leads.
- There are both verbal and mathematical definitions and approaches.

Ghobadian and Husband (1990) suggested that, within the similar definitions, there are three broad categorisations:

- The technological concept: the relationship between ratios of output to the inputs used in its production.
- The engineering concept: the relationship between the actual and potential output of a process.
- The economist concept: efficiency of resource allocation.

It is understandable that productivity integrates different variables, such as people, technology, machinery, resources used to produce goods and services, that benefit all the parties involved in the process, i.e., productivity is a multidimensional term, the meaning of which can vary depending on the context within which it is used. From the analysis done herein, we conclude that the definition of productivity has varied over time since it first appeared in 1766, and it has adapted to the times, while different meanings have been included in it. Productivity is seen as one of the most vital factors to affect a manufacturing company´s or a country's competitiveness, which is sometimes neglected or ignored.

Improving productivity is a key issue to survival and success in the long run. However, the authors hope that this paper has illustrated that there is a shared understanding of the basic features that characterise this term.

4 References

Adam, E.E., Hershauer, J.C. & Ruch, W.A. (1981). Productivity and Quality Measurement as a Basis for Improvement. Englewood Cliffs, N.J. Prentice-Hall.

Agarwal, N.C. (1979). Research Notes: On the Interchangeability of Size Measures. Academy of Management Journal, Vol. 22, Nº2, pp. 404-409

Al-Darrab, I. (2000). Relationships between productivity, efficiency, utilisation, and quality, Work Study, Vol. 49, Nº3, pp. 97-103.

Asian Productivity Organization (2006). Productivity Measurement. APO News, Tokyo, Japon. Vol 37, Nº5, pp. 1-8.

Logistics structure and Competitiveness: evidence across countries

Carvalho HD[1], Fonseca HT[2], Alvarenga DC[3], Vieira TA[4], Alvarenga CP[5]

Abstract: The importance of logistics structure to economies is becoming increasingly significant and in order to support the economic growth based on exports, governments have sought to constantly improve the quality of logistics infrastructure of their countries, ensuring and promoting competitiveness of its production internationally. The consensus is that the logistics structure forms a vital link in the entire chain of trade, contributing to the international competitiveness of a country. This study aims to characterize the country as its logistics structure and relationship of this result to the promotion of competitiveness for them by relevance participation in world trade. To reach that goal the methodological procedure was performed a literature search and analysis of secondary data. Initially, through the identification and validation of data for countries and hence the application of multivariate data analysis methods to measure dimensions that allow such classification, planning, and especially the identification of dimensions of logistics infrastructure components in terms of promotion competitiveness.

Keywords: logistics structure, multivariate data analysis, competitiveness.

1 Introduction

The logistical structure of a country, by its potential productivity generation and competitiveness generated to industries by itself, may be responsible for supporting existing competitive advantages and even the improvement of trade, internal and external, given its capability to influence on the time and transportation costs.

The importance of logistics structure for national economies is becoming increasingly significant (Cullinane et al., 2005) and in order to support economic growth, governments have sought to constantly improve the quality of logistics infrastructure their countries, ensure and promote the competitiveness of its production internationally. The consensus is that the logistics infrastructure forms a vital link in the entire chain of trade, contributing to the international competitiveness of a country (TONGZON, 1989; CHIN; TONGZON, 1998).

The continuous measurement of the logistical structure and its consequent contribution in generating efficiency and productivity in terms of global exchange is very important in improving the understanding of the logistics factor contributions to the economic growth.

In this context, this paper aims to categorize countries given its logistical structure and relate this result to its respectively competitiveness promotion terms by share in world trade. Initially, through the identification and validation of countries data and, consequently, by the application of multivariate analysis methods to measure items that allow such classification, rating and, especially, to identify the items of the logistical structure components in terms of competitiveness promotion.

2 Methodology

For data analysis, Principal Component Analysis (PCA) and Cluster Analysis multivariate methods were used. PCA reduces the number of observed variables to a smaller number of principal components which

1 **Henrique Duarte Carvalho** (henrique.carvalho@funcesi.br)
2 **Henrique Terra Fonseca** (ht_fonseca@yahoo.com.br)
3 **Débora Camilo de Alvarenga** (deboracamiloalvarenga@gmail.com)
4 **Tancredo Augusto Vieira** (tancredo.vieira@funcesi.br)
5 **Cristiano Penido de alvarenga** (cristiano.alvarenga@funcesi.br)
FUNCESI. Rua Venâncio Augusto Gomes, 50, Itabira/MG.
CEP:35900-842. Brazil | www.funcesi.br

account for most of the variance of the observed variables. The total amount of variance in PCA is equal to the number of observed variables being analyzed. In PCA, observed variables are standardized, e.g., mean=0, standard deviation=1, diagonals of the matrix are equal to 1. The first principal component identified accounts for most of the variance in the data. The second component identified accounts for the second largest amount of variance in the data and is uncorrelated with the first principal component and so on. Components accounting for maximal variance are retained while other components accounting for a trivial amount of variance are not retained. Eigenvalues indicate the amount of variance explained by each component. Eigenvectors are the weights used to calculate components scores.

Data were collected in the IBGE, IPEADATA, Brazil Central Bank, Penn World Table, World Economic Forum and World Bank websites. Database references to the 2011 year given the availability of 109 countries data. Table 1 presents the selected variables, as well as categories (logistics and economics variables) and abbreviation of each variable.

Table 1
Analysis variables.

Categories	Variables	Abbreviation
Logistics Variables	Merchant Marine (total ships with 1.000 GRT or over)	MM
	Motor vehicles (per 1,000 people)	MV
	Cost to export (US$ per conteiner)	CE
	Railways density (km of road per 100 sq. km of land area)	RD
	Road density (km of road per 100 sq. km of land area)	ROD
	Waterways density (km of road per 100 sq. km of land area)	WD
	Paved Roads (% of total roads)	EP
	Airports density (paved and not paved per 100 sq. km of land area)	AD
	Pump price for diesel fuel (US$ per liter)	CDIESEL
	Pump price for gasoline (US$ per liter)	CGASOL
Economics Variables	Global Competitiveness Index	GCI
	Trade (% do GDP)	TRD
	GDP (current US$)	PIB

3 Results

The Principal Components Analysis were kept the first four components (with Eigenvalues> 1), which represent 72.4% of total variance. The result is presented in Table 2. The values shown in columns are coefficients of the main components related to each of the variables presented. The Eigenvalues represent the variance of each principal component of all variables.

Table 2
Total vector of the coordinates - Analysis of the principal components.

Variables	PC1	PC2	PC3	PC4
Merchant Marine	0.004	0.086	**0.558**	0.004
Motor vehicles	**0.547**	0.125	-0.088	**0.508**
Cost to export	-0.010	-0.099	**-0.533**	-0.028
Paved Roads	**0.504**	0.100	-0.066	0.030
Road density	**0.558**	-0.087	0.032	0.012
Railways density	0.365	**0.698**	-0.117	0.010
Waterways density	0.028	-0.040	**0.614**	0.017
Airports density	0.002	**0.678**	-0.033	-0.024
Diesel Cost	0.024	0.026	0.012	**-0.615**
Gasoline Cost	0.019	0.020	0.011	**-0.601**
Eigenvalues	**1.939**	**1.163**	**1.042**	**1.021**
Variance %	**37.60%**	**13.50%**	**10.90%**	**10.40%**
Cumulative variance %	**37.60%**	**51.10%**	**62.00%**	**72.40%**

By observing the most relevant variables for each component, highlighted in bold in Table 2, you can name the analysis groups as the most significant variables for each. Table 3 shows the groups already been named according to the information of the estimated components.

In order to sort the countries according to analysis variables, Table 4 presents the top ten countries ranked as a result of index estimated based on principal component analysis, taking into account the obtained factor loadings and standardized data for countries, as well as the classification of Brazil and Portugal in each category.

Table 3
Analysis groups according to estimated components.

Components	Groups
PC1	Roads and Vehicles
PC2	Railways and Airports
PC3	Waterways, merchant marine and cost to export
PC4	Cost of fuel and potential consumption by the fleet

Table 4
Ranking of the estimated index for countries - Top Ten, Brazil and Portugal.

Ranking	Roads and Vehicles	Railways and Airports	Waterways, merchant marine and cost to export	Cost of fuel and potential consumption by the fleet
1	Belgium	Singapore	Panama	Kuwait
2	Luxembourg	Germany	Netherlands	Qatar
3	Netherlands	Czech Republic	Vietnam	Bahrain
4	Germany	Switzerland	China	Saudi Arabia
5	Switzerland	Luxembourg	Belgium	Venezuela, RB
6	Czech Republic	Belgium	Indonesia	Iran, Islamic Rep.
7	Singapore	United Kingdom	Malaysia	Iraq
8	Italy	Denmark	Cambodia	Oman
9	Slovenia	Israel	Singapore	United States
10	France	Slovak Republic	Philippines	Malaysia
Brazil	***84***[a]	***86***[a]	***77***[a]	***33***[a]
Portugal	***25***[a]	***28***[a]	***48***[a]	***89***[a]

From the scores obtained by principal component analysis, it was possible to perform a sorting analysis through cluster analysis. The purpose of this analysis is to identify clusters of countries with common characteristics when grouped by the estimated components, as seen above, were determined according to coefficients presented in Table 2 and classified as outlined in Table 3. For the Cluster Analysis solution was used Ward method and Euclidean distance. The representation dendrogram obtained by applying the method to those obtained indices is shown in Figure 1.

With this result countries were divided into four analysis groups, by the dendrogram you can view the division into four groups is very well defined, involving countries by common characteristics, and generating groups containing 25, 21, 24 and 39 countries respectively. To facilitate the visualization of the groups and their characteristics, Table 5 shows the composition of the groups, with the countries belonging to each, and the mean values found for each classification context.

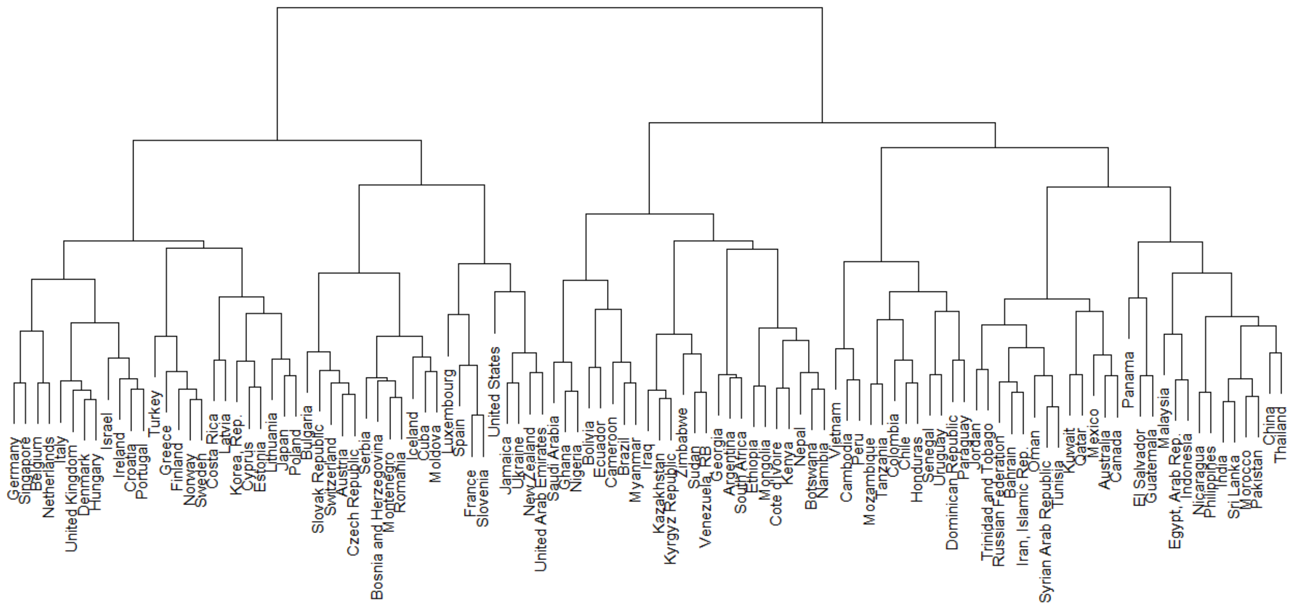

Fig.1
Hierarchical Cluster for countries as a result of factor loadings obtained in the principal component analysis.

By observing the conditions for the cluster of countries, can be interpreted common features revealed by the average of the calculated rates. For the first group, a composition observed most notably is the representation of South America, Africa and the Middle East countries.

Among the member countries of this first group it´s possible to view some competitive advantage in terms of logistics infrastructure through the cost of fuel and/or the density of the fleet, however the absence of structural potential associated with other modes of transport also indicate countries with a concentration of the flow of production in a single modal, in this case we observe the predominance of road transport over the others, certainly with greater vascularization and density than the others.

For group 2 it can be seen that, despite the homogeneity observed for results of the indices, the group performs very heterogeneous in the composition of countries, with representatives from all regions considered in this paper.

Most of countries members in the third group are European representatives, with an emphasis on the United States and the United Arab Emirates as members. The third group members have a lower density of waterways in their territory, a merchant marine less expressive and/or lack of competitiveness in the cost to export. The fourth group analyzed is predominantly European, with the inclusion of countries representing Asia such as Japan, South Korea and Singapore. The fourth group has a lower average observed for the potential consumption of the fleet and/or a little competitive fuel costs. However, the fourth group have better structural conditions observed for its waterways, merchant marine and/or presenting competitiveness in costs to export compared to the third group.

Table 5
Cluster results and respective averages for each topic.

G	Countries	Roads and Vehicles	Railways and Airports	Waterways, merchant marine and cost to export	Cost of fuel and potential consumption by the fleet
1	Argentina, Bolivia, Botswana, Brazil, Cameroon, Cote d'Ivoire, Ecuador, Ethiopia, Georgia, Ghana, Iraq, Kazakhstan, Kenya, Kyrgyz Republic, Mongolia, Myanmar, Namibia, Nepal, Nigeria, Saudi Arabia, South Africa, Sudan, Venezuela and Zimbabwe	22,17	18,54	27,00	76,13
2	Australia, Bahrain, Cambodia, Canada, Chile, China, Colombia, Dominican Republic, Egypt, El Salvador, Guatemala, Honduras, India, Indonesia, Iran, Jordan, Kuwait, Malaysia, Mexico, Morocco, Mozambique, Nicaragua, Oman, Pakistan, Panama, Paraguay, Peru, Philippines, Qatar, Russian Federation, Senegal, Sri Lanka, Syrian Arab Republic, Tanzania, Thailand, Trinidad and Tobago, Tunisia, Uruguay and Vietnam	40,67	42,82	69,64	67,23
3	Austria, Bosnia and Herzegovina, Bulgaria, Cuba, Czech Republic, France, Iceland, Jamaica, Luxembourg, Moldova, Montenegro, New Zealand, Romania, Serbia, Slovak Republic, Slovenia, Spain, Switzerland, Ukraine, United Arab Emirates and United States	82,19	83,48	28,52	50,05
4	Belgium, Costa Rica, Croatia, Cyprus, Denmark, Estonia, Finland, Germany, Greece, Hungary, Ireland, Israel, Italy, Japan, Korea, Rep., Latvia, Lithuania, Netherlands, Norway, Poland, Portugal, Singapore, Sweden, Turkey and United Kingdom	86,04	85,08	81,28	23,16

The third and fourth group highlighted countries that have representative indices for more than one component, this result refers to the distribution of logistics structure in these countries in more than one transport modal, where besides the quality associated with the conditions necessary for road transport, indicate better distribution of railways and airports, and in some cases, such as members of the fourth group, associated to a larger waterway structure.

In order to verify these conditions, an indicator was designed considering the position observed for each country, for each of the four components estimated. Intuitively, it was possible to find a general ranking for countries, called here only as a general logistics structure index.

The graphs in Figures 2 and 3 show the relationship of general logistics structure index with Trade and the Global Competitiveness Index. In both cases we observe a positive association between the variables, which could indicate that countries with better conditions observed for their logistics structures tend to have better results in terms of trade, measured by the representativeness of the corresponding GDP to the total value of trade realized by the country, as well as better conditions of competitiveness, measured by the global competitiveness index. The value of the correlation coefficient is respectively 0.57 and 0.68 for the total value of trade and global competitiveness index.

By quadrants of the graphics is also possible to categorize countries according to the variables considered, the highest incidence of the countries in lower left and upper right quadrants contribute to the view that the logistics structure is positively correlated with its trade and competitiveness results.

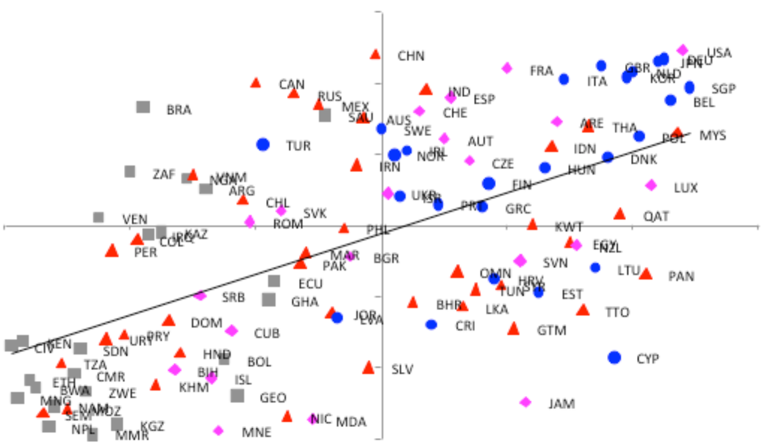

Fig.1 General Logistics Structure (Horizontal Axis) and Trade (Vertical Axis)
Members of (results of Table 5):■ Group1▲Group2 ◆Group3 ● Group 4.
Source: Trade and GCI obtained from World Bank – Countries abbreviations[4]

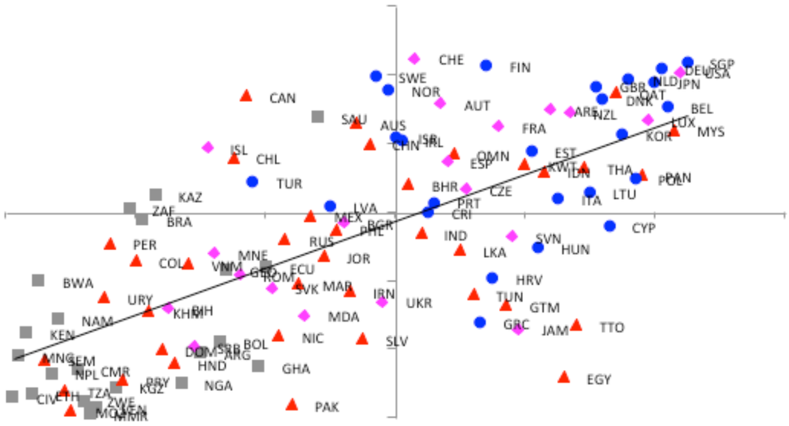

Fig.2 General Logistics Structure (Horizontal Axis e Competitiveness (Vertical Axis)[6]
Members of (results of Table 5): ■ Group1 ▲ Group2 ◆ Group3 ● Group 4
Source: Trade and GCI obtained from World Bank - Countries abbreviations[7]

4 Conclusion

In the approach used in this paper for index construction, two multivariate data analysis techniques were used, the Cluster Analysis and Principal Component Analysis. In many cases it may be interesting to take advantage of the highly descriptive power of these two techniques to interpret the resulting index.

In general, it can be highlighted the logistics structure and the combination of modals in the flow of production and territory interconnection of European countries, as well as noted great potential associated with the cost of fuel for Middle Eastern countries and low cost for export of Asian countries. In the division by clusters was possible to identify structural factors that promote integration in the use of transportation modals mainly by countries with better logistics structures.

Best logistics structure conditions and factors that allow the integration of transport modals, strongly contribute to reduce the logistics costs throughout the supply chain. In order to verify this relationship, it was observed that the conditions of the logistical structure, associated with its use in an integrated manner, can promote commercial and productive competitiveness for countries.

The graphical analysis enabled visualization of a positive association between competitiveness and trade variables with the logistic structure of countries, this result confirms the hypothesis proposed by this paper and encourages further research in order to investigate beyond the relations between these variables, such the identification of determinant factors and causal relationships between them.

[6] Countries such as Iraq, Syria, Sudan and Cuba were not included in this graph because the World Bank does not calculate the Global Competitiveness Index for these countries.

[7] Argentina (ARG), Australia (AUS), Austria (AUT), Bahrain (BHR), Belgium (BEL), Bolivia (BOL), Bosnia and Herzegovina (BIH), Botswana (BWA), Brazil (BRA), Bulgaria (BGR), Cambodia (KHM), Cameroon (CMR), Canada (CAN), Chile (CHL), China (CHN), Colombia (COL), Costa Rica (CRI), Cote d'Ivoire (CIV), Croatia (HRV), Cuba (CUB), Cyprus (CYP), Czech Republic (CZE), Denmark (DNK), Dominican Republic (DOM), Ecuador (ECU), Egypt, Arab Rep. (EGY), El Salvador (SLV), Estonia (EST), Ethiopia (ETH), Finland (FIN), France (FRA), Georgia (GEO), Germany (DEU), Ghana (GHA), Greece (GRC), Guatemala (GTM), Honduras (HND), Hungary (HUN), Iceland (ISL), India (IND), Indonesia (IDN), Iran, Islamic Rep. (IRN), Iraq (IRQ), Ireland (IRL), Israel (ISR), Italy (ITA), Jamaica (JAM), Japan (JPN), Jordan (JOR), Kazakhstan (KAZ), Kenya (KEN), Korea, Rep. (KOR), Kuwait (KWT), Kyrgyz Republic (KGZ), Latvia (LVA), Lithuania (LTU), Luxembourg (LUX), Malaysia (MYS), Mexico (MEX), Moldova (MDA), Mongolia (MNG), Montenegro (MNE), Morocco (MAR), Mozambique (MOZ), Myanmar (MMR), Namibia (NAM), Nepal (NPL), Netherlands (NLD), New Zealand (NZL), Nicaragua (NIC), Nigeria (NGA), Norway (NOR), Oman (OMN), Pakistan (PAK), Panama (PAN), Paraguay (PRY), Peru (PER), Philippines (PHL), Poland (POL), Portugal (PRT), Qatar (QAT), Romania (ROM), Russian Federation (RUS), Saudi Arabia (SAU), Senegal (SEM), Serbia (SRB), Singapore (SGP), Slovak Republic (SVK), Slovenia (SVN), South Africa (ZAF), Spain (ESP), Sri Lanka (LKA), Sudan (SDN), Sweden (SWE), Switzerland (CHE), Syrian Arab Republic (SYR), Tanzania (TZA), Thailand (THA), Trinidad and Tobago (TTO), Tunisia (TUN), Turkey (TUR), Ukraine (UKR), United Arab Emirates (ARE), United Kingdom (GBR), United States (USA), Uruguay (URY), Venezuela, RB (VEN), Vietnam (VNM) and Zimbabwe (ZWE).

5 References

CHIN A, TONGZON J (1998) Maintaining Singapore as a major shipping and air transport hub. In: Toh, T. (Ed.), Competitiveness of the Singapore Economy. Singapore: Singapore University Press, p. 83-114.

CULLINANE K, SONG D, WANG T (2005) The application of mathematical programming approaches to estimating container port production efficiency. Journal of Productivity Analysis, v. 24, p. 73-92.

JOHNSON RA, WICHERN DW (1992) Applied Multivariate Statistical Analysis.Prentice-Hall, Inc., A Simon & Schuster Company Upper Saddle River, New Jersey.

TONGZON J (2008) The impact of wharfage costs on Victoria's export-oriented industries. Economic Papers, v. 8, p. 58-64, 1989.

WORLD BANK. World development report 2009: reshaping economic geography. Washington, DC.

Reduction Lead time Production – CASE STUDY OF THE SOUND COMPANY

Antonio W[1], Tainã R[2], Baia B[3], Teixeira I[4]

Abstract: This paper presents a proposal for improving the Production lead time in the company of the Automotive sound branch, Sound. After general analysis of the factory floor, were found points delaying production. The company aims to reduce the production time in the short and medium term of their projects. It was observed in this company that the adoption of 5S program especially in inventory management, positive impact in handling operations, storage and personnel, as it leads to optimization of resources and greater motivation to reviewers by the possibility of direct participation and the well-be due to the more clean and organized work environment.

Keywords: *Lead time*, program 5’s, project, reduction.

1 Introduction

This work is justified as a way to relate the theoretical foundations raised with the practice experienced on the shop floor, enabling the development of a theoretical study / practical, but also the improvement solutions for reducing lead times of product analyzed.

Currently, changes in the global market have as amended prices and consumer insight increasing its requirements regarding the production and adding value to its products and services from the beginning of the chain until the end of this, with the final delivery. The great competitiveness in the market requires companies to offer differential seeking to meet the needs of customers with the right product at the right time and the right place, offering quality products, fair price and excellent service (Slack 2009).

Lead Time is the period between the customer requests an order and delivery of the final product. A small order of a pre-existing item can only have a few hours of *lead time*, but a larger custom order parts may have a lead team weeks, months or even more. It all depends on a number of factors and the lead time can change according to seasons, holidays or product demand. (Pollick, 2010). As the *lead time* and a measure of time, it is related to flow of the production process to answer the customer's request, that is, the shorter production for the finished product, the lower the system costs and greater satisfaction customer (Tubino, 2009).

2 Company and Problem

The Sound, located in Brazil, state of Pará, currently characterized as a corporation whose corporate name is Electronics Leal. LTDA. It is installed on a plot of 800 m2. The fair Electronics's product mix consists of electronic parts in general, Accessories, films and projects of automotive sounds. The services provided in company facilities are sound and security in automobiles and furniture equipment. The company's mission is to offer the best differentiated products and services in the automotive sector, with technological innovation and quality that meet or exceed the expectations of our customers.

1 **Wilson Antonio Ferreira Costa** (wilsontonio3@gmail.com)
2 **Roberta Tainã Campos Soares** (robertat_soares@hotmail.com)
3 **Bruna Baia da Cunha** (brunabaiacunha@gmail.com)
University Estácio Belém- IESAM.
Gov. José Malcher, 1148 - Nazaré, Belém – PA, Brazil.
4 **Ivete Teixeira da Silva** (sivete@gmail.com)
Coordinator of the course of production engineering
at the University Estácio Belém – IESAM.
Gov. José Malcher, 1148 - Nazaré, Belém – PA, Brazil.

Second Sight, In reference serve the automotive aftermarket in Pará, finding solutions that successfully meet all customers. Form a company that positively influence the lives of all who participate. Values: Honesty and commitment to its customers; Confidence in interpersonal relationships; Competencies and discipline to perform the services; Humility To recognize mistakes and correct them; Consciousness Not to be negligent in their responsibilities.

The company's after-sales department has received some complaints from customers who rightly question the delay of delivery of projects. The lack of standardization of its processes is clear. When was the last that should be done - but not the way to handle, allowing each employee to perform his task in his own way, and not necessarily the best. As the lead internal team is unknown, the deadline passed to customers are made arbitrarily: Customers who complain most end up being treated preferentially.

3 Methodology

The research is characterized as a case study, as well as exploratory and descriptive. Case study because there will be a thorough study of the phenomenon "the possibility of reducing actions lead time" to take place through the application of diversified data collection techniques that complemented and helped in his exhaustive study.

Data collection will be of primary and secondary sources. Being the primary source the opinions of internal and external customers of the company and literature searches, and the secondary source data of the company. With the analysis of the collected data will be proposed techniques for continuous improvement of Lead time.

Being guided by the PDCA methodology, as (Werkema, 2006), the PDCA cycle is a management method widely used in business, in which is a path to be followed, so that its targets can be achieved successfully. For their use, some tools can be employed to help with resources in the collection, processing and provision of information to conduct the PDCA cycle.

3.1 Program 5's

Known in some organizations as housekeeping, Second Nadia Vanti (1999) the Administration 5S Program was born in Japan in the early 1950s, and was motivated by the need to reorganize at all levels, this country partially destroyed by World War II. In Brazil the program was launched in the early 1990s, as Bertaglia (2003).

The program aims to manage in a participatory manner and improve the working environment providing quality of life, quality of service and ease the implementation of other improvement programs.

For the purposes of 5S is required behavior modification of employees, otherwise they may not be completed. As stated Falconi (2004), The 5S program is not only an episodic event cleaning, but a new way of conducting business with effective productivity gains.

Following will be presented concepts and objectives for each of the five senses:

1. SEIRI- Sense of use: aims to optimize the spaces, the allocation and use furniture, equipment and work materials in general. It is indicated that in the workplace are only organized the necessary and proper layout for effective use.
2. SEITON- organization Sense: aims to sort rationally furniture, equipment, use of materials and documents for easy access and the use of various resources in a coherent layout. Search also define new ways to store consumables and set new production flows.
3. SEISO- cleaning Sense: aims to leave always clean and in good terms to use physical resources, furniture and equipment used.
4. SEIKETSU- standardization Sense: aims to promote good health in relation to physical and mental limitations. Still looking for the standardization of good habits of technical standards and procedures and effective actions.
5. SHITSUKE- Sense of disciplines: aims to create a culture to educate, raise awareness and discipline the employee in order to behavior and habits that motivate continuous improvement through physical, mental, and moral. Search still maintaining the first four senses.

4 Project Results

To determine the effects that does not add value in the projects manufacturing process was initially carried out brainstorming with a team of 10 people, composed of employees and partners of the company. The objective was to identify the potential effects of failure is to subsequently mount the cause and effect diagram.

Were discussed in the brainstorming points of causes involving Mao labor, business environment, machines such method, materials and measurement as shown in the figure 1.

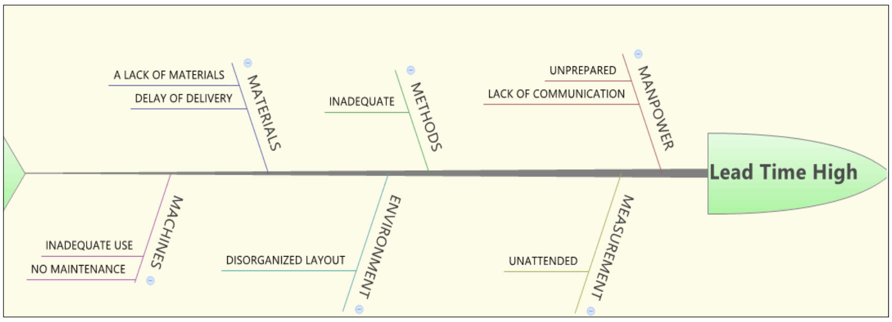

Fig.1
cause and effect diagram.
Source: prepared by the author 2015.

After brainstorming, an analysis of 73 events took place which were scored points that does not add value to the process and therefore generates delayed LEAD TIME as shown in the Pareto diagram below.

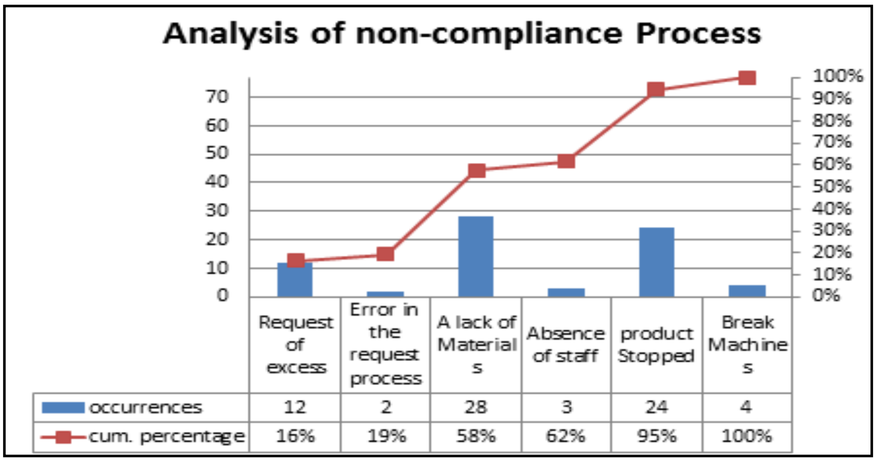

Fig.2
Pareto diagram.
Source: prepared by the author 2015.

After analyzing the Pareto chart data we found that among the causes that lead to the delayed receipt of applications, a special attention to the following incidents is required: excessive requests, lack of materials and product quit because these three events account for about 95% of delays causes. Through research on the spot it as decided that the average length of lead time for small projects, medium and grade is recorded in table 2 with a range of 8 days or so.

Table 1
With the specifications Lead Time production company.
Source: Sound data in 2014.

Product Types	Production Time
Automotive bicycle	32 days
Box Sound A1	32 days
Box Sound A2	38 days
Box Sound A3	40 days

Through research, and methods used in other companies with the 5S program, adapted from the best 5S implementation in Sound company, developing according to the need of the same. The company has the participation of 22 employees, including partners.

In brainstorming we developed an Implementation Plan, ie a way to plan and carry out the 5S program in a systematic way and within a management guideline, describing the successive steps to be met and a description of the activities to be developed.

Table 2
Phases and activities of the implementation of 5S.
Source: prepared by the author 2015.

Phase	Description	Results
training	Training employees on the 5S program	Employees are involved in program 5s.
diagnosis	Identification of weaknesses described as operational problems to be solved with implementation of the 5S program.	The main problem identified was in relation to environmental cleaning, as there was previously no responsible for this task, some sectors of the unit did not have proper layout, excess materials obsolete, damaged, damaged with a total loss, junk.
preparation	Definition of the company responsible for the program	Commitment and awareness.
implantation	Beginning of the implementation phase.	Organized collective effort to dispose of useless materials; Labeling materials; Change the "lay out" the environment; Definition of teams responsible for the activities; Script property: disposal; organization and cleanliness; Setting standards; Location set for the reserved material for disposal.
control	periodic review	Establishment of inspection routines, goals and continuous improvement.

On 23.11.2014 was held the activity known as 'The BIG CLEANING DAY', the day on which the first three senses were put into practice. Utilization sense of where they were discarded items that had not utilities and separate those who could become utilized.

Fig.3
Unusable items found on the big cleanup.
Source: prepared by the author 2015.

Fig.4
Rest of production found on the big cleanup.
Source: prepared by the author 2015.

During the sense of cleanliness, with the aid of all, it wiped the internal and external walls, equipment, tables, chairs, cabinets, shelves and other materials that had the need for cleaning. It was created during deployment, the habit of leaving everyone should keep your site clean and organized labor.

In the sense of organization, each tool has its proper place marked for easy reference. The tools were arranged which has higher output, ie, are used daily. These should be close and those that are little used should be somewhere far, however demarcated. Put into practice the order of "first in, first out".

In senses of standardization and discipline, an evaluation form was created from a scoring system where certain items, amounted to certain points. Always held by the shareholders of the company. The score and from 0 to 5 and the audit once a month without notice.

The project goal was achieved by reducing the production lead time in 56.26%

As the table shows.

Table 3
Before and after production lead time.
Source: prepared by the author 2014.

Product Types	Production Time before 5'S	Production Time after 5'S	Difference
Automotive bicycle	32 days	14 days	18 days
Box Sound A1	32 days	14 days	18 days
Box Sound A2	38 days	22 days	16 days
Box Sound A3	40 days	26 days	14 days

5 Conclusions

The use of quality tools through the PDCA method and the implementation of 5S Program for troublesho-oting was proposed adequately to the reality of the company, resulting in several opportunities for impro-vement, especially with regard to the reduction of LEAD TIME production in 56.26%, which was objective of this project.

For this action research were possible and feasible, meetings and training sessions were held to explain the reasons why the work would be developed. The commitment and dedication of all involved in the process were essential to that in seven months held various activities that contribute directly to the attainment of goals. It is important that the work is closely monitored, ensuring that rules and procedures are always follo-wed. Managers and employees should work together so they can seek quick solutions to the difficulties encountered. The change must come from both sides

6 References

BERTAGLIA, Paulo R. (2003). Logística e Gerenciamento da Cadeia de Abastecimento,1.ed, São Paulo, Saraiva.

FALCONI, Vicente (2004). TQC – Controle Total da Qualidade, 2.ed. Minas Gerais: INDG.

PORTER, Michael E. (1992). Vantagem Competitiva. 7. ed., Rio de Janeiro, Campus.

SLACK, Nigel et al. (2009). Administração da produção. São Paulo, Atlas.

TUBINO, Dalvio Ferrari. (2009). Planejamento e controle da produção: teoria e prática. São Paulo, Atlas.

VANTI, Nadia. (1999). Ambiente de qualidade em uma biblioteca universitária: aplicação do 5S e de um estilo parti ipativo de administração, Artigo Científico –UFRGS Campus Rio Grande do Sul.

WERKEMA, Maria C. (2006). Ferramentas estatísticas para o gerenciamento de processos. Belo Horizonte, Werkema Editora.

An Empirical analysis on Supply Chain Risk Mitigation Strategies

Arantes A[1], Ferreira L M[2], Thun J[3], Hamann M[4]

Abstract: Despite the fact that risk management in the supply chain has gained attention in recent years, there is still a lack of research on the topic. Thus, this paper performs an empirical analysis to validate possible dimensions related to supply chain risk mitigation strategies. The literature review covering supply chain risk management uncovered three dimensions, namely, preventive-downstream, preventive-upstream and reactive risk mitigation strategies. A factor analysis of survey data from Portuguese manufacturing companies made it possible to verify and validate the existence of the three dimensions and their statistical significance. Finally, this result led to the proposal of a three-dimensional framework that allows companies' supply chain risk mitigation strategies to be differentiated according to their nature (preventive-downstream, preventive-upstream or reactive). Hence, this framework could be a useful tool for managers to assess and develop the supply chain risk mitigation strategies of their companies.

Keywords: supply chain risk management; risk mitigation; empirical analysis.

1 Introduction

Many companies are confronted to act in a business environment characterized by high complexity and uncertainty. Major issues such as the catastrophes like 9/11, hurricane Katrina, the Tsunami in 2004, or the nuclear disaster in Fukushima have raised the attention of supply chain risk management. Furthermore, the financial crisis has worsened the business environment not only for banks but also for many manufacturing companies. Besides these catastrophes and negative developments, also other problems such as supplier losses or quality problems have increased the importance of Supply Chain Risk Management (SCRM). Hence, manufacturing companies are challenged to manage their supply chains effectively in order to deal with these demanding developments.

The main purpose of SCRM is to mitigate the negative impact of external disturbances and internal problems or to prevent various risks to happen. Due to the fact that particular supply chain risks would have a higher or lower impact on a supply chain there is a need for identifying effective Supply Chain Risk Mitigation Strategies (SCRMSs) in order to respond to a demanding business environment with respect to various risks.

Despite the fact that in recent years SCRM has won wide attention, there is still a deficiency of scientific research (Jüttner, 2005). Hence, the key objective of this paper is to validate the possible dimensions of SCRMSs through a survey of manufacturing plants conducted in Portugal.

1 **Amílcar Arantes** (Amilcar.arantes@tecnico.ulisboa.pt)
CERIS, CESUR, Instituto Superior Técnico, Universidade de Lisboa,
Av. Rovisco Pais, Lisbon 1049-001 Portugal

2 **Luís Miguel D. F. Ferreira** (lmferreira@ua.pt)
Economics, Management and Industrial Engineering Department,
University of Aveiro, Aveiro, 3810-193, Portugal.

3 **Jörn-Henrik Thun** (jh.thun@fs.de)
4 **Michael Hamann** (m.hamann@fs.de)
Industrieseminar Frankfurt, Sonnemannstraße 9-11, 60314
Frankfurt am Main, Germany.

2 Literature review

Independently of the particularities of an incident, the degree of damaging consequences depends greatly on the supply chain design vulnerability. Christopher and Peck (2004: 3) define vulnerability as "an exposure to serious disturbance, arising from risks within the supply chain as well as risks external to the supply chain". The SCRM main purpose can be "the identification and management of risks for the supply chain, through a co-ordinated approach amongst supply chain members, to reduce supply chain vulnerability as a whole" (Jüttner et al., 2003: 201).

On the one hand, the vulnerability of a supply chain depends on the number and variety of risks; on the other hand, the way the supply chain is secured against these risks determines the degree of vulnerability. Consequently, the selection of an appropriate SCRMS by means of a strategic fit among supply chain risks and the matching instruments must be regarded as central element of SCRM. Hence, it is important to shed light on the question which SCRMS would safeguard a supply chain against what kind of supply chain risks.

Atkinson (2006) studies SCRM in the context of companies that apply global sourcing and lean manufacturing. Moreover, the results show that SCRM strategy demands a close relationship among risk managers and others in the organization. Blackhurst et al. (2005) identified critical issues linked to supply chain disruption discovery, recovery and redesign and conclude that more effort in both the development of theory and tools is needed. Hendricks and Singhal (2005) found that disruptions have important negative economic costs and the absence of signs of rapid recovery highlight the need to pay more care to the disruptions' risks. Craighead et al. (2007) presented five variables that relate the severity of supply chain disruptions and the supply chain characteristics, such as complexity, mode criticality, density, the supply chain mitigation capabilities of recovery and warning. Thun and Hoenig (2011) found that supply chains, in the automotive industry, are viewed as being vulnerable and that SCRM seems to increase the performance. Thun et al. (2011) verified that large-scale companies focus on preventive instruments, whereas SMEs mainly concentrate on reactive instruments for SCRM. Recently Lavastre et al. (2012) conclude that effective SCRM must be inter-organizational and in close linked to strategic and operational issues of the companies. Furthermore, the results of the study suggest that effective SCRM is sustained on collaboration and the creation of joint and common transverse processes with supply chain members.

3 Proposal of a framework for supply chain risk mitigation strategies

In the following, risks driving the vulnerability of supply chains are discussed based on an approach by Christopher and Peck (2004) who distinguish between external and internal supply chain risks. These internal risks can be differentiated into demand risks and purchasing risks. Purchasing risks are concerned with "upstream" activities in the supply chain (Zsidisin, 2003); companies are faced with the risks connected to suppliers, e.g. quality problems of delivered products. Therefore, in this situation, an objective of SCRM could be the decrease of the number of errors or to increase quality levels. Demand risks are grounded on "downstream" activities in the supply chain (Svensson, 2002). They can be associated to the distribution of final products or can be related with demand uncertainties, which might end in delivery bottlenecks, high level of inventories, or deficient capacity use (Cachon and Lariviere, 2001). In this case, an objective of SCRM is to reduce the bullwhip effect, increasing flexibility and responsiveness.

Lastly, external supply chain risks deal with environmental causes that can barely be influenced and lead to disorders within the supply chain (Kleindorfer and Saad, 2005), which can be caused by sociopolitical, economical, technological or geographical reasons (earthquakes or hurricanes as well as terrorist attacks or political instabilities, etc.). Therefore, the main objective, in this case, is the decrease of vulnerability against external situations that can disrupt the supply chain.

There exists no single definition for SCRMS in the literature. Most of the research papers that deal with supply chain strategies do not consider the supply chain risks explicitly. Nevertheless, the debate of supply chain strategies offers a solid fundament for a practical definition of supply chain risk strategy. Following to Chopra and Meindl (2001: 314), "a supply chain strategy specifies what capabilities the supply chain network must have to support a firm's competitive strategy." According to these characteristics, we define SCRMS as a strategic approach for managing risks within a supply chain in order to support its competitiveness.

The SCRMSs' instruments can have a preventive or reactive nature. Both types of instruments are implemented before an incident happen; however, only preventive ones display their impact in advance, while reactive ones only show their impact later when the incidents actually occurred. Preventive instruments are cause-related measures that attempt for lower the probability of risk event. Examples are the focus on products with constant demand and small diversity or the focus on safe markets. Additionally, some risks, like natural disasters, can be avoided by locating facilities in safe areas. Frequently, the adopted instruments do not completely eliminate the risks, but they decrease their probability of occurrence considerably. For example, companies can select certified suppliers in order to assure a good compromise between quality and on-time delivery. Moreover, supplier relationship management, or even supplier development, can support the reduction of uncertainties related with the supplier and therefore lead to reduce supply chain risks (Giuni-pero and Eltantawy, 2004). The preventive instruments can be further divided in upstream and downstream.

Reactive instruments are effect-oriented measures that attempt to mitigate the negative impact of an incident and do not directly act on the risks but attempt to absorbing the loss caused by a risk. Consequently, the design of the supply chain should be in a way that the consequences of an incident are softened. For that, the supply chain must be resilient, which can be attained in two ways: increasing flexibility or creating redundancies (Rice and Caniato, 2003). The common approach for building up redundancies is to create and increase safety stocks (Sheffi and Rice, 2005). The approach of dual or multiple sourcing is another classical example; if one supplier has delivery problems, still at least other supplier is available guaranteeing the delivery of parts. Although most of the mentioned instruments lead to higher costs, which result from the creation of redundancies, this decisions must however be viewed as rational if these costs are understood as an insurance premium (Sheffi, 2001).

In order to identify differences in the nature of SCRMSs, we suggest three dimensions: preventive-downstream, preventive-upstream, and reactive. The preventive-downstream dimension includes instruments to deal with uncertainty in the demand-side of the supply chain in a preventive way. The focus on products with stable demand is an example. On the contrary, the preventive-upstream dimension of the supply chain risk strategy pretends to deal with risk linked to the supply-side. An example is the focus on reliable suppliers. Finally, the reactive dimension comprises instruments that deal with supply chain risks by creating redundancies. In this case, the creation of safety stocks is a widely used strategy.

Given that a supply chain risk mitigation strategy may have different dimensions, a three-dimensional framework can be created to assess the nature of the SCRMSs adopted by a company (Figure 1). In this three-dimensional framework, SCRMSs can be differentiated, in terms of their nature, in pure or combined strategies. A pure strategy aligns with one SCRM' dimension exclusively;. The risk mitigation strategies of one of the dimension are adopted on a high degree, whereas the strategies of other dimensions are only adopted to a weak or medium extend. On the contrary, a combined risk mitigation strategy covers at least two dimensions. A particular case of combined strategy is the simultaneous strategy, which includes all three-dimensions SCRMSs to a high degree.

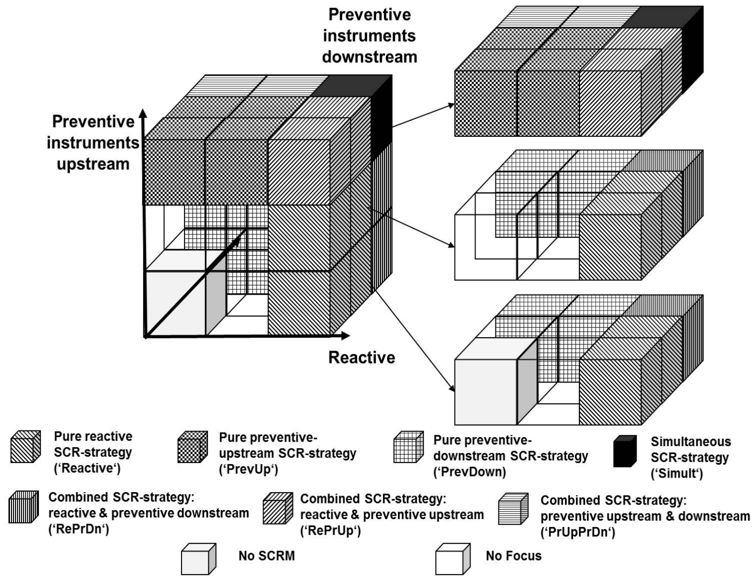

Fig.1
The three-dimensional framework of supply chain risk mitigation strategies.

4 Analysis

An adapted version of the questionnaire developed by Thun and Hoenig (2011) was used to data collection through an online survey. The recommendations of Following Dillman's (2000) were followed, and an email was sent to potential respondents with a short summary of the objectives of the study, the contacts of the researchers and a link to the online questionnaire. After a week another email was sent. Lastly, three weeks after the first email, another email was sent to the non-respondents.

The data collection occurred over a time period of two months. The email with the link to the survey was sent to a potential respondents list including purchasing managers, supply chain managers and executives randomly selected from the subscribers of the newsletter of APCADEC (the Portuguese Association of Purchasing Management). From the list with 650 potential respondents, a total of 117 responses were obtained, which means a response rate of 18%. The non-response bias was tested by using the extrapolation method, as recommended by Armstrong and Overton (1977). The comparison between early (58) and later responses (59) revealed no statistical significant differences (< 0.05) at between the distribution of the number of employees, respondent's position, and business revenues, which shows that non-response bias does not affect the data.

Next, the risk mitigation strategies are analyzed. The risk mitigation strategies are aggregated using a factor analysis (table 1). The criteria for validity and reliability of the data, the obtained factor loadings and their respective cross-loadings are displayed in table 1.

Table 1
Validity and reliability of factors.

Risk Mitigation Strategies	Factors		
	Preventive upstream	Preventive downstream	Reactive
Suppliers with high quality	*0.780*	0.237	-0.004
Suppliers with a high on-time delivery ratio	*0.749*	0.345	0.094
Supplier Development	*0.766*	0.079	0.014
Implement communication systems	*0.645*	-0.149	0.078
Maintain high levels of safety stock	0.029	0.011	*0.712*
Install surplus production capacity	0.082	0.198	*0.812*
Having excessive storage capacity	-0.079	0.065	*0.792*
Prioritize products with constant demand	0.184	*0.816*	0.170
Prioritize products with reduced range	0.001	*0.859*	-0.026
Stabilize demand by forgoing discounts	0.136	*0.523*	0.277
Eigenvalue	2.256	1.939	2.293
Chronbach's Alpha	0.669	0.725	0.733

The first factor stands for a (latent) preventive risk mitigation strategy related to upstream activities in the supply chain, such as concentrating on suppliers with high quality, high on-time delivery ratio, supplier development and communication systems. The second factor represents a (latent) preventive risk mitigation strategy related to downstream activities in the supply chain, such as the prioritization of products with constant demand, reduction of range and a stabilization of demand by forgoing discounts. Additionally, the third factor consists of a set of risk mitigation strategies related to a (latent) reactive risk mitigation strategy aggregating strategies such as high safety stocks, surplus production capacity, and excessive storage capacity. The three identified factors support the proposed three-dimensional framework of SCRMSs.

As the eigenvalue of each extracted factor surpasses the minimum threshold of 1.0, we can accept factors as valid. Additionally, all factor loadings are larger than 0.5 and the corresponding cross-loadings are lower than 0.35.

To check the reliability of the factors the Cronbach's Alpha was used. According to Nunnally (1978), a value of 0.7 is seen as satisfying, whereas Sakakibara et al. (1997) consider a value of 0.6 as satisfying for newly created scales. All extracted factors have at least a Cronbach's Alpha above 0.6. Consequently, all extracted factors meet the criteria for validity and reliability and can be utilized for further analyses.

5 Conclusion

In this paper, supply chain risk mitigation strategies have been investigated through a survey of manufacturing companies located in Portugal. The results achieved using a factor analysis are consistent with the literature reviewed and confirm the existence of the three dimensions: preventive-downstream, preventive-upstream and reactive risk mitigation strategies.

Thus this work contributes to the body of knowledge on risk management and strategies in the supply chain literature. As a managerial implication, one may say that in order to manage supply chain risk, companies should be aware of the nature of the different risk mitigation strategies. The proposed framework could be a valid tool for to managers to assess and develop their supply chain risk mitigation strategies in order to improve their effectiveness.

This study only focuses on manufacturing companies; therefore a generalization of the results should be handled with care. Furthermore, future research should address the importance of the implementation since this aspect might have a significant impact on the effectiveness of supply chain risk mitigation strategies. Finally, comparable studies should be carried out in other countries and on other types of organizations.

References

Armstrong, J. S., Overton, T. S., 1977. Estimating non response bias in mail surveys. Journal of Marketing Research, 14 (3), 96–402.

Atkinson, W., 2006. Supply Chain Management: New Opportunities for Risk Managers. Risk Management, 53 (6), 10–15.

Blackhurst, J., Craighead C.W., Elkins D., and Handfield, R.B., 2005. An empirically derived agenda of critical research issues for managing supply-chain disruptions. International Journal of Production Research, 43 (19), 4067–4081.

Cachon, G. P. and Lariviere M.A., 2001. Contracting to Assure Supply: How to Share Demand Forecasts in a Supply Chain. Management Science, 47(5), 629–646.

Chopra, S. and Sodhi, M.S., 2004. Managing Risk to Avoid Supply-Chain Breakdown. MIT Sloan Management Review, 46 (1), 53–62.

Christopher, M. and Peck, H., 2004. Building the Resilient Supply Chain. The International Journal of Logistics Management,15 (2), 277–287.

Craighead, C.W., Blackhurst, J., Rungtusanatham, M.J., and Handfield, R.B., 2007. The Severity of Supply Chain Disruptions: Design Characteristics and Mitigation Capabilities. Decision Sciences, 38 (1), 131–156.

Dillman, D. A., 2000. Mail and Internet: The Tailored Design Method. John Wiley & Sons, New York.

Giunipero, L.C. and Eltantawy, R. A., 2004. Securing the upstream supply chain: a risk management approach. International Journal of Physical Distribution & Logistics Management, 34 (9), 698–713.

Hendricks, K.B., Singhal V.R., 2005. An Empirical Analysis of the Effect of Supply Chain Disruptions on Long-Run Stock Price Performance and Equity Risk of the Firm. Production & Operations Management, 14 (1), 35–52.

Jüttner, U., 2005. Supply chain risk management – Understanding the business requirements from a practicioner perspective. The International Journal of Logistics Management, 16 (1), 120–141.

Jüttner, U., Peck, H., and Christopher, M., 2003. Supply Chain Risk Management: Outlining an Agenda for Future Research. International Journal of Logistics, 6 (4), 197–210.

Kleindorfer, P. R. and Saad, G.H., 2005. Managing Disruption Risks in Supply Chains. Production and Operations Management, 14 (1), 53– 68.

Lavastre, O., Gunasekaran, A. And Spalanzani, A., 2012. Supply chain risk management in French companies. Decision Support Systems, 52, 828–838.

Nunnally, J. C., 1978. Psychometric Theory, New York.

Rice Jr., J.B. and Caniato, F., 2003. Building a Secure and Resilient Supply Network. Supply Chain Management Review. 7 (5), 22–30.

Sakakibara, S., Flynn, B. B., Schroeder, R. C., Morris, W. T., 1997. The impact of Just-In-Time manufacturing and its infrastructure on manufacturing performance. Management Science, 43 (9) 1246–1258.

Sheffi, Y. and Rice Jr., J.B., 2005. A Supply Chain View of the Resilient Enterprise. MIT Sloan Management Review. 47 (1), 41–48.

Sheffi, Y., 2001. Supply Chain Management under the Threat of International Terrorism. The International Journal of Logistics Management, 12 (2), 1–11.

Svensson, G., 2002. A conceptual framework of vulnerability in firms' inbound and outbound logistics flows. International Journal of Physical Distribution & Logistics Management, 23 (2), 110–134.

Thun, J. H., Drüke, M. and Hoenig, D., 2011. Managing uncertainty – an empirical analysis of supply chain risk management in small and medium-sized enterprises. International Journal of Production Research, 49 (18), 5511-5525.

Thun, J.-H. and Hoenig, D., 2011. An empirical analysis of supply chain risk management in the German automotive industry. International Journal of Production Economics, 131 (1), 242-249.

Zsidisin, G.A., 2003. A grounded definition of supply risk. Journal of Purchasing & Supply Management, 9, 217–224.

Shipping: Management of Import and Export Processes and Transition from Public to Private

Roa I[1], Duran E[2], Amante B[3]

Abstract: The Port Authority of Barcelona (PAB) manages one of the 46 ports of general interest in Spain. Title of all those ports is public and therefore all activities in which PAB participates are developed from a public point of view. In this research, the possibility of performing these tasks from a private point of view will be considered. We will study the flows of imports and exports, focusing on administrative and transport processes.

Keywords: Import, export, public, private, port.

1 Introduction

Spain is the country of the European Union, which has greater long coastline, reaching about 8,000km. The Spanish port system is composed of 46 ports of general interest, managed by 28 Port Authorities and is coordinated and controlled by the "Ente Público Puertos del Estado" (EPPE), under the Ministry of Public Works and has attributed the execution of port policy of the Government.

This port management model implies that the ownership of the land on which port facilities are built is public, but also that the infrastructures are publicly owned. The provision of services tends to be private and regulation is carried out by a public official (Martin Bofarull 2010). Typically, port authorities use to concession terminal spaces to private entities (Roa et al. 2013). The more efficient private sector (Guasch 2004), then begins to take over everything that is specific to their activity (cranes, warehouses, equipment, etc.).

This organizational model is known as "Landlord" because the port manager owns the land on which it sits. Although there is no single model for managing ports worldwide, the general trend is to use this model (Ramos-real & Tovar 2010) because it allows competition between different service providers in the same port (Notteboom & Merckx 2006).

The Port of Barcelona currently holds the third position in the ranking of Spanish ports. It is classified after Algeciras and Valencia (Lloyds 2013) which move more transhipment cargo.

As a public port authority, the PAB is involved in all processes necessary to allow trade between the entities involved in the port business. Therefore, participates in key process flows of import and export of goods.

In this research we focus on the import and export processes, specifically those flows that have to do with transport processes and / or administrative and evaluate the role of PAB in all of them. The purpose of this study is to discern whether these activities that are carried out by a public authority would be assumable for a privately owned one.

2 Activity Characterization

This research focuses on two fundamental processes: the import and export of goods. Within the processes of import and export, hundreds of activities and flows that are related to administrative processes, to transport and other like security, purely customs operations, etc. can be detected. We will

1 **Iván Roa** (roabcn@gmail.com)
2 **Eduard Duran Example** (eduran@portcemen.com)
3 **Beatriz Amante** (beatriz.amante@upc.edu)
Barcelona TECH (Spain). C/ Mas Sagrera no 15.
17246 Santa Cristina de Aro, Gerona. España

only fix in those flows which involve the Port Authority (administrative and transport) because it seeks to determine whether they would be assumable by a private entity. Regardless of the type of cargo (bulk, containerized cargo, general cargo, etc.) are concerned, we will determine through process diagrams which activities are performed by the Port Authority and depart from the case study, which is the port of Barcelona.

Table 1 shows in rows the 13 activities that the Quality Plan of the Port of Barcelona relate to import and export processes, focusing in these flows. For columns, we study who is responsible, which can be a company (business) or an institution and that responsibility is highlighted with grey boxes.

The study case examines the activities of the PAB, so we look exclusively in that column to identify which activities are performed by the same.

Table 1
Activities and responsible.
Source: PAB (adapted)

			Business											Institutions					
			Exporter / Importer	Financial institution	Shipper / Shipping company	Rail logistics operator	Rail company	Freight forwarder / Customs broker	Transport company	Port rail terminal	Container depot	Inner terminal	Bassic port services	Port Authority (APB)	ADIF (Rail infrastructure manager)	Maritime Captaincy	Customs	Border inspection Services (BIS)	
Goods	Commercial	Commercial recruitment	■	■															Importer / Exporter of goods
Goods	Transportation	Shipping recruitment	■		■			■											Importer / Exporter of goods
Goods	Transportation	Rail transport recruitment	■			■													Importer / Exporter of goods
Goods	Transportation	Terrestrial transport			■	■	■	■	■	■	■	■		1					Importer / Exporter of goods
Goods	Transportation	Operational of maritime terminal			■				■	■									Importer / Exporter of goods
Goods	Transportation	Operational of rail terminal			■	■	■			■									Importer / Exporter of goods
Goods	Management	Customs clearance			■			■		■		■		2			■		Importer / Exporter of goods
Goods	Management	Border inspection services (BIS)			■			■		■				3				■	Importer / Exporter of goods
Goods	Management	Leave to enter dangerous goods			■			■		■				4					Importer / Exporter of goods
Transportation	Related with vessel	Administrative management of the scale			■									5		■			Shipping company
Transportation	Related with vessel	Ship services			■								■						Shipping company
Transportation	Rail	Circulations management					■							6	■				Rail company
Transportation	Rail	Rail services				■	■								■				Rail company

In yellow and numbers, the following activities are highlighted:

1. Terrestrial transport. This involves managing land transport and mo-movement of goods entering or leaving the port

2. Customs clearance. It is communicating data from the ship reaches port to the Tax Office, so you can make the customs clearance of goods.

3. Border inspection services (BIS): The PBA has the responsibility to validate the control of the goods.

4. Leave to enter dangerous goods. The Port Authority is the only one who can, after certain checks, allow input or output port, of certain goods.

5. Administrative management of the scale. Berth allocation. It is an activity that can be delegated to each terminal.

6. Circulations management. Control and management of inputs and outputs by train.

Studied the main activities of the PAB, we build some process maps in order to determine when those activities appear, what activities precede them and how they develop

2.1 Management Controls

Management processes are those in which the PAB acts as management authority and tries to ensure its potentiation. Processes constructed diagrams highlight the activities of the PAB on those made by other entities. Thus, Fig. 1 shows the diagram of management controls on imports.

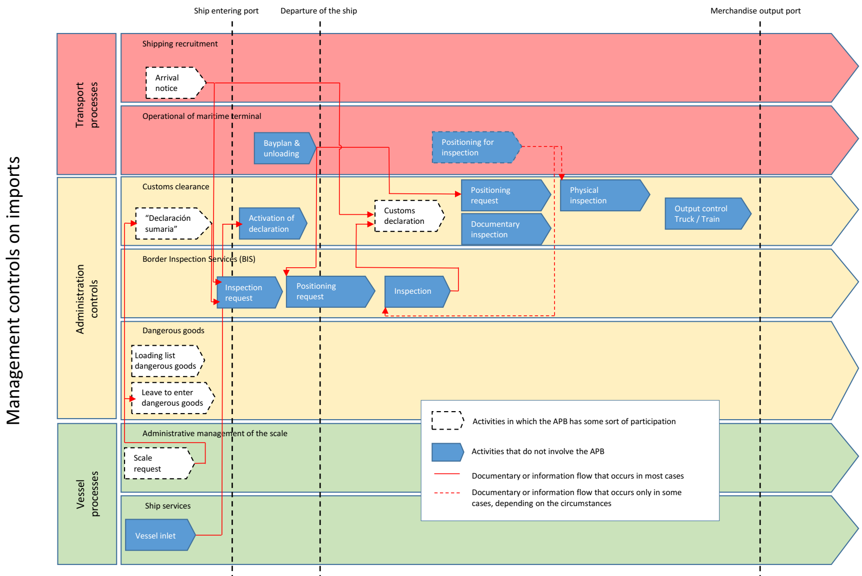

Fig.1
Management controls on imports.
Source: PAB (adapted)

Basically, before the arrival of the ship, two processes occur. The first is the "scale request", which consists in PAB ask for permission to call at the Port of Barcelona and perform the tasks of loading and unloading goods. To grant this permission before docking ship, the PAB check the "Declaración sumaria". This statement must be filed with the Tax Office to assign the goods customs destination.

The "Ente Público Puertos del Estado", has today an agreement of "single window" with the Inland Revenue, which streamlines the procedures for submission of the "Declaración sumaria", but may be submitted by an individual or company directly from the Inland Revenue, so it would not be strictly necessary to be done by a public body.

Another important process that starts when the ship calls scale is the "Leave to enter dangerous goods". The vessel has the obligation to declare the origin and nature of the dangerous goods on board through the "Loading list dangerous goods" irrespective of whether they will be discharged in Barcelona or at a later scale. It is a process that affects port security and, if necessary, triggers certain control and management processes, and can also trigger emergency plans. Process management can be carried out also by private coordinator, to the extent that the only public entity that participates are the Forces of State Security, to which only the nature of the cargo is reported to their address of the incidence.

When the ship arrives in port, it communicates to the PAB through the "Arrival notice" and PAB (or directly the terminal) assign berth, a fact which triggers the process of customs control. In this process, the PAB only communicates Customs vessel data transmitted to it and once he has made the whole process of "Customs declaration", Customs informs the PAB the result. Possible customs inspections are not conducted by the PAB but by Customs itself.

If we now look just as management controls in exports (see Fig. 2), we can observe the activities currently undertaken by the public entity PAB.

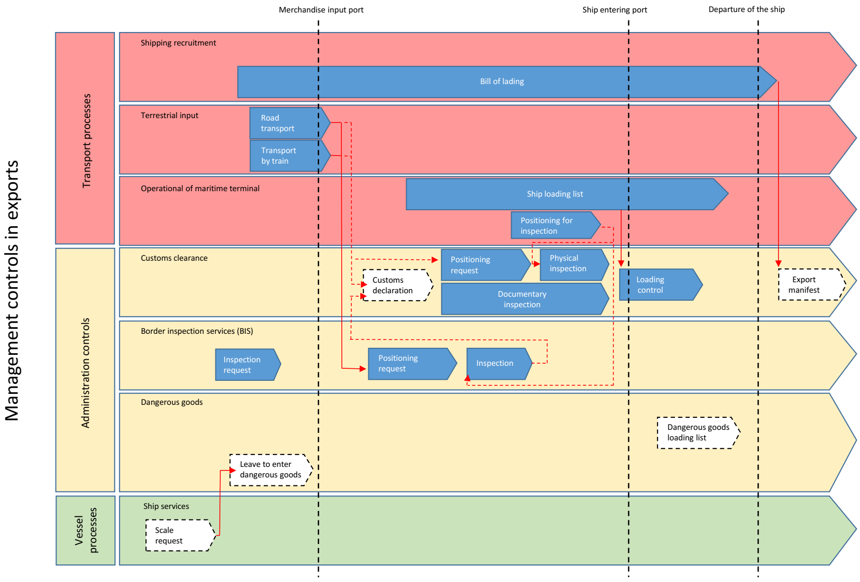

Fig.2
Management controls in exports.
Source: PAB (adapted)

It can be seen that the order of realization is different, but essentially the activities are similar. In a document management procedure as above, the PAB know the "Export manifest", a report that is issued twice a week and reflects the maritime exports a country has made.

All activities of this group could be assumable by a private entity, because it only involve bureaucratic coordination and document processes done, at present, by Portic Platform, a private entity that manages document processes between companies, Dealers and PAB.

2.2 Transport Processes

Those processes deal with the physical movement of cargo and, in most cases occur when the ship has left the dock to its next destination. Transport processes also have some administrative and commercial tasks, without which they would be totally unworkable. In Fig. 3 the import transport process diagram is shown and as before, the activities currently carried out by the PAB are highlighted.

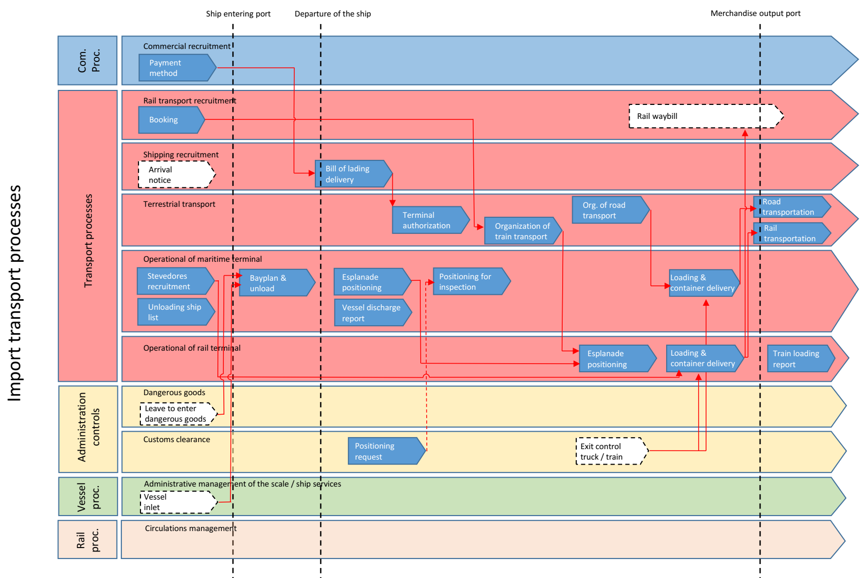

Fig.3
Import transport processes.
Source: PAB (adapted)

All activities above and that have to do with scales and authorizations entry into port, are analogous to those shown in Fig 2. Only two new activities appear. The "Rail waybill" communicating what comes loaded (Rodrigo de Larrucea et al. 2012) and "Exit Control truck / train" which, although not developed directly by the PAB, it’s true that it controls through its security forces if necessary. Therefore, we find related document management or coordination of activities, which could be perfectly performed by a private entity processes.

If we now analyze the transport processes in exports (Fig. 4), It can be seen that are analogous to import, but obviously with a different order. We will see that any new process or activity does not appear, so it can be concluded that existing can be developed from the perspective of a private entity.

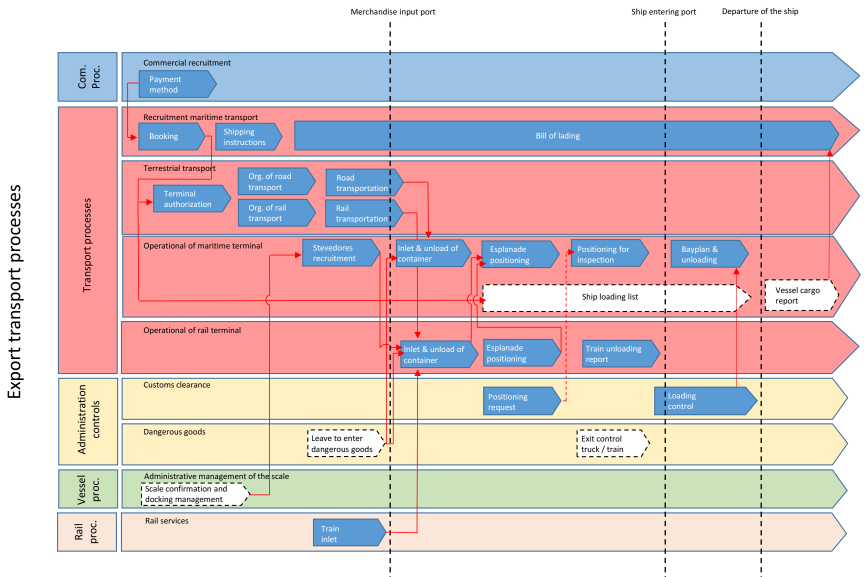

Fig.4
Export transport processes.
Source: PAB (adapted)

3 Conclusions

Having analyzed the two flows, administrative and transportation for import and export processes, we have seen that there are activities made today by a public body (specifically, the PAB). However, after detailed analysis thereof, has not been found in any activity that must necessarily be developed by the public body and that was not acceptable from the perspective of a private actor. It could be concluded that, from an operational point of view, the management of these activities could be undertaken by a private entity. This could occur if a change is generated in the administration, potentially acceptable because public policies depend on market developments (De Borger & De Bruyne 2011).

EPPE is responsible in Spain to set port tariffs and subsidies, so that a private entity would always be under the influence of a body which regulates competition law in Spain. In the current port model, could not conceive a port to fix rates well below those of other ports, because would substantially increase their ability to attract cargo and thus, raise business, so that could unbalance the overall port system. The only possibility that the port managed by a private Port Authority set its own rates would go through all the ports of the State were in the same situation or forks with minimum and maximum for this particular port were set. This would then generate a situation of free market and competition.

The Port Authorities are responsible for campus security police "Security" and have assigned responsibilities for surveillance and monitoring of compliance with the regulations by the terminals. They also have responsibilities for coordination of operational safety enclosure "safety" tasks that could easily be assigned to another agency of the administration like Harbourmaster, that has currently exclusive functions dedicated to shipping and vessel monitoring. The PAB also performs management of concessions, regulated by the Ports Act and, today, are not assumable by a private entity sticking to the

Spanish Ports Law. On the other hand, one of the main activities of the PAB is to facilitate the port business and enhance the business of the area, so the private property of a new player should have necessarily barriers to ensure a maximum and minimal in these fields and guarantee that the general strategic lines of the government are enhanced.

Finally, we conclude that in the activities studied from process diagrams drawn, the PAB is responsible for document management of information flows. Therefore, its role could be assumed by a private company which should only mediate appropriate confidentiality agreements, being in evidence for these activities is not required at all public intervention.

4 References

De Borger B & De Bruyne D (2011) Port Activities , Hinterland Congestion , and Optimal Government Policies; The Role of Vertical Integration in Logistic Operations. *Journal of Transport Economics and Policy*, 45(November 2009), pp.247–275.

Guasch J.L. (2004) Granting and renegotiating infrastructure concessions; Doing it right, *The International Bank for Reconstruction and Development*.

Lloyds (2013) Ports worldwide and ratings by container movement, *Lloyd´s List.*

Martin Bofarull M (2010) El sistema portuario español: Regulación, entorno competitivo y resultados. Una Aplicación del Análisis Envolvente de Datos. *Rovira i Virgili*.

Notteboom T & Merckx F (2006) Freight Integration in Liner Shipping : A Strategy Serving Global Production Networks. *Growth and Change*, 37(4), pp.550–569.

Ramos-real FJ & Tovar B (2010) Productivity Change and Economies of Scale in Container Port Terminals A Cost Function Approach. *Journal of Transport Economics and Policy*, 44(May), pp.231–246.

Roa I et al. (2013) Ports: Definition and study of types, sizes and business models. *Journal of Industrial Engineering and Management*, 6(4), pp.1055–1064. Available at: http://www.jiem.org/index.php/jiem/article/view/770/523.

Rodrigo de Larrucea J, Marí Sagarra R & Martín Mallofré J (2012) Transporte en contenedor 2nd ed. M. Books, ed., Barcelona.

Study on Productivity in the Automotive Industry

Estelles-Miguel S, Andrés Romano C[1]

Abstract: A production process is essential for generating added value in organisations. Today when the globalised world of industry relies on finding new competitiveness factors to enhance customer satisfaction, it is common practice to break down the scope of production systems into processes to obtain a competitive advantage because some historically less explored leading practices (innovation, optimising logistics flows, implementing information systems, etc.) are yielding positive results. The automotive sector has abandoned the use of work measurement and standards time tools, and everything that using such tools implies. Yet these tools are still useful for planning and managing productivity, and are becoming increasingly necessary. This paper analyses perceptions about productivity, work measurement and standards time, and explores how companies use these tools in the Automotive Industry in Valencia (Spain). A survey that collected responses from interviews with 24 automotive companies was used to collect data on these companies. Perceptions: data from these interviews were analysed. This article presents the results of this analysis.

Keywords: Productivity, Work Measurement, Standards Times, Automotive Companies.

1 Introduction

For several decades, the automotive industry in Spain has been a worldwide reference for its great capacity to generate employment, develop new technologies and use the most advanced processes.

To find out how productive a job is, the first thing to do is to assign time to each job; i.e., calculate the amount of time required to perform a task. For this purpose, various methods exist. Then it is necessary to check whether the time spent by an operator is the expected time. The earmarked time to perform work should take into account workers' personal requirements and some time to recover from fatigue, and these times also usually considered to be conditions of the job, industry, etc.

Moreover, people dedicated to ergonomics and production engineers have a long-standing history of being interested in organising working time, particularly as far as highly repetitive tasks are concerned. The most well-studied characteristics have been measures of productivity and quality (system responses) and acute physiological responses, such as muscle activity and fatigue (of operators). These measures have been studied for over a century by engineers and physiologists to optimise production systems (Dempsey et al. 2010). Despite a common interest in time, the contributions of manufacturing engineers and ergonomists to modify allocation of times rarely agree. For example, efforts made by engineers to cut production systems or to minimise variance in processes can have negative ergonomic consequences (Wells et al. 2007).

The purpose of this paper was to study productivity in the Automotive Sector of Valencia (east Spain) to know the industry from within, and to also collect and analyse information on the activities that form part of it, the number of companies engaged in this sector, working conditions, methods for assessing productivity, new challenges, etc.

This paper is organised as follows: Section 2 discusses productivity; Section 3 explains the method and presents some results; Section 4 presents the conclusions.

1 **Sofía Estellés Miguel** (soesmi@omp.upv.es)
Carlos Andrés Romano (candres@omp.upv.es)
Dpto. de Organización de Empresas.
Universitat Politècnica de València.
Edificio 7D, Camino de Vera S/N, 46022 Valencia.

2 Productivity

In an environment characterised by strong competition, technological change, globalisation, market deregulation and fragmentation of demand, productivity has emerged as one of the main factors that contributes to determine competitiveness. Although the productivity concept is lengthily discussed by politicians, economists, managers and the media, it is often vaguely defined and poorly understood. In practice, lack of this knowledge results in productivity being ignored by those who influence production processes (Tangen, 2002)

Productivity is defined as the efficiency of a production system; that is, the ratio of the outcome of the production system and the amount of resources used. So in a production system, there are as many productivity levels as there are resources. Labour productivity is defined as an increase or decrease in yields depending on the work required for the final product. This paper addresses only the part that relates to human resources; i.e., productivity of labour.

The definition of productivity has varied over time since it first appeared in 1766, and it has adapted to the times, while different meanings have been included in its definition, or even tools to measure productivity.

Human resources today play a strategic role in increasing the productivity of any organisation, which makes it superior in industrial competition. If human resources are effectively and optimally used, all the advantages that productivity growth supply can be obtained (Attar et al., 2012).

If the factors that affect productivity are correctly measured and identified, the likelihood of successfully analysing these factors, diagnosing the conditions of a company´s productivity, and fundamentally knowing which actions should be undertaken to improve productivity, will be greater.

For all the above reasons, the authors decided to analyse herein how companies actually view productivity, how they measure productivity and how they think productivity affects them.

Labour productivity is a useful measure as it relates to the single most important factor of production, is intuitively appealing and is relatively easy to measure. Labour productivity is also a key determinant of living standards, measured as per capita income, and is of significant policy relevance from this perspective. Yet it only partially reflects labour productivity in terms of the personal capacities of workers or the intensity of their efforts. Labour productivity reflects how efficiently labour is combined with other production factors, how many of these other inputs are available per worker, and how rapidly embodied and disembodied technical changes proceed. This makes labour productivity a good starting point for analysing some of these factors. One way of carrying out a further analysis is to turn to multifactor productivity (MFP) measures (OECD, 2001).

3 Method and Results

3.1 Methodology

In the present study, 24 companies from the automotive sector in Valencia were visited and surveyed.

Although identification data and contact data (e.g., company's name, interviewer's name, telephone number, e-mail, sector and product type) were collected to identify companies and to follow up if responses were incomplete or not fully understood, these data were always treated confidentially.

Data on the companies´ sector proved useful to categorise questionnaires because they were completed not only by automotive sector companies, but also by companies in other productive sectors in Valencia.
General questions (e.g., number of employees and turnover) were also asked to characterise companies. The questionnaire delved into measuring productivity through the description of working methods and engineering measurement times.

Surveys were completed by a range of means, including personal visits to the company, e-mail and via some associations that helped us conduct the survey.

Objectives:

- Analysing and identifying the factors that directly influence productivity.
- Describing the techniques used to measure productivity.
- Better knowing automotive companies.

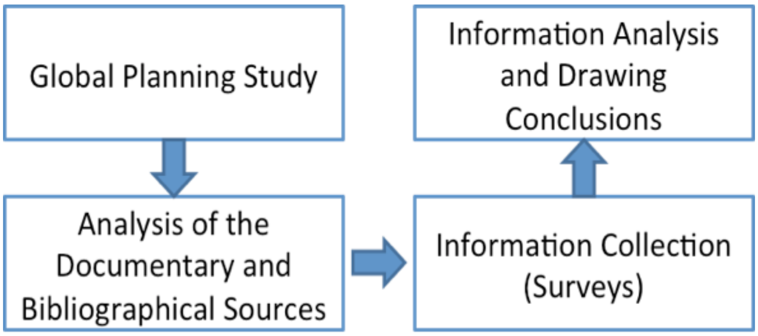

Fig.1
Methodology.
Source: The Authors.

3.2 Results

The sample comprised 24 automotive companies from Valencia. The total number of employees in each company ranged between a minimum of 17 and a maximum of 700. The average company size was 286 employees, with a mode of 50 and a median of 320. The number of direct workers or the size of the direct work force ranged between 12 and 698, and the mode and median were both 250. The questions addressed how the company was structured and how important the company considered productivity and its measurement.

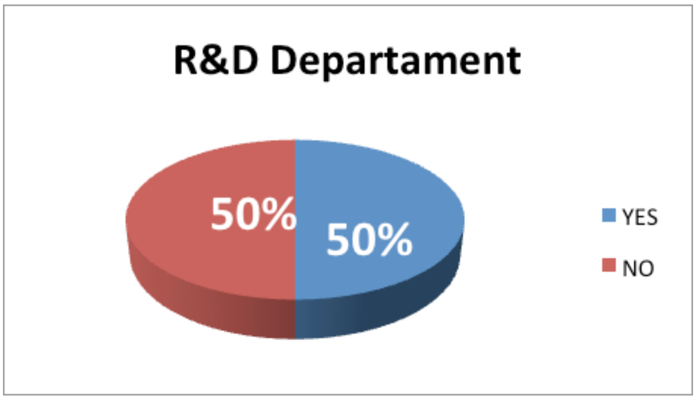

Fig.2
Does the company have an R&D Department?
Source: The Authors.

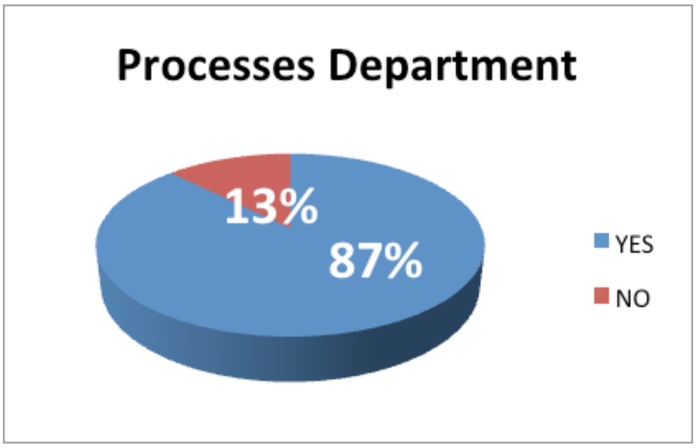

Fig.3
Does the company have a Processes Department?
Source: The Authors.

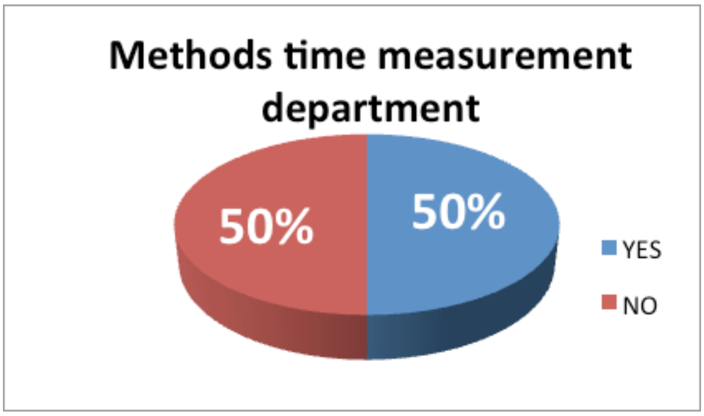

Fig.4
Does the company have a Measurement and Standard Times Department?
Source: The Authors.

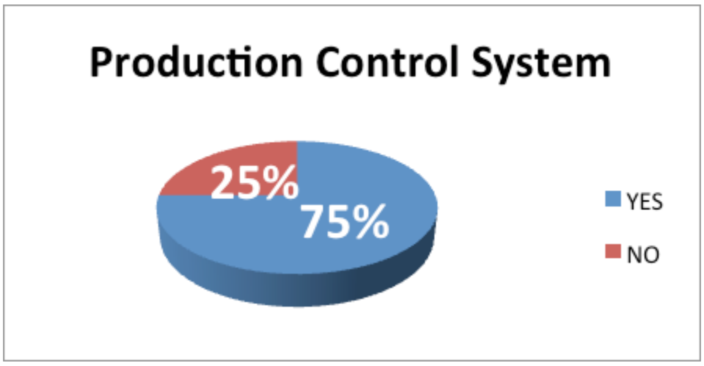

Fig.5
Does the company have a Production Control System?
Source: The Authors

All the surveyed companies had implemented a quality system and only 12% had not yet certified it. All the interviewed company managements believed that it is useful to use methods and times.

Note that for the following questions, companies could choose more than one option.

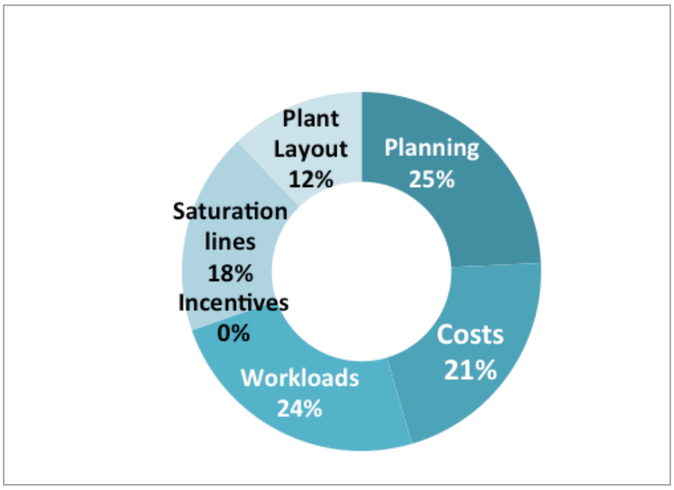

Fig.6
What is measuring production times useful for?
Source: The Authors.

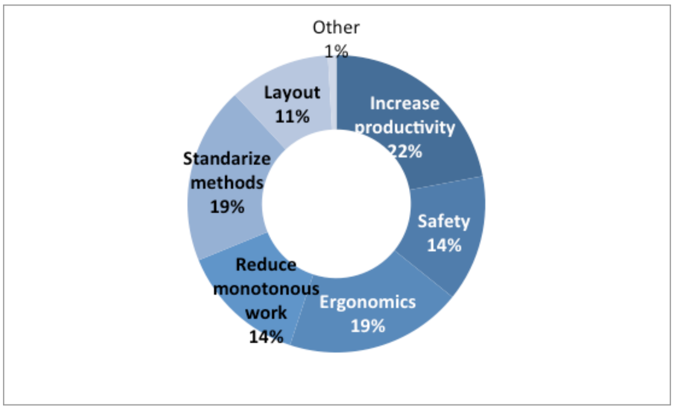

Fig.7
What is studying methods useful for?
Source: The Authors.

5 Conclusions

The participants of the survey neither gave a definition of productivity nor received a request to do so. Perhaps it would have been interesting to see how each company understood productivity, and the distinctions that different companies may have included in the concepts.

The participating companies understood that productivity is important for their company and for maintaining the company in the market, as seen in the questions that addressed how companies were structured, and how important they considered productivity and its measurement. In fact 100% of companies reported that they should improve their productivity. The majority of companies (87%) had a Processes Department, whereas only 50% had a Methods and Time-Management Department, although a Processes Department often performs the job of assigning a time to each task. The automotive industry attaches much importance to quality systems; indeed 100% of the interviewed companies had quality systems.

The main important reasons to use times were planning, workload, cost and saturation lines, and in that order. It is interesting to note that nobody indicated the issue of incentives in the automotive industry. although it was an important issue in other surveyed sectors. This may be because the automotive sector works on assembly lines which must always work at the same speed, where none must be faster than others. Therefore time serves to plan rather than to incentivise. The use of methods were: increase productivity, ergonomics, standarise methods, safety, and reduce monotonous work.

The authors of the present study consider productivity to be fundamental for companies. Nevertheless, the majority of companies failed to attach the importance they should to productivity. Yet when they reflected on this fact, they realised but they should give more priority to productivity. Methods and time management are not only tools to improve productivity, but can also be used to plan, calculate costs of outputs, workloads and overburdening in the company, improve job security, analyse job ergonomics, and perform many other important tasks.

Another block of questions was also included in the questionnaire, but these will be analysed in other related studies. This paper forms part of a larger work on productivity in various productive sectors.

References

Attar, A.A., Gupta, A.K. & Desai, D.B. (2012). A study of various factors affecting labor productivity and methods to improve it. In IOSR Journal of Mechanical and Civil Engineering- Second International Conference on emerging trends in engieering, pp. 11-14.

Dempey, P., Mathiassen, S.E, Jackson, J.A. and O´Brien, N.V. (2010). Influence of three principles of pacing on the temporal organisation of work during cyclic assembly and disassembly tasks. Ergonomics, Vol. 53, Nº 11 pp. 1347-1358.

OECD (2001).Organisation for Economic Co-Operation and Development. Measuring Productivity. Measurement of Aggregate and Industry-Levey Productivy Growth. http://www.google.es/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0CCIQFjAA&url=http%3A%2F%2Fwww.oecd.org%2Fstd%2Fproductivity-stats%2F2352458.pdf&ei=PkvwVKLpMsX8UrKQgbgE&usg=AFQjCNGOoApxOY2MedXOXijDIgR09P5OEQ&bvm=bv.87269000,d.d24. Retrieved 12/01/2015.

Tangen, S. (2002). Understanding the Concept of Productivity. Proceeding of the 7th Asia Pacific Industrial Engineering and Management Systems Conference (APIEMS2002), Taipei.

Wells, R., Mathiassen, S.E., Medbo, L., & Winkel, J. (2007). Time-A key issue for muscoloskeletal health and manufacturing. Applied Ergonomics, Vol., 38, pp. 733-744.

Application of Hybrid Symbiotic Organism Search on Flow Shop Scheduling with a New Learning Effect

Amirian H, Sahraeian R[1]

Abstract: The present article proposes a hybrid learning effect model which takes into account the previous experience of the operator, separates the machine/manual times and considers truncation. The developed model is fitted to experimental data to investigate its accuracy. The fits are compared with those of four other well-known position based learning models. Next, each learning model is applied to the large scale flow shop problems which makes them strongly *NP*-hard. Hence, the problems are tackled by a hybrid meta-heuristic named Symbiotic Organism Search Simulated Annealing (*SOS-SA*). The algorithm combines the fast and easy implementation of *SOS* with the powerful local search of *SA*. The proposed algorithm is tested on flowshop benchmark problems and the results show its validation.

Keywords: Scheduling; Learning Effect; Flow shop; Symbiotic Organism Search; Simulated Annealing.

1 Introduction

Classic scheduling treats the processing times of jobs on different machines as constant input data. Empirical analysis of processing times, however, indicates contradictory results (Biskup, 1999). In other words, the workers are likely to demand less time to perform tasks as repetitions take place due to increasing familiarity with the operation, the tools and the workplace, and because shortcuts to the task execution are found (Jaber, 2011). This phenomena is known as "learning effect" in scheduling. The importance of the effect lies in the fact that under the effect of learning, the optimum schedule might change. Thus ignoring the effect leads to considerable loss in profit, time and energy. Learning effects are formulated according to empirically developed learning curves (*LC*s). A *LC* is a mathematical description of workers' performance in repetitive tasks. With each passing year new models for position based learning effect are proposed but most are based on four commonly adopted learning curves. These are classic log-linear, Dejong's, *S*-curve and Plateau *LC*s. In the present study, the models based on these *LC*s are compared with a newly proposed hybrid learning effect. Understanding the differences between *LC*s with this comparative analysis leads to the selection of an appropriate learning model in respect to the work environment. This, in turn, leads to a good estimation of processing times, a proper scheduling and finally, a considerable reduction in production cost. Moreover, to emphasize the applicability of learning effects, the models are carried out on large scale classic flow shop problems using a hybrid version of a recently introduced meta-heuristic named Symbiotic Organisms Search (Cheng & Prayogo, 2014) with Simulated Annealing (Kirkpatrick et al., 1983). The rest of this paper is organized as follows. Section 2, shows the available learning curves formulations and examines our proposed model. In section 3, we discuss the pros and cons of each curve. Section 4, gives a brief introduction on *SOS-SA* and shows the results achieved by adding learning effects to classic flow shop systems. The paper is then concluded in section 5.

1 **Rashed Sahraeian** (sahraeian@shahed.ac.ir)
Department of Industrial Engineering, College of Engineering,
Shahed University, Tehran, Iran

2 Position Based Learning Curve Models

Let p_{ijr} be the processing time of j^{th} job in r^{th} position of i^{th} machine, $a(a \le 0)$ the learning rate, $M(0 \le M \le 1)$ the machine time ratio, B the prior experience and C the steady-state performance of an operator. Now, we summarize the most popular position based *LC*s previously used in the scheduling literature (Table 1).

Table 1
Summary of commonly used *LCs*

Model	Formulation	*Parameters*	*Feature*	*Reference*
Log-linear	$p_{ijr} = p_{ij} r^a$	a	Added the learning rate	Biskup (1999)
Dejong	$p_{ijr} = p_{ij}.(M + (1-M).r^a)$	a, M	Separation of manual and machine times	Okolowski & Gawiejnowicz (2010)
S-Curve	$p_{ijr} = p_{ij}.(M + (1-M).(r+B)^a)$	a, M, B	Adding Operator's experience	Jaber (2011)
Plateau	$p_{ijr} = C + p_{ij}.r^a$	a, C	Added Truncation effect using steady-state performance	Baloff (1971)

Proposed Hybrid LC: In our paper (Amirian & Sahraeian, 2015), we introduced a model based on the previous learning curves as (2.1). However, the model used *maximum* operator for truncation. This led to higher errors in comparison to the models such as Plateau that uses *addition* operator as a means of truncation. Hence, imitating Plateau *LC*, the model is modified as (2.2). This modification decreases the mean square error while maintaining the generalization of the model.

$$p_{ijr} = p_{ij}.(M_{ij} + (1-M_{ij}).\,max\{(B_j + r)^{a_i}, C_{ij}\}). \quad i = 1,...,m, j, r = 1,\dots,n \qquad (2.1)$$

$$p_{ijr} = p_{ij}.(M_{ij} + (1-M_{ij}).(C_{ij} + (B_j + r)^{a_i})). \quad i = 1,...,m, j, r = 1,\dots,n \qquad (2.2)$$

3 Which Learning Curve Should Be Used?

It's a constant challenge for managers to find the correct *LC* model for a work environment. The best way to make sure that the learning model is in tune with a particular production is by gathering the empirical data on the site. Then we can estimate the parameters by fitting the models to the data using mean square method (*MSE*). The *LC* with the lowest *MSE* is usually considered to be the most precise option. However, other factors such as the prediction ability of the model and the number of required parameters should be considered as well before choosing a learning model. An example is suggested by Zhang et al. (2014) for a construction project in China. The data for the accumulative average time needed to finish 40 levels of a high-rise project can be found at their paper. To test our hybrid model and compare it to the others, we fitted each model to the first 20 real data of the construction project and calculated the mean square error of each model in table 2. Then we predicted the 40 points using the fitted model in figure 1. As can be seen in table 2, the Dejong's and Plateau have the lowest *MSE*, closely followed by the proposed hybrid and log-linear model. *S*-curve, however, showed the worst performance. Now, let's examine figure 1, where the variance of achieved results from the real data for each model are plotted. Note that values close to zero are more desirable. As can be seen in figure 1, the proposed hybrid has the lowest variance in all 40 points which basically means it has found the real data with very little error.

Once again Dejong and Plateau show similar performance. Next comes log-linear, and finally *S*-curve shows the worst performance. However, in evaluating a *LC*, most researchers believe that the model with the lowest *MSE* is the best option. This is only partially true, since a mean square error which is calculated on limited data (e.g. 20 data here), does not guarantee a good prediction ability of that model for all the points (e.g. all 40 points). Now, in relation to human learning, there is always a point where the operator stops learning since s/he has fully grasped the workings of the process and from that point on there is no reduction in the processing times. Imitating the literature, we will call this phenomena the "truncation effect" and emphasize that only a model that takes this effect into account can be a good option. Among the available models, both the Plateau *LC* and the proposed hybrid model have this feature. However, our model takes into account the operator's former experience while Plateau *LC* forgoes this feature.

Table 2
Fitted function of different learning curves.

Learning model	Fitted function	*MSE*
Log-linear	$p_r = 10.97(r)^{-0.1665}$	0.0034
Dejong	$p_r = 2 + (11.035 - 2).(r)^{-0.2185}$	0.0028
S-Curve	$p_r = 2 + (14.158 - 2).(r + 2)^{-0.3184}$	0.0265
Plateau	$p_r = 1.73 + 9.29(r)^{-0.2097}$	0.0030
Proposed hybrid	$p_r = 2 + (14.54 - 2).\,(0.289 + (2 + r)^{-0.7822})$.	0.0034

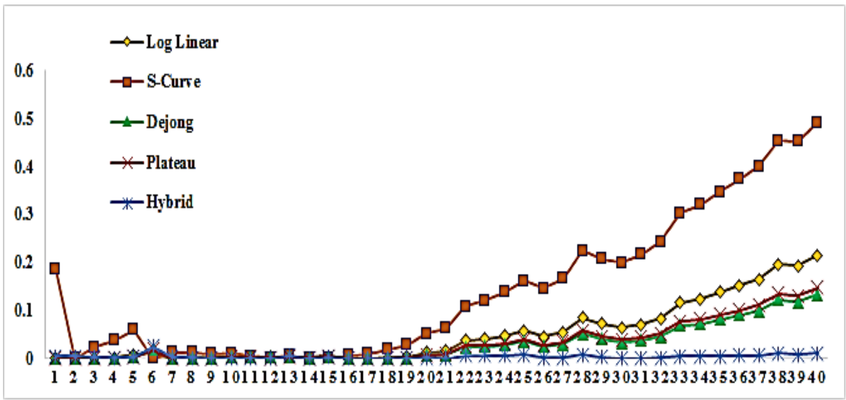

Fig.1
Variations of different learning curves from the actual data.

4 Application of Learning in Large Scale Flow shops

Among the different environments of scheduling, flow shops are of the most applicable and well-known systems, and have been proved to be strongly *NP*-hard. In a classic flowshop system, *n* jobs in sequence go through *m* machines one by one so that no machine can process more than one job at one point in time and vice versa. If the sequence of the jobs on all machines is the same, then the system is called permutation flowshop. In such systems, the goal is often to find the maximum completion time among the jobs on the last machine (i.e. the makespan). Due to the *NP*-hardness of the flowshop systems, meta-heuristics are usually proposed as solution techniques. Similarly, in this section, first a hybrid meta-heuristic is proposed and is used to calculate the makespan of *classic flowshop* benchmarks (Taillard, 1993). Once the algorithm is verified, we use it to solve the *learning effect flowshop* problems with each of the *LC*s previously presented.

4.1 Hybrid SOS-SA for Flowshop Scheduling

SOS (Cheng and Prayogo, 2014) is a newly introduced population based meta-heuristic. It begins with a randomly-generated population called ecosystem. Each individual (organism) in the population represents a candidate solution to the corresponding problem. The phases in *SOS* are governed by imitating the biological interaction between two random organisms in the ecosystem. These phases are mutualism, commensalism and parasitism. Mutualism is based on mutual benefit from a relation. Here, two organisms are selected randomly from the ecosystem (i.e. X_i, X_j). Then *Mutual Vector* is calculated as $MV = (X_i + X_j)/2$. Since in a relation, one party can gain more/less than the other, a benefit factor (*BF*) is introduced for each of the selected organisms. The new solutions in (4.1), (4.2) are calculated using X_{best} which is the best solution in the current population. The new solutions replace the older ones as long as they are better, otherwise they are discarded:

$$X_{i\,New} = X_i + rand(0,1).(X_{best} - MV.BF_1) \tag{4.1}$$

$$X_{jNew} = X_{ij} + rand(0,1).(X_{best} - MV.BF_2) \tag{4.2}$$

In commensalism phase, one individual benefits from the interaction while the other is unaffected. Here, organism X_i is selected randomly to be improved by another randomly chosen organism X_j as follows in (4.3). Once again the new solution is accepted only if it is better than the old one.

$$X_{i\,New} = X_i + rand(-1,1).(X_{best} - X_j) \tag{4.3}$$

Parasitism: Here, the relation between the selected organisms is harmful. First a vector X_i is selected and modified in some dimensions randomly. The resultant vector is called parasite vector which acts as a disease, ready to infect another organism X_j; known as host. If the parasite vector is better than the host X_j then it replaces it.

SOS is an easy and fast algorithm since it has few steps and given a good initial population it finds the global optimum in a short time. However, this algorithm is only tested in continuous space where *SOS* has been reported to show utmost precision (Cheng and Prayogo, 2014). When tested on a discrete problem such as flowshop system, however, more often than not, the algorithm finds a local optimum solution rather than the global optimum which shows low diversity in *SOS.* The concept of adding a powerful local search to a meta-heuristic has been employed by many researchers. Similarly, to improve *SOS* in diversity, we have added the conditional local search mechanism used in *SA* to the algorithm. This way, the population of individuals found in each iteration is improved greatly in diversity and somewhat in convergence before entering the *SOS* loop. Note that *SA* is employed on the whole population so that for every individual in the population, a neighbor is created, then the neighbor is evaluated against the original solution. If the neighbor is better, it replaces the original solution, if not, then the neighbor is accepted conditionally. For more information on *SA*, we refer the interested reader to Kirkpatrick et al. (1983). The combination of *SA* and *SOS*, returns good results in flowshop scheduling problems. A brief overview of this algorithm can be given as follows[2]:

Step 1: Problem definition, set SA parameters, maximum iterations, population size
Step 2: Initialization - Create random population and evaluate it
Step 3: Main Loop
For main=1: maximum iterations
Step 3-1: SA loop:
For out=1: outer loop
For in=1: inner loop
For pop=1: population size loop
Create Neighbor

2 The MATLAB implementation of this algorithm is stored at http://le-scheduling.blogfa.com/ for comparison purposes.

If the neighbor is better
Accept the neighbor
Else
Accept the neighbor conditionally
End if
End of population size loop
End of inner loop
Update the temperature
End of outer loop
End of SA Loop (Step 3-1)
Step 3-2: Sort Population
Step 3-3: SOS loop:
For i=1: population size
Mutualism Phase
Commensalism Phase
Parasitism Phase
End of SOS Loop (Step 3-3)
End of Step 3 (Main Loop)
Step 4: Display the results

The experiments are conducted on a PC with Intel i5 CPU @ 1.70 GHz with 4 GB of RAM with a population size of 100 and maximum iterations of 5 and 50 for the SA loop and the main loop respectively (i.e. 250 iterations overall). The code is tested on the first 10 Taillard's benchmark problems (i.e. *Ta001-Ta010*) to calculate the makespan and the results are shown in Table 3. The error ratio (*ER*) is calculated as $ER = (R - Opt) / Opt$ where *R* is the achieved result and *Opt* is the known optimal value of the objective extracted from the available benchmarks. Note that lower *ER* is more desirable since it shows higher precision.

Table 3
Testing hybrid *SOS-SA* on Taillard's benchmarks[1]

Model	Ta001	Ta002	Ta003	Ta004	Ta005	Ta006	Ta007	Ta008	Ta009	Ta010
Optimum Makespan	1278	1359	1081	1293	1235	1195	**1234**	1206	1230	1108
Makespan by *SOS-SA*	1278	1359	1081	1293	1235	1195	**1251**	1206	1230	1108
ER	0.00	0.00	0.00	0.00	0.00	0.00	**0.01**	0.00	0.00	0.00
Time	290.9	288.0	287.5	266.9	380.5	390.1	905.7	965.2	1147.3	1142.7

[1]The results are the best result of 10 runs and time is recorded in seconds

In table 3, out of 10 problems, *SOS-SA* found the best point for nine tests with the *ER* of zero which indicates the efficiency of the algorithm. For problem Ta007, the result is found by a 1% deviation (i.e. *ER*=0.01). We also test the effectiveness of adding *SA* to *SOS*. Table 4 shows the performance of *SOS* with and without *SA*. As can be seen in table 4, adding *SA* lowers *ER* which indicates higher precision. In table 5, *SOS-SA* is applied to the flow shop scheduling for different learning models and the results are reported. The learning parameters are set as $a = -0.322$, $M = 0.5, B = 0.5$ and C is set to 50% of the minimum processing times of all jobs. Since there is no benchmark on *learning effect flowshop*, the data in table 5 is given simply for comparison purposes.

Table 4
Testing *SOS* with and without *SA*
(The results are the *best* of 10 runs).

	Ta001	Ta002	Ta003	Ta004	Ta005	Ta006	Ta007	Ta008	Ta009	Ta010
ER (SOS)	0.014	0.005	0.019	0.019	0.012	0.012	0.013	0.014	0.020	0.013
ER (SOS-SA)	0.000	0.000	0.000	0.000	0.000	0.000	0.013	0.000	0.000	0.000
Best Solution found (SOS)	1297	1366	1102	1318	1250	1210	1251	1224	1255	1123
Best Solution found (SOS-SA)	1278	1359	1081	1293	1235	1195	1251	1206	1230	1108

Table 5
Makespan achieved by *SOS-SA* on different *LC* models[1]

Model	Ta001	Ta002	Ta003	Ta004	Ta005	Ta006	Ta007	Ta008	Ta009	Ta010
Log-linear	632.58	748.56	607.53	704.79	616.22	629.15	648.45	642.05	663.92	599.41
Dejong	940.29	1066.55	851.58	998.32	906.56	908.48	942.40	920.87	948.88	852.52
S-Curve	934.78	1047.33	835.78	982.40	901.14	898.53	933.30	911.95	932.75	841.34
Plateau	644.39	796.57	625.85	740.84	629.66	660.99	661.60	665.34	676.65	610.62
Hybrid	982.13	1079.19	855.58	1007.12	935.22	935.29	963.46	934.64	963.25	857.58

[1]The results are the best of 10 runs

It can be used in evaluating a meta-heuristic on *learning effect flowshop* when the results of a specific *LC* (e.g. log-linear) found by *SOS-SA* is compared to the results of the same *LC* (i.e. log-linear) found by any other meta-heuristic. It is illogical to compare the result of one *LC* to another *LC* since each of them follows different concepts and any of them can be employed in a work environment, it is only the matter of precision needed and the characteristics of the workplace. For instance if in a work place, low precision is sufficient, then log-linear model is the ideal choice since it has only one parameter and relatively acceptable precision. Similarly, if all the job is done manually then there is no need to use Dejong's model.

5 Conclusion and Future Works

In the present article, log linear, Dejong, *S*-curve, Plateau learning models are compared to a proposed hybrid learning effect. The results indicate that Dejong, Plateau and the proposed hybrid have similar precision while the hybrid model has the best prediction ability and generalization. These learning models are added to the classic flow shop problems which are solved by a hybrid meta-heuristic. The meta-heuristic (named *SOS-SA*) combines the robustness and efficiency of symbiotic organism search with the powerful local search and diversification method of simulated annealing. *SOS-SA* is then tested on Taillard's benchmarks and the results show its accuracy. In the future, we hope to develop more applicable learning models and solution techniques in different scheduling environments.

References

Amirian H, Sahraeian R (2015) Augmented ε-constraint method in multi-objective flowshop problem with past sequence set-up times and a modified learning effect. Int J Prod Res, DOI: 10.1080/00207543.2015.1033033

Biskup D (1999) Single machine scheduling with learning considerations. Eur J Oper Res 115: 173-178

Baloff, N (1971) Extension of the learning curve: Some empirical results. Oper. Res. Quarterly 22: 329-340

Cheng M, Prayogo D (2014) Symbiotic Organisms Search: A new meta-heuristic optimization algorithm. Comput Struct 139: 98–112

Jaber M-Y (2011) Learning curves: Theory, models, and applications. CRC Press

Kirkpatrick S, Gelatt C-D, Vecchi M-P (1983) Optimization by Simulated Annealing. Sci. 220: 671-680.

Okolowski D, Gawiejnowicz S (2010) Exact and heuristic algorithms for parallel-machine scheduling with DeJong's learning effect. Comput Ind Eng 59: 272-279

Taillard E (1993) Benchmarks for basic scheduling problems. Eur J Oper Res 64: 278–285

Zhang L, Zou X, Kan Z (2014) Improved strategy for resource allocation in repetitive projects considering the learning effect. J Constr Eng Manage, doi: 10.1061/(ASCE)CO.1943-7862.0000896

Applying social opinion mining to the innovative product design through the use of FITMAN / FIWARE technology

Anaya V[1], Ortiz A[2]

Abstract: The current manufacturing landscape is defined by a strong emphasis on innovation and design, in an ever increasing society that uses different electronic devices and where individuals and companies use diverse digital channels to give their opinion, to share knowledge or to communicate in general. IT trends have evolved from democratization of the web (web 2.0), to the analysis of unstructured data, handling of big amount of data and predictive analysis. There are sectors where some of those technologies are under test. All those enforce that differentiation is a competitive advantage only when products and services are covering customers' needs. This paper probe into how these techniques (analysis of unstructured data, social opinion mining, semantic annotation, etc) can be applied in the conceptualization phase of the product lifecycle to support designers in the innovative design of products, while considering the interaction with manufacturing restrictions. The provided solution is built on software modules develop in FITMAN (Fitman (2015)) and FIWARE (Fi-ware (2015)) European projects.

Keywords: Social opinion mining, product lifecycle, IT architectures, IT software platform.

1 Introduction

Collaboration is at the heart of any enterprise activity. Business processes running on enterprises and network of enterprises are fueled with collaboration among people where skills, resources, traits and information is exchanged with the aim of raising efficiency, competitiveness and generate common value benefiting the parts and the final customers (Ming X, et al (2008)).

Among the processes at the supply chain, such as customer service management or the manufacturing flow management, there is one where no so much work has been developed, the product development and commercialization (Lambert D, Cooper M (2000)). Product development has been considered an effort from a specific department within a company where an idea is translated to a prototype, but this approach is very limited, as it doesn't benefit from the knowledge and restrictions that suppliers and customers could bring to the table. Suppliers are decisive in an end-to-end competitive value proposition, and many innovative products are the result of new components coming for suppliers that are transform in business products by the marketing department in the manufacturing firm. A stronger exchange of decisional information flow is necessary between suppliers and the OEM, as the main focus of the supplier relationship management has been done on the operation exchange of lead-times, stock levels and the like.

In the other hand, the collaboration with the customer is a must have. Final customers determine with their purchases if brilliant products are worth it. Although co-creation is a topic where work is ongoing [3, 4], companies have not benefit widely from it. Finally, a less demanding approach for customers inclusion on product design is make the most of the information that millions of customers share in blogs and social networks. There is a lot of latent knowledge embedded and though some efforts have been done by different companies (See-To E, Ho K (2014)) the stated of acquisition by companies is really immature.

1 **Víctor Anaya** (vicanfon@upvnet.upv.es)
2 **Angel Ortiz** (aortiz@cigip.upv.es)
Research Center on Production Management and Engineering (CIGIP).
Polytecnical University of Valencia, Valencia, Spain.

Although there are already solutions trying to analyze the opinions of customers, influencers and competency, the current solution show how SMEs networks can build their own customized solutions builds on top of already existing software components provided by the FIWARE European project (Fi-ware (2015)) and FITMAN European project (Fitman (2015)). The approach of those projects is to provide a Rapid Application Development philosophy while keeping development costs low. They key point is that these kind of solutions are (i) affordable by SMEs networks, (ii) extensible and customizable to those SMEs that do not have so much bureaucracy as the large organizations and networks and need easy to use tools.

The present paper is the result of the development and deployment of a business platform on top of FITMAN [8, 10] and FIWARE [7, 9] results for social opinion mining that has been applied to the furniture sector. The development and research to these results has received funding from the European Community's Seventh Framework Program (FP7/2013-2015) under grant agreement n° FP7-ICT-FI.ICT-2011.1.8-604674.

2 Opinion mining in the Furniture sector

The current case has been carried out in the FITMAN project. The SMEs network of companies involved are AIDIMA, the technology institute furniture word and packaging, ARDI, and specifically, diseños tapizados muñoz, a manufacturer that assembles sofas and chairs, 3rd party designers, that design new lines for ARDI and material suppliers.

The problem addressed by the SMEs is not about production efficiency, but increase market grown in a sector where sales are decreasing. Pieces of furniture are a long life product and on a global market where price is a strong factor for sales, differentiation and customer satisfaction is mandatory.

The Opinion mining in furniture software is dealing with that problem, how to translate the voice of the customer to the conception phase in the product lifecycle and how this information can be useful for manufacturers, suppliers and designers. In the other hand, how all of the previous actors can exchange information to create the next blockbuster piece of furniture.

ADIMA's platform is composed of three different software tools that are being developed based on different compositions of the specific and generic enablers (FIWARE) and specific enablers (FITMAN), all of them deployed in a public cloud environment. As far as many of the information addressed is collected from already public information sources such as blogs, Facebook web pages and twitter accounts, and as the information collected could large depending on the project configuration, full-cloud environment will allow extensibility cost and performance advantages.

The new software solutions will address market growth and business sustainability in a business environment where design is already a commodity. The AIDIMA platform supports trends identification process, the mining of customer opinions and innovative and collaborative design process. The goal is not only create appealing-last-fashion furniture according to designers and influencers, but consider what the final customers are demanding.

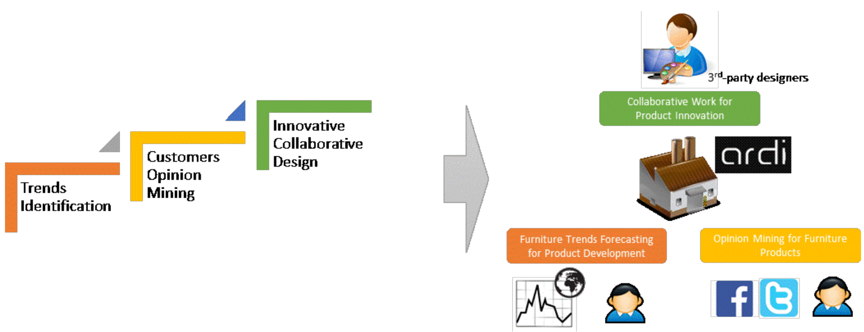

Fig.1
Main processes and software components.

The scope of this article is to explain the opinion mining for the furniture products. The application developed supports 3rd party designers working for ARDI in conception phase of new lines of products. The conception phase is a creative phase where new ideas, research and problem solving are intertwined, and where the only limits of a designer are the restrictions that materials impose on dimensions, shape, ergonomics and price, and the manufacturing process as far as some of the sketches generated by the designers could not be feasible from a manufacturing point of view.

Ideas generated by the designers must be driven by the interest that final customers can have on it. If the final customer do not show interest by its own and neither the influencers (such as relevant designers or furniture fairs), the ratio of appealing could show that the idea or product brief could not have a market, so that it should be changed.

When designers analyze the different criteria of their ideas and sketches, the opinion mining in furniture products software tool provides a way to evaluate the sentiment of the customers. First of all, the solution provided has taken profit of the the Anlzer specific enabler developed by the DSSLab at the National Technical University of Athens (Anlzer (2015)). This specific enabler is parameterized with the sources of information that designers, manufacturers, suppliers and other relevant partners such as AIDIMA, consider relevant. The tool is configured with blog sources, twitter accounts and Facebook accounts and starts collecting information from those unstructured data sources and analyzing opinions from them. The opinions go through a data mining engine that analyses them and according to an ontology tags opinions on positive, negative or neutral opinions and store all that information. The system could be trained.

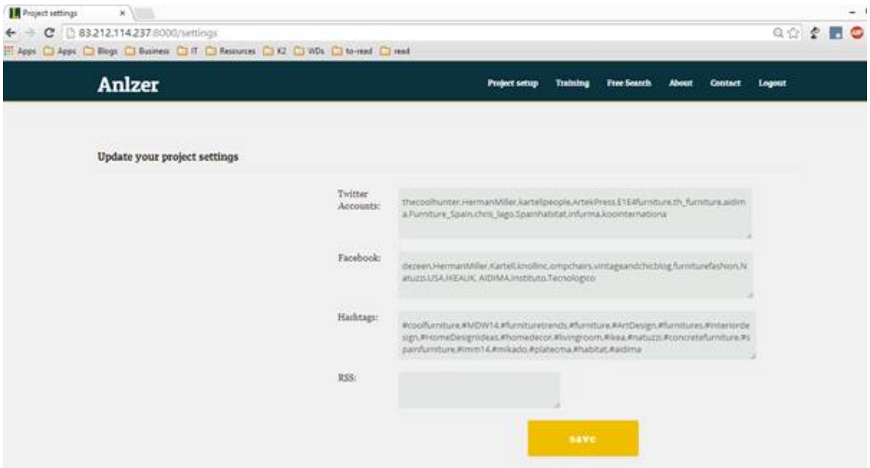

Fig.2
Anlzer screen for project set up (Anlzer (2015))

When the system is configured and trained (Anlzer (2015)), and enough information is gathered, the designers can submit search words to evaluate the sentiment of customers / influencers on those topics. For that purpose UPV has developed an easy to use interface using the information retrieved by the Anlzer (see picture below). That is a good practice on how FITMAN can accelerate the development of solutions improving the time to market to get IT technology that can support manufacturing processes.

The interface developed by UPV is intended for retrieving thoughts/sentiments that people have on issues that affect the product design, such as materials, sizes, kind of furnitures, and so on. The tool provides a set of statistics such as a pie chart with the whole sentiment percentage is shown, the sources of information of the opinions retrieved, the evolution of the sentiment along the time and photos and specific opinions retrieved.

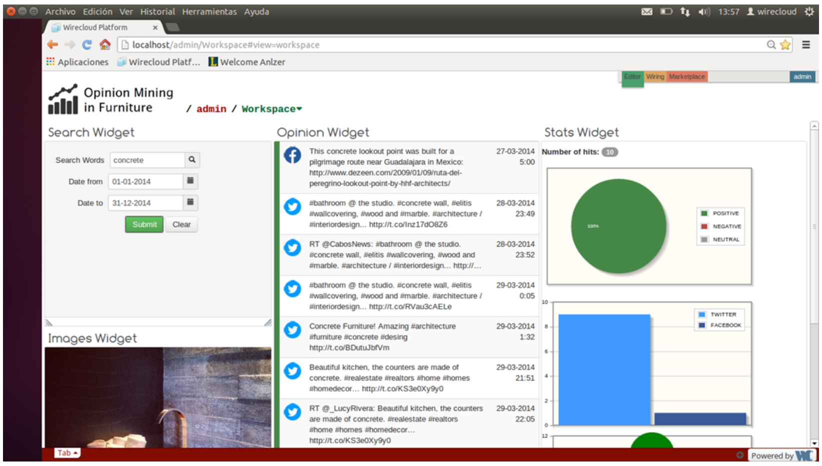

Fig.3
Opinion mining for furniture product software.

That is the point where decisions much be taken considering what the market segment is thinking about your search words.

3 Software architecture affordable to SMEs networks

The Opinion mining for furniture products is based on already existing software components building blocks from the FIWARE European project (Fiware catalogue (2015)), and the FITMAN European project (Fitman catalogue (2015)). FI-WARE (Fi-ware (2015)) is an innovative, open cloud-based infrastructure for cost-effective creation and delivery of Future Internet applications and services, at a scale not seen before. FI-WARE API specifications are public and royalty-free, driven by the development of an open source reference implementation which accelerates the availability of commercial products and services based on FI-WARE technologies. The large catalogue of fi-ware composed are divided 6 areas: data/context management, internet of things, Security, Cloud Hosting, Applications/Services ecosystem and Interface to Networks and Devices.

FITMAN (Fitman (2015)) uses FI-WARE components to build use cases and software specific open source components focused on the future of the manufacturing companies (Fitman catalogue (2015)).
The architecture of the Opinion Mining for the furniture products is shown in the following picture.

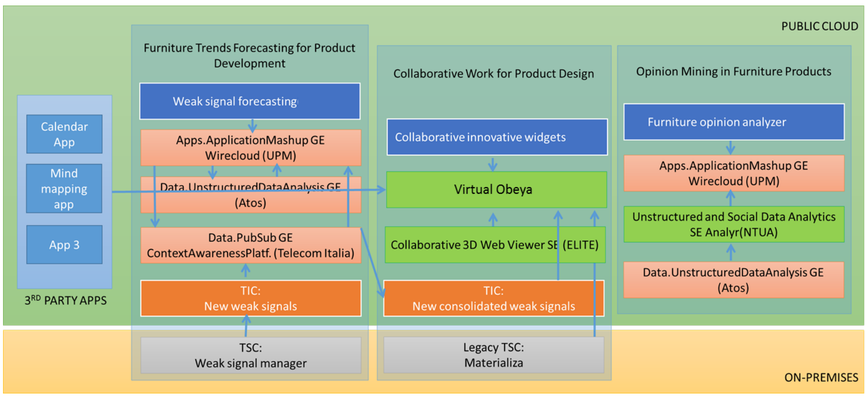

Fig.4
AIDIMA trial cloud architecture strategy.

The tool is based on a software components generated on FIWARE (Wirecloud mashup platform by the Conwet lab from the Polytechnic University of Madrid [9, 12]) and one component generated in FITMAN (the Unstructured and Social Data Analytics SE Anlzer by the DSSLab of the National Technical University of Athens (Anlzer (2015))).

The architecture of the unstructured and social data analytics component (Anlzer (2015)) shows how information collected nowadays is unstructured and the traditional ways of managing that information are ineffective. The raise of NoSQL database systems, such as the document NoSQL databases, allow the indexing and effective search of information and media in the current web.

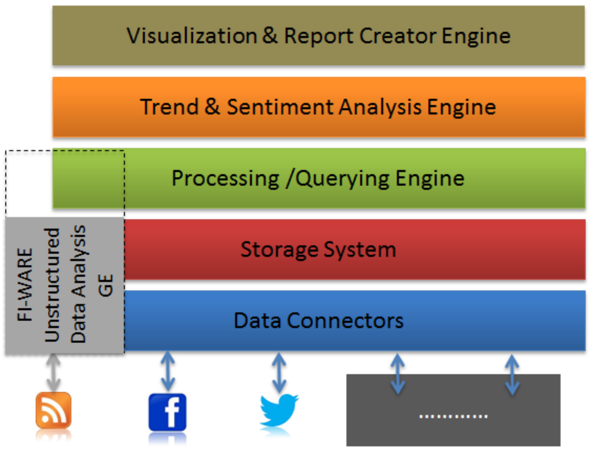

Fig.5
Technology Stack of "Unstructured and Social Data Analytics" Specific Enabler (Wirecloud (2015))

4 Project outcomes and Impact

The business objectives of the current work are to gain access to customer's latent demands and suggestions expressed as online comments and opinions for improving user-centered product development, while building a solution from already existing software components.
The expected benefits for this use case will have a really positive impact on and will enhance the product quality and demand response skills of product designers since they will be able to get "closer" to real customer demands.

The success of the tool is measure through the application of it, but also from the development of it, as far as the building of the solution from existing components allow to make customizations to the final solution depending on the company that the tool is applied to.

Business indicators are derived from the impact that the software has had in the process that supports, the product innovation phases on the product design lifecycle.

Some of the KPIs measured to assure the success of the project are:

- % of sources managed by the tool: % of sources of information that were handle manually and are now handle using the tool. 72% of sources are now processed with the tool
- % Increase in number of trends: Nº of trends / terms identified and its comparison with the previous numbers. 26% of additional trends.
- % Time cycle reduction: Time to analyze social information. The application reduced the time cycle in a 40%. Automation of information treatment and better index cards management required less time.
- Number of trends than impacted in the design of a line of furniture pieces. To be measured yet, however in a qualitative senses, now it is possible to track this information with third-party designers.

References

Lambert D, Cooper M (2000) Issues in Supply Chain Management. Industrial Marketing Management. Volume 29, Issue 1, January 2000, Pages 65–83.

Ming X, et al (2008) Collaborative process planning and manufacturing in product lifecycle management" Computers in Industry 59, no. 2 154-166.

Durugbo C, Pawar K (2014) A unified model of the co-creation process, Expert Systems with Applications, Volume 41, Issue 9, July 2014, Pages 4373-4387, ISSN 0957-4174, http://dx.doi.org/10.1016/j.eswa.2014.01.007.

Hoyer W, Chandy R, Dorotic M, Krafft M, Singh S (2010). Consumer cocreation in new product development. Journal of Service Research, 13(3), 283-296.

Martini A, Massa S, Testa S (2014) Customer co-creation projects and social media: The case of Barilla of Italy, Business Horizons, Volume 57, Issue 3, May–June 2014, Pages 425-434, ISSN 0007-6813, http://dx.doi.org/10.1016/j.bushor.2014.02.003.

See-To E, Ho K (2014) Value co-creation and purchase intention in social network sites: The role of electronic Word-of-Mouth and trust – A theoretical analysis, Computers in Human Behavior, Volume 31, February 2014, Pages 182-189, ISSN 0747-5632, http://dx.doi.org/10.1016/j.chb.2013.10.013.

Fi-Ware (2015) FI-WARE FI-PPP European project, http://www.fi-ware.org/, last accessed, April 2015.

Fitman (2015)FITMAN FI-PPP use case European project, http://www.fitman-fi.eu/, last accessed, April 2015.

Wirecloud (2015). http://conwet.fi.upm.es/wirecloud/, last accessed, April 2015.

Anlzer (2015) http://catalogue.fitman.atosresearch.eu/enablers/unstructured-and-social-data-analytics, last accessed, Feb 2015.

FITMAN catalogue (2015) http://catalogue.fitman.atosresearch.eu/, last accessed, Feb 2015.

FIWARE catalogue (2015) http http://catalogue.fi-ware.org/, last accessed, Feb 2015.

A Theoretical Framework Proposal for Formalization in Reverse Logistics

Han H[1], Ponce-Cueto E[2]

Abstract: Formalization can help firms better manage their reverse logistics operations. The main goal of this paper is to propose a theoretical framework to help companies formalize their reverse logistics programs. The theoretical model provides executed instructions for firms formalization, with written rules and standard procedures, in consequence to better control their reverse logistics. The theoretical structure covers all the stages in reverse logistics, from return collection to sorting and treatment processes. Companies can set up and improve their own formalization system based on the theoretical framework proposed in this paper.

Keywords: Theoretical framework; Formalization; Reverse logistics.

1 Introduction

Reverse logistics (RL) emerged because of government enforcement, consumer awareness and social responsibilities towards environment. Recently RL has received increasing attention due to economic value potentials from the returned products. There are different ways to classify the returns. According to Toktay's classification, two major types of returned merchandises are considered. One type is used returns, where the product has been used by the customer, the other is in the form of commercial returns, where the commodity is returned before use (Toktay, 2003).

Used returns include warranty return, reusable articles, product recalls, end-of-use return (EOU) and end-of-life return (EOL).

In accordance with Guide et al. (2006), the return rates vary widely by product category, by season, and across global markets. For example, the average e-commerce return rates are between 20 to 30 percentages (Fabrikant, 2013). Large traditional retailers, such as Home Depot, can have return rates of 10% of sales or even higher due to liberal returns policies (Guide and Van Wassenhove, 2009). Interviews conducted by Richey et al. indicated fashion apparel (particularly women's clothing) to be one of the highest return categories. One major catalogue retailer reported returns in the women's apparel category exceeding 60% (Richey et al., 2005). A survey of catalogue retailers of electronics products declared an average return rate of 9.71% (Daugherty et al., 2001).

The beneficial impact of formalized returns is gaining a widespread recognition from academics and practitioners (Daugherty, 2011; Stock and Boyer, 2009; Sachan and Datta, 2005; Tibben-Lembke, 2002). Generally formalization of reverse logistics can improve firm efficiency, because standardizing repetitive activities eliminates the need to treat every event as a new decision. The benefit is particularly obvious among companies, which fiercely compete on the basis of customer service in the modern marketplace (Cottrill, 2003; Merritt, 2001).

1 **Hui Han** (hui.han@alumnos.upm.es)
Department of Industrial Engineering, Business Administration and Statistic
E.T.S. Industrial Engineering, Universidad Politécnica de Madrid
C/ José Gutiérrez Abascal 2, 28006 Madrid, Spain
The first author is funded by the China Scholarship Council (CSC) from the Chinese Ministry of Education
2 **Eva Ponce-Cueto**, PhD (eva.ponce@upm.es)
Department of Industrial Engineering, Business Administration and Statistic
E.T.S. Industrial Engineering, Universidad Politécnica de Madrid
C/ José Gutiérrez Abascal 2, 28006 Madrid, Spain

However, numerous companies would seem to have no consistent formalization system to tackle with returns. In the research study conducted by Tibben-Lembke in 2002, more than one third of survey respondents demonstrated that inadequate and/or misdirected formal policy represents a main barrier to success in reverse logistics program (Tibben-Lembke, 2002). Formalization is widely accepted to improve firm performance. In reality, the lack of formalized reverse logistics programs/ processes to deal with the massive volumes of returns in modern companies, is somewhat surprising (Autry, 2005).

Formalization can help firms better manage their reverse logistics operations. The related question "how to formalize reverse logistics?" becomes the next step in many companies. Therefore providing a theoretical structure to help companies realize reverse logistics formalization becomes a necessity (Genchev et al., 2011).

The main goal of this paper is to develop a theoretical model to help firms achieve formalization in reverse logistics. Based on this model, firms can set up or better design their own formalized reverse logistics systems varying by different companies and industries.

The paper is organized as follows: first, introduce the formalization concept and the RL process formalization; second, provide a RL formalization model according to theoretical study; third, outline the relevant managerial implications; and finally, conclusions and future research lines are presented.

2 Formalization

Practitioner perspectives (Sachan and Datta, 2005; Stock and Boyer, 2009) and also relevant scientific researchers (Daugherty, 2011; Tibben-Lembke, 2002) point out that formalization is necessary for managing all aspects of the reverse logistics, including the returns activities and relevant services for customers (Genchev et al., 2011). The rise in commercial returns has prompted many companies to work to formalize their reverse logistics processes in recent years (Malone, 2004).

2.1 Description

Formalization has been described by Pugh et al. (1968) in page 75 as:

> Formalization denotes the extent to which rules, procedures, instructions, and communications are written (Pugh et al., 1968).

Formalization implies that control mechanisms take the form of written regulations or contractual obligations (Price et al., 1980)

Ruekert et al. (1985) defined formalization as control mechanisms such as rules, processes, or procedures guide intra-firm or inter-firm operations (Ruekert et al., 1985).

Formalization can be implemented with such tools as articulated and/or written policies, job descriptions and roles, organizational-responsibility charts, strategic and operational plans, objective setting systems, standardization of processes, and formalized communication systems, both intra and inter-firm (Dahistrom et al., 1996; Genchev et al., 2011; John and Martin, 1984; Robert Baum and Wally, 2003; Schwenk and Shrader, 1993).

Formalization is defined as the agreed-upon written rules and procedures regarding a particular business operation (Genchev et al., 2011).

2.2 Characteristics

More and more researchers notice the importance of formalization in reverse logistics, and the research contributions on this topic is increasing since 1985. Practitioners and academics have studied formalization from different aspects. Table 1 summarized the formalization characteristics based on the review from the academic scientific papers in this relevant area.

Table 1
Main characteristics of formalization process
based on the literature review (own development).

Content	Literature
Benefits of Formalization	
Efficiency	Ruekert et al., 1985; Walker and Ruekert, 1987; Bowersox and Daugherty, 1992; Bowersox et al., 1992; Richey et al., 2005; Autry, 2005
Simplify Complex Business Programs	Walsh and Dewar, 1987
A Crucial Component of Control System	Eisenhardt, 1985; Dahlstrom and Nygaard, 1999
Reduce Ambiguity and Uncertainties	Davenport and Beers, 1995; Yeung, 2008
Streamline RL Operations	Norek, 2002; Rogers and Tibben-Lembke, 1999
Decrease Costs	Genchev et al., 2011
Negatives of Formalization	Eisenhardt, 1985
Formalization Scales and Measurement Items	Ferrell and Skinner, 1988; Dahlstrom and Nygaard, 1999; Ayers et al., 1997; Sohi et al., 1996; Dahistrom et al., 1996; Robert Baum and Wally, 2003; Song and Parry, 1993
Others	
Compare Benefits and Negatives	Bowersox et al., 1992
Difference between Formalization and Control	Papadakis et al., 1998; Genchev et al., 2011

2.2.1 Benefits and disadvantages of Formalization

Main benefits for companies that adopt formalization are summarized in Table 2.

Table 2
Benefits of formalization in reverse logistics operations.

Benefits	Brief description
Efficiency	Formalization of internal operations increased the efficiency by the use of standards operating procedures and rules. External operations are also formalized (e.g. contracts with other actors) (Autry, 2005)
Better control of operations	Formalization helps to monitoring the system and contribute to a better control
Streamlining RL operations	Formalization helps to rationalize and simplify the RL operations
Reduce ambiguity and uncertainty	Formalization helps to know exactly the procedure to manage the returns flow, which contributes to reduce various uncertainties (relating to the RL program) and ambiguity
Decrease costs	Formalization system provides instructions to customers specifying how to return their products, ways to be shipped, who pays for the shipping costs, and where to return merchandise. To have a clear process reduce time and cost along the process

Potential disadvantages of formalization could be: the reduction of operational flexibility, since it is mandatory to follow the procedures and the rules; inhibit innovation, since it is necessary to follow the process defined (Eisenhardt, 1985); and finally could generate paperwork and a lot of administrative tasks.

3 Theoretical Framework

In order to help firms better control of their reverse logistics, we propose a theoretical framework to formalize their reverse logistics operations. The framework proposed refers to manufacturing companies, retailers, wholesalers, distributors, agents, resellers and third-party logistics providers (included in (3)), each of which is critical in the processing of returns. In addition, the companies in the model were involved with various types of returned merchandise, which are commercial product and used product respectively (which are more complexity). While used product includes reusable articles, product recalls, warranty return, end-of-use return and end-of-life return (see Figure 1).

We divide the whole reverse logistics processes into returns generation (1), transporting returned products to collection points (2), receiving returns at collecting points (3) and treating returned merchandises (in-house or outsourcing) (see Figure 1). In the returns treating facilities, there are two main operations: inspection/separation procedure and re-processing procedure (see Figure 2). According to formalization definition, every procedure is offered with detailed instructions, which serve as formalization tools for companies to follow.

3.1 Formalization for Generation, Transportation and Collection

Figure 1 shows the overall reverse logistics process that we propose as a theoretical framework for conducting a formalization process in reverse logistics.

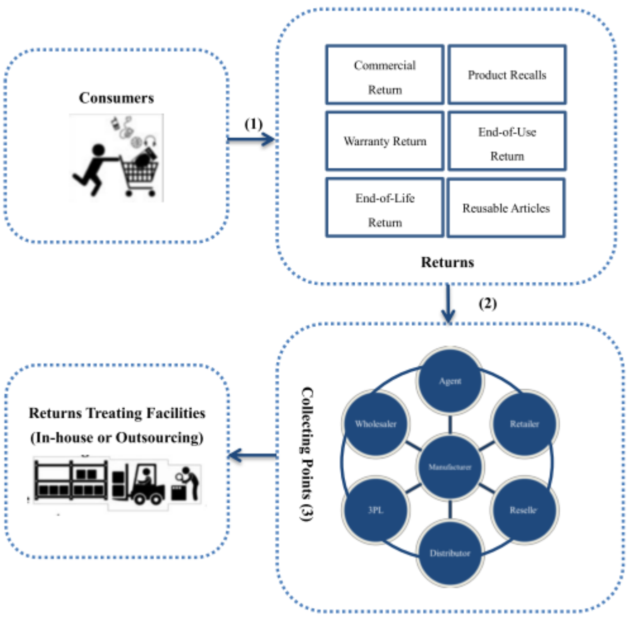

Fig.1
Theoretical framework for formalization
in Reverse logistics (own development).

For generating returns, we provide formal rules and standard procedures that govern return authorization requests. Then there are formal returns shipping guidelines to transport returned products. At collecting points different contract requirements are afforded. More details are shown as below:

Table 3
Formalization for generation, transportation and collection of returns.

Procedure	Formalization
1. Return authorization (RA) information (the formal rules and procedures that govern RA requests)	• Methods: –24/7 artificial service call – Easy-to-use online tool – Customer service sites • The return profile (electronic profile) – Product specifications: invoice number/part number, quantity/invoice age, the unit price, the customer reference number, and the item's(s') serial number(s) – The reasons for the return – Other specific customer requirements: crediting, disposition options and return time • Procedures – Finish the return profile – Based on written rules (such as return product eligibility requirements) to respond: Approve, Deny, Review, Mix – After the request has been approved, the relevant department has assigned the return an RA number, then consumers can send back the product.
2. Formal return shipping guidelines	– Any costs for return goods? – Who pays shipping for the returning goods? and (if applied) who pays for the replacement goods? – Where the goods can be returned? Collection points options – When they will receive a credit or replacement item? – How long they have to perform a return? – What kind of transportation service providers (for example, small-package returns by truck while heavy weight returns both air and ground) – How to send back the return? (size/weight, specific service-level agreements such as same-day delivery vs. three working days, different carriers)
3. Contracts between these collecting points	– Returns allowance – Logistical control – Different treatments on returns' conditions: factory sealed product, product damaged in transit, vendor quality defect, wrong product received, product recall, EOL return and EOU return – Agreed negotiation rules with customers (customers service-level agreements, consistent credit system) – Responsibilities

3.2 Formalization for Treating Returns

Treating returned merchandises are divided into two parts: inspection/separation and re-processing. At the same time, firms could choose two ways to treat their returns (in-house or outsourcing).

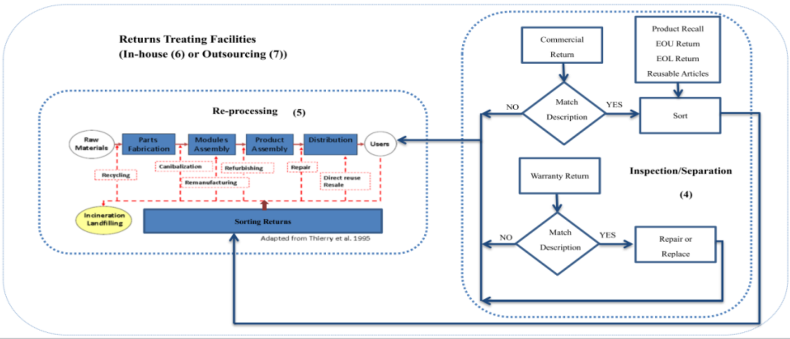

Fig.2
Returns treating model (own development and adapted from Thierry et al. 1995).

Based on Figure 2 illustration, we supply formalized instructions in details as below:

Table 3
Formalization for treating returns (own development).

Procedure	Formalization
4. Formalized inspection/separation	•Commercial return and warranty call –If the physical condition of the product matches electronic profile about customer RA request, according to predetermined policy and individual service level agreements, inspector assigns a disposition code for the return. For warranty call, repair and replacing will be carried out, then send back consumers. –If not, according to official exceptions policy, inform consumers immediately with a detailed description of the problem, for the sake of proof explanatory photos may be added. •Product Recall, EOU Return and EOL Return –Enforced environmental legislation such as Extended Producer Responsibility (EPR) and WEEE Directive –Environmental Management Standard ISO 14000 / ISO 14001 –Take-back obligations
5.Re-processing	–Direct reuse/Resale –Repair –Refurbishing –Remanufacturing –Cannibalization –Recycling –Incineration/Landfilling
6. In-house	–Formal work instructions –Sequence of information process activities – Information system for administrative order processing and production control – Job descriptions – Formalized hierarchical structure – Formalized consultative structure
7. Outsourcing (contracts with third party logistics providers)	–Aid the return process (scheduling the pickup and transportation) –Collect customer information –Track the status of returned items –Value added services –Waste handling

Finally we especially mention the third-party logistics (3PL). While recognizing the importance of reverse logistics, companies and especially e-businesses are increasingly outsourcing their reverse logistics efforts to 3PL providers. On the one hand, reverse logistics could be extremely complex and very important. On the other hand, many firms have limited resources. Outsourcing reverse logistics operation to 3PL is optimal choice for them (Cottrill, 2000; Krumwiede and Sheu, 2002).

4 Managerial Implications

The more formalized reverse logistics processes become, the more performance gains (such as reduced inventory investment or increased profitability) yield by returns handling capabilities. We provide implications for managerial practices to the efficient and effective of formalization.

First, attracting senior management attention and support seemed to be the most difficult task regarding returns. Managers should come to realize that formalized handling of reverse logistics could bring social and economic benefits. Furthermore, managers should request feedback from both employees and customers to assess the viability of the policies from a practical standpoint, and should insure that reverse logistics policies are consistent with firm strategic goals (Autry, 2005).

Secondly, clear responsibilities must be assigned to return programs (initiating returns, transporting returned products, receiving returns at collecting points and treating returned merchandises, accounting, sales, finance, marketing), in order to increase the efficiency and effectiveness of formalization in reverse logistics (Genchev, 2009).

Finally, to develop formal written policies and procedures, relatively moderate investment is required in terms of time and resources, such as internal and global transparency, flexibility in changing controls, reduce complexity, widespread process control.

5 Conclusions and Future Research

The theoretical model maps out the reverse logistics program, and identifies the different procedures directly or indirectly involved in returns handling. Simultaneously, from return generation with formal return authorization system, to receiving and inspection/separation, to re-processing the returns, written rules and standard procedures are provided to guide execution. Companies (manufacturers, retailers, wholesalers, distributors, agents, resellers and third-party logistics providers) can set up or improve their own formalization system based on the theoretical structure. By pinpointing the corresponding rules to each procedure, the model motivates relevant customers to actively participate in reverse logistics. Also the theoretical framework articulating characteristics of reverse logistics system itself, may contribute to enable nature of formalization.

The theoretical model is proposed according to existing studies and literature resources, which is limited to just theoretical and methodological considerations. Consequently, in the future research, we propose to directly collect managerial practices data in a reverse logistics context, through in-depth interviews and observation from field study, in order to apply and assess the theoretical model proposed.

Reference

Autry CW (2005) Formalization of reverse logistics programs: A strategy for managing liberalized returns. *Industrial Marketing Management*, 34(7): 749–757.

Ayers D, Dahlstrom R and Skinner SJ (1997) An Exploratory Investigation of Organizational Antecedents to New Product Success. *Journal of Marketing Research*, 34(1): 107–116.

Bowersox DJ and Daugherty PJ (1992) Logistics leadership-Logistics organizations of the future. *Logistics Information Management*, 5(1): 12–18.

Bowersox DJ, Daugherty PJ, Droge CL, et al. (1992) *Logistics Excellence: It's Not Just Business as Usual*. Burlington: MA7 Digital Press.

Cottrill K (2000) Return to sender. *Traffic World*, 262(7): 17–18.

Cottrill K (2003) *Reversal of fortunes*. *Traffic World*.

Dahistrom R, McNeilly KM and Speh TW (1996) Buyer-Seller Relationships in the Procurement of Logistical Services. *Journal of the Academy of Marketing Science*, 24(2): 110–124.

Dahlstrom R and Nygaard A (1999) An Empirical Investigation of Ex Post Transaction Costs in Franchised Distribution Channels. *Journal of Marketing Research*, 36(2): 160–170.

Daugherty PJ (2011) Review of logistics and supply chain relationship literature and suggested research agenda. Crum M (ed.), *International Journal of Physical Distribution & Logistics Management*, 41(1): 16–31.

Daugherty PJ, Autry CW and Ellinger AE (2001) REVERSE LOGISTICS: THE RELATIONSHIP BETWEEN RESOURCE COMMITMENT AND PROGRAM PERFORMANCE. *Journal of Business Logistics*, 22(1): 107–123.

Davenport T and Beers M (1995) Managing Information about Processes. *Journal of Management Information Systems*, 12(1): 57–80.

Eisenhardt KM (1985) Control: Organizational and Economic Approaches. *Management Science*, 31(2): 134–149.

Fabrikant G (2013) A Generation Gap? Not on This Web Site. *New York Times*, Available from: http://www.nytimes.com/2013/01/13/fashion/a-20-somethings-web-site-for-women-over-40.html?_r=1& (accessed 23 February 2015).

Ferrell OC and Skinner SJ (1988) Ethical Behavior and Bureaucratic Structure in Marketing Research Organizations. *Journal of Marketing Research*, 25(1): 103–109.

Genchev SE (2009) Reverse logistics program design: A company study. *Business Horizons*, 52(2): 139–148.

Genchev SE, Richey RG and Gabler CB (2011) Evaluating reverse logistics programs: a suggested process formalization. *The International Journal of Logistics Management*, 22(2): 242–263.

Guide VDR and Van Wassenhove LN (2009) The Evolution of Closed-Loop Supply Chain Research. *Operations Research*, 57(1): 10–18.

Guide VDR, Souza GC, Van Wassenhove LN, et al. (2006) Time Value of Commercial Product Returns. *Management Science*, 52(8): 1200–1214.

John G and Martin J (1984) Effects of organizational structure of marketing planning on credibility and utilization of plan output. *Journal of Marketing Research*, American Marketing Association, 21(2): 170–183.

Krumwiede DW and Sheu C (2002) A model for reverse logistics entry by third-party providers. *Omega*, 30: 325–333.

Malone R (2004) Closing the Supply Chain Loop: Reverse Logistics and the SCOR Model. *Inbound Logistics*, 24(1): 217–222.

Merritt K (2001) Integrated reverse logistics solution allows Levi Strauss to profit off returns. In: *Frontline Solutions*, p. 41.

Norek CD (2002) Returns management: making order out of chaos. *Supply Chain Management Review*, 6(3): 34–42.

Papadakis VM, Lioukas S and Chambers D (1998) Strategic Decision-Making Processes: The Role of Management and Context. *Strategic Management Journal*, 19(2): 115–147.

Price JL, de Ven AH Van and Ferry DL (1980) Measuring and Assessing Organizations. *Administrative Science Quarterly*, Wiley, 26(2): 324.

Pugh DS, Hickson DJ, Hinings CR, et al. (1968) Dimensions of Organization Structure. *Administrative Science Quarterly*, Administrative Science Quarterly, 13(1): 65–105.

Richey RG, Chen H, Genchev SE, et al. (2005) Developing effective reverse logistics programs. *Industrial Marketing Management*, 34(8): 830–840.

Robert Baum J and Wally S (2003) Strategic decision speed and firm performance. *Strategic Management Journal*, 24(11): 1107–1129.

Rogers DS and Tibben-Lembke RS (1999) *Going Backwards : Reverse Logistics Trends and Practices*. RLEC Press. *Logistics Management*, Pittsburgh.

Ruekert RW, Walker OC and Roering KJ (1985) The Organization of Marketing Activities: A Contingency Theory of Structure and Performance. *Journal of Marketing*, 49(1): 13–25.

Sachan A and Datta S (2005) Review of supply chain management and logistics research. *International Journal of Physical Distribution & Logistics Management*, 35(9): 664–705.

Schwenk C and Shrader C (1993) Effects of formal strategic planning on financial performance in small firms: A meta-analysis. *Entrepreneurship: Theory & Practice*, 17(3): 53–64.

Sohi RS, Smith DC and Ford NM (1996) How does Sharing a Sales Force between Multiple Divisions Affect Salespeople? *Journal of the Academy of Marketing Science*, 24(3): 195–207.

Song XM and Parry ME (1993) R&D-marketing integration in Japanese high-technology firms: Hypotheses and empirical evidence. *Journal of the Academy of Marketing Science*, 21(2): 125–133.

Stock JR and Boyer SL (2009) Developing a consensus definition of supply chain management: a qualitative study. *International Journal of Physical Distribution & Logistics Management*, 39(8): 690–711.

Tibben-Lembke RS (2002) Life after death: reverse logistics and the product life cycle. *International Journal of Physical Distribution & Logistics Management*, 32(3): 223–244.

Toktay B (2003) Forecasting Product Returns. In: *Business Aspects of Closed-Loop Supply Chains - Expoling the Issues*, pp. 203–220.

Walker OC and Ruekert RW (1987) Marketing's Role in the Implementation of Business Strategies: A Critical Review and Conceptual Framework. *Journal of Marketing*, 51(3): 15–33.

Walsh J and Dewar R (1987) Formalization and the organizational life cycle. *Journal of Management Studies*, 24(3): 215–231.

Yeung ACL (2008) Strategic supply management, quality initiatives, and organizational performance. *Journal of Operations Management*, 26(4): 490–502.

Genetic algorithms applied in realistic job-shop scheduling problems with alternative routes and dependent setup times

Branco R[1], **Coelho A**[2], **Mayerle S**[3]

Abstract: This paper discusses the application of heuristic-based evolutionary technique in search for solutions concerning the dynamic job-shop scheduling problems with dependent setup times and alternate routes. With a combinatorial nature, these problems belong to an NP-hard class, and they have an aggravated condition regarding their application in realistic, dynamic and more complex cases than the traditional static ones. At first, due to the flexibility of routes, the routes are chosen and then the activities scheduling in relation to a particular planning horizon. Considering that setup times are dependent upon these choices, the proposed genetic algorithm combines these two phases and applies heuristics to accelerate genetic convergence, but without losing the homogeneity of the population.

Keywords: genetic algorithms; dispatching rules; scheduling in job-shop.

1 Introduction

The growing competition from companies, arising from the market globalization, calls their attention to quality and productivity, focusing on the relationships in the supply chain and with the flexibility increasing the efficiency in manufacturing.

In this context, the Flexible Manufacturing System (FMS) combines high flexibility, productivity and low levels of stock: characteristics that accept the alternative routes of production and make it more agile and robust in face of failures. So, if a machine breaks during a task, a reschedule to find an alternate route is done to finish this job, respecting due dates already planned. (Porter et al, 1999; Chan, 2003).

In respect to manufacturing systems directly involved with cells and FMS, Porter et al (1999) and Matsuzaki (2004) point to the job-shop class in the production of small volumes and more variety of concurrent processes. In general, the job-shops are process-oriented production systems and obey a pre-defined sequence of processing. The scheduling problems are widely studied because they assume difficult conditions to solve in polynomial time (NP-hard), due to their combinatorial nature (allocating machines to produce parts). Also, the flexibility of alternate routes increases the combinations of resources to compose sequences, promoting even more complexity.

The literature also presents researches involving the SDST-JSSP - Sequence Dependent Setup Times Job-Shop Problems, which are classic JSSP extensions and in which a setup time between two consecutive operations is required. These extensions make the classic cases closer to realistic situations and more complex.

In dynamic cases, another extension commonly seen is the NDD-JSSP - Non Deterministic Dynamic Job Shop Problems, which differs from classical because the process does not start at time 0, with strong random characteristics over starting times and thus, also very close to realistic cases found in industries.

1 **Rogério Malta Branco** (rogerio.branco@gmail.com)
Couse of Industrial Automation.
IFRS Campus Rio Grande. Rio Grande, RS, Brazil.
2 **Antônio Sérgio Coelho** (coelho@deps.ufsc.br)
3 **Sérgio Fernando Mayerle** (mayerle@deps.ufsc.br)
Dept. of Production Engineering.
Universidade Federal de Santa Catarina. Florianópolis, SC Brazil.

Regarding this perspective, this paper propounds combined heuristics techniques and genetic algorithms to solve the combination of these two kind of problems, called NDD-SDST-JSSP. The scheduling algorithm contemplates the goals of shorter processing time and delivery due dates and considering machinery breaks, late start times, variations in processing times of tasks and dependent setup times. Also, there's another one that forms routes and their internal sequencing, integrated in the GA's evaluation function.

2 The JSSP problem

The scheduling problems belong to the NP-hard problems and exact methods are applied only for relatively small examples of the problem (Araújo, 2006). Also, the real problems are more complex than classical because their additional details imply in more combinations (Herrmann et al, 1995).

The classical JSSP is a group of n jobs to be processed into a set of m machines. Each task has a number of operations and a technological sequence of process. These operations require an uninterrupted processing time over a designed machine. Therefore, it is a time-completion problem that satisfies the constraints: the goal is the minor total completion time (makespan) (Vazquez and Whitley, 2000).

About the SDST-JSSP, there is a setup time between consecutive operations in the same machine. Thus, once the operation O_{jv} leaves the machine Mv, before the O_{kv} process starts, a setup time $S_{oiv,okv}$ is added (Gonzales et al, 2005).

3 Methods

In general, the solution method proposed for NDD-SDST-JSSP is a combination of a genetic and GT algorithms (Giffler and Thompson, 1960). Thus, several considerations were made, starting from the chromosome coding, application of genetic operators and evaluation of individuals (modified GT algorithm).

3.1 The genetic algorithm

In view of its wide application solving problems in class NP - complete, Evolutionary Algorithms (EAs) make heuristic search techniques based on natural mechanisms of selection, simulating computational environments based on these principles of evolution and heredity (Goldberg, 1989).

3.1.1 The proposed chromosome structure

The chromosome has two parts: head and body. The "head" contains route information's and the "body" will act in the operation sequence, both with the same dimensions and, for each operation, the locus contains a machine index.

Also, the "body" contains whole alleles, not repeated, in the interval ai=[0,total operations-1] and, in the scheduling, it indexes the order of operations.

3.1.2 Building the initial population

Since the "head" must be built first, this is made using random numbers in the range of $[0,nm_{ij}-1]$, where nm_{ij} is the number of available machines to process operation j of the process i. The Fig. 1 shows this construction part.

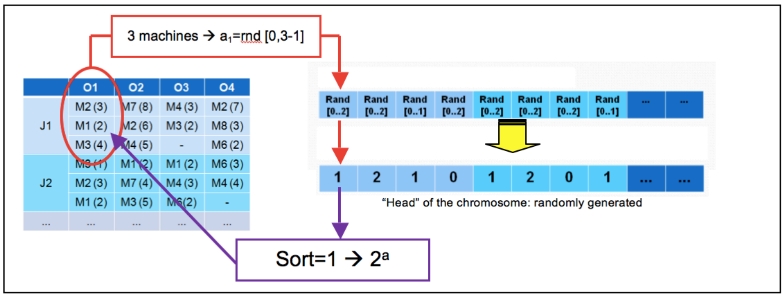

Fig.1
Example of random generation of chromosome's "head".

The resource allocation starts building the "body", an ordered 0 to nm_{ij-1} array.

3.1.3 The fitness function

The fitness is the adaptation's quantification of each individual. Here, it means to apply the modified GT algorithm to make the active scheduling for each chromosome. The time completion can be the objective function. Where: n = number of tasks; o_{ik} = operation k of *job* i; t_{ik} = time able to start operation k of *job* i; p_{ik} = processing time of operation k of *job* i;

Algorithm G & T_A-modified

Step 1: Place the first schedulable operation of each task (of the active planning horizon) in the set of candidate operations C, $C = \{o_{i1} | 1 \le i \le n\}$;
Step 2: Choose an operation o' of C, with earliest completion time;
Step 3: Determine the machine M', in which o' must be processed and thus build the set G (the conflict set of M'), consisting of all operations of C to be executed in M';
Step 4: Remove operations that do not start before o' finish, ; $G = \{o_{ik} \in G | t_{ik} < t' + p'\}$
Step 5: Run the sub- algorithm to select an operation o*ik of G;
Step 6: Remove o^*_{ik} from C, where $C = C \setminus \{o^*_{ik}\}$
Step 7: Insert the operation o^*_{ik} in the schedule and calculate start time;
Step 8: Insert the successor operation of the o^*_{ik} in the set C (if any);
Step 9: If $C \neq \varnothing$, go to Step 2, if not END.
End of the algorithm

Step 5: sub-algorithm - Choose_oik*_of_G

Create CR: set of operations using M', unscheduled, and with previous scheduled;
If G ∩ Cr ≠ {} then
Choose operation G∩Cr with higher priority index (RHP's)
If not
Create PG: set of processes belonging to the G operations;
Create CrG: subset of Cr, with the operations ∈ to the processes of PG;
If CrG ≠ {} then
Find O: operation of CrG with higher priority index;
Find J*: process that contains the task O;
Find O*: operation of G belonging to J*;
If not
Find O*: operation of G with low priority;
End if;
End if;
End of the algorithm

For M' machine, if the operation is to be the one sequenced by the chromosome's "body" and the one with highest priority index, it will also be the operation O*, i.e., the candidate operation elected to be scheduled. Otherwise, if the sequence does not match with the job-shop problem, conflicts may occur.

Because there are two conflicting interests, both of them without the creation of unfeasible individuals must be considered. The solution is to find, in G, an operation that most closely matches to that suggested by the chromosome's " body", i.e., to the machine M', it is tried to schedule an operation of G which belongs to the same process of the highest indexed operation from the set Cr.

If no intersection of G with the operation indicated by the sequencing for M' exists, then the one with less priority is selected, relaxing in some choice criterion.

3.1.4 The individual selection

The selection process must list individuals, which will be part of the reproduction. The selection method adopted was proposed by Mayerle (1994), which consists in a ordered stochastic selection, having, in maximization, individuals in decreasing order according to their fitness, as follows:

$$Selection(R) = \left\{ r_j \in R \,\middle|\, j = m + 1 - \left\lceil \frac{-1 + \sqrt{1 + 4 \cdot rnd(m^2 + m)}}{2} \right\rceil \right\} \quad (1.1)$$

Where: R is the set of the *m* individuals; r_j is the j-th chromosome; *rnd* is random uniformly distributed $\in [0,1)$; $\lceil x \rceil$ is the smallest integer greater than x.

The method provides a selective pressure inferior to Monte Carlo's selection (roulette), and also allows that more apt individuals have greater chance of crossing than less able ones with the merit of recovering the super-individual effect, which will possibly exist due to the elitist strategy regarding the population formation.

3.1.5 Strategy of population formation

The population is formed considering four different formation processes: by cloning, by random formation, by greedy formation and by reproduction. Because there is a sorting process, the best are cloned to the current population, but in a small fraction of the total population. Other small fraction is designed to individuals generated by the original algorithm of the first population. The fourth way of formation consists in generating a very small population part using dispatching rules (DRs) widely discussed in the literature, as: SPT, S/PRT, CHR and RND (shortest processing time, slack per remaining time, combined heuristic rule and random, respectively). The user also defines the number of individuals to compete for reproduction. This strategy is based on Gonçalves et al's idea (2005), whose intention is to avoid population premature convergence.

3.1.6 Crossover and mutation operators

The crossover, the main operator of genetic algorithm, perpetuates the characteristics of the fittest individuals through the exchange of parents' information, passing it to the offspring individuals. The application is different to the "head" and to the "body". To the first ones, their alleles are copied to the offsprings. For this, the uniform crossover is applied, based on a binary mask formed by 0/1 digits.

In crossover process, an allele "zero" means, to the offspring, that the gene's donor is father 1. Otherwise, the donor is father 2. To another offspring, the reversal of the mask is required before the process. Also, no harmonization is required.

After, individuals are subjected to the second phase of the crossing, now using order-based operators. This is necessary due to the desire to keep the sequence proposed by the parents as faithful as possible. The operator now is the PPX (precedence preservative crossover), acting in the chromosomes' "bodies" and using the masks involved in the previous step. Inheriting from his father 1 all the genes situated in his respective locus of the "zero" allele mask, it starts to complete the sequence based on the father 2. If the allele obtained from the father 2 already exists in some locus of offspring 1, we seek for the next, until the gap can be completed.

As viewed in previous sections, this operator was applied based on the observations of Gonçalves et al (2005), such operators produce good effects when applied to schedules, instead of the traditional one or two cut points.

Moreover, during the crossover process, the mutation operator will actuate changing the value sampled by another one, randomly generated. In phenotype terms, it's a new route, meaning a new machine assignment to that operation.

In the "body" chromosome, the mutation will exchange genes between two randomly selected points, forcing task sequence changes. This swap is subtle, because it does act overall in all sequencings.

4 Tests and discussions

With interest in to observe the ability to solve the problems of the proposed types and their characteristics, the data from problems of Chan (2003) and Kumar et al (2003) were applied in the tests.

4.1 Scheduling tests with expansion of alternative routes

In order to evaluate the algorithm ability with alternative routes combinations, Araujo (2006) expanded the original CHAN problem, introducing another machine and so, turning some task processes more flexible.

The average makespan with the proposed conjuncture was reduced, at minimum values from 931 t.u. to 786 t.u., with average computational time close to 20s. It was expected, since the increase of machine number also increases the number of routes and thus the processing options. Araujo (2006), observing it has raised the issue that, since it increases the amount of routes and thus reduces the total processing time, it also reduces the frequency of use of machines.

4.2 Tests involving Non-Deterministic Dynamic characteristics

For the tests involving NDD-JSSP (realistic) simulation routines in the original algorithm were introduced with the aim to generate random variables.

Simulated times are: instant start operation processing, transport time between machines, operation processing time in the machine. All these times are crucial for defining the end time of each operation, in each process (job).

The simulation of turbulent environment schedules consists in generated random variables with defined average and standard deviation. The average is equal to the original time and standard deviation will be between 2, 5 and 10%.

This simulation is a turbulence generator, creating indeterminism during the scheduling. Varying setup times (dependent), processing times, start and traveling time are important to evaluate the behavior of the solution NDD-JJSP proposed in this work, since it reacts at the time when the change is detected, adapting itself instantly to the information provided by the system.

Regarding the results, there are no significant differences between the heuristics used, which shows that the CHR has comparable quality with the other rules.

Considering the objective function, the minimum and average data obtained for each case are: 960 and 990, 1013 and 1045, 995 and 1022, respectively, for the turbulence simulations with 5, 10 and 20%. It is noticed that they vary according to the disturbances generated, varying little from one class to another, which demonstrates a good response during process scheduling with regard to dynamic environments.

The same performance analysis is done in relation to the KUMAR problem, where the closeness of the makespans results is also observed, which were: 381, 424, 501s, with computational times of 14, 17 and 21 seconds. The adopted conjuncture demonstrates robustness with regard to schedules in turbulent environments.

5 Conclusions

It's possible to observe the behavior of the proposal in simulated turbulent situations, with good ability to schedule without exceeding the offered completion time. Good results against those obtained by other authors for the same tests made its application in decision-making economic aid even more encouraging. The heuristic rule CHR was efficient in the test results, which usually get good solutions with time quite satisfactory, probably due to components based on rules that are also evident in the tests: SPT and S/PRT. Regardless, the adopted situation for the genetic algorithm, which inserts individuals formed by other heuristics, could "dope" at low rates the population that was being built at each iteration.

The super-individual absence was important to the good performance obtained by the GA, as a result of the selection proposed by Mayerle (1994).

In general, the observed good performance in those problems demonstrates the proposal ability to organize, for a given planning horizon, the tasks to be scheduled, whether belonging to a physical or virtual manufacturing cell, which may form an alternate route, also considering dependent setup times.

References

Araujo, L O (2006) Método de Programação de Sistemas de Manufatura do Tipo Job Shop Dinâmico Não Determinístico. Doctoral Tesis, Universidade de São Paulo, São Paulo.

Chan F T S (2003) Effects of dispatching and routeing decisions on the performance of flexible manufacturing system. International Journal of Advanced Manufacturing Technology, 21: 328-338.

Giffler B, Thompson G (1960) Algorithms for solving production scheduling problems. Operations Research 8: 487-503.

Goldberg D E (1989) Genetic Algorithms in Search, Optimization, and Machine Learning. US: New York

Gonçalves J F et al (2005) A hybrid genetic algorithm for the job-shop scheduling problem. European Journal of Operational Research 167: 77-95.

Herrmann J (1995) Global job shop scheduling with a genetic algorithm, Produt and operations management 4: 1.

Kumar R et al (2003) Scheduling of flexible manufacturing systems: an ant colony optimization approach. Proc. Instn Mech. Engs 217, B, J. Engineering Manufacture.

Matsusaki, C T M (2004) Modelagem de Sistemas de Controle Distribuídos e Colaborativos De Sistemas Produtivos. Doctoral Tesis, Universidade de São Paulo, São Paulo.

Mayerle S F (1994) Um algoritmo genético para a solução do caixeiro viajante. Tecnical Report, Departamento de Engenharia de Produção e Sistemas, UFSC.

Porter K et al (1999) Manufacturing classifications: relationship with production control systems. Integrated Manufacturing Systems 10(3-4): 189-198.

Vázquez M Whitley D (2000) A comparison of Genetic Algorithms in solving the Dynamic Job Shop Scheduling Problem. *GECCO*. Available via google. https://docs.google.com/file/d/ 0B0xb4crOvCgTMXpKRnp6NFo3bTQ/edit

Current Trends in Recovering Used Products in Retail Fashion Industry: An Exploratory Study

Bukhari M[1], Carrasco-Gallego R[1], Ponce-Cueto E[1]

Abstract: Fashion industry is currently shifting towards sustainable practices through the entire supply chain. Many fashion retailers like H&M, Zara and others consider sustainability the cornerstone of their corporate social responsibility programs. At the same time, Extended Producer Responsibility (EPR) legislation is holding manufacturers and retailers responsible, especially in Europe, for waste generated at end-of-use and end-of-life phases for some specific products. Finding alternatives to the landfill for textile waste will extend textile life, contributing to the development of circular economy and sustainable business models in the fashion industry. This study identifies and characterizes, as a first stage research, current practices of product recovery for used textile in France and Germany using comparative case studies. Characterizing the reverse logistics models for textiles in each country will help identifying best practices for recovering used clothing in Europe.

Keywords: Reverse logistics, fashion industry, textile waste, product recovery, take-back.

1 Introduction

Fashion industry, as a relevant agent contributing and impacting our economy, societies and the environment, requires more research and development towards circular economy and sustainability-based models. Millions of tonnes of textile waste, such as fabrics and fibers, end up in landfills or incinerators every year. The technological and business-model revolution in fashion industries in the late 20th century has contributed to increased environmental effects by establishing more factories, producing more goods, and creating global-sourcing based models associated with disposable fashion that designers deliver to a mass market at relatively low prices and quality. Every year consumers buy new garments not only because their old ones are worn out, but because they seek to satisfy their desire of buying fashionable products. Fashion retailers attract us by offering a wide variety of styles, colors, and materials and selling them at affordable prices. According to American Apparel and Footwear Association (AAFA, 2015), an average American bought around 68 garments and 7 pairs of shoes in 2011. The European Commission reports that EU consumers discard 5.8 million tonnes of textiles every year: only 1.5 million tonnes (25%) are being reused or recycled by charities or industrial enterprises, while the reminder ends up in landfills or incinerators (Beasley & Georgeson, 2014). In the UK, according to the Waste and Resource Action Programme (WRAP, 2012), about 350,000 tonnes of used clothing (worthing €180 million) are sent to landfills each year.

In other words, we are generating millions of tonnes of waste clothing and disposing billions of Euros in landfills every year. Are there other options for apparel waste streams? Product take-back practices establishing reverse logistics channels, closed-loop supply chains and circular economy business models are already being developed for specific products in some countries, with the aim of keeping the environment healthy by reducing, reusing and recycling. Some fashion retailers such as Patagonia, Puma and H&M have already started their journey to environmentally sustainable business models by selling ecological garments, donating clothing, using recycled materials for manufacturing new products, and planning for having their closed-loop line of products.

1 **Mohammad Bukhari** (mohd.bukhari@yahoo.com)
Ruth Carrasco-Gallego (ruth.carrasco@upm.es)
Eva Ponce-Cueto (eva.ponce@upm.es)
Dpto. de Ingeniería de Organización, Administración de Empresas y Estadística.
Escuela Técnica Superior de Ingenieros Industriales.
Universidad Politécnica de Madrid. C/José Gutiérrez Abascal 2, 28006 Madrid

In this study, we explore and analyze all the aspects related to reverse logistics in the retail fashion industry, including collection, sorting and recycling and potential actors, drivers and barriers involved in this process.

2 Objectives and Methodology

This study is exploratory and it aims to characterize the reverse logistics system of the fashion industry in Europe. The specific objectives are to answer the following research questions: How and why is the recovery of apparel done? What are the processes and facilities involved in the RL system? And what is the best recovery practice existed throughout fashion retailing?

The study will be based on desk research (literature review) using secondary data sources such as journal papers, news, magazine press, official national legislation, and technical and working papers. In addition, fashion retailers and textile companies' websites have been examined for analyzing their annual reports and publications. This case research will provide two descriptive scenarios for product recovery of used clothing. Two case studies are developed in this research to discuss and analyze the current practices for waste clothing collection, recycling, and re-distribution in two European countries. France and Germany have been selected to illustrate two different initiatives, approaches, motivations and actors for collecting used clothing. France is the first and only country in the world that issued extended producer responsibility (EPR) policy for used clothing. Yet, Germany's waste recovery rates are the highest in the world and it is generating from the total waste recovery an annual turnover of approximately 50 billion Euros (WRAP, 2012). Although Germany has EPR programs for some products, clothing and shoes have not been included yet in the legislation. Comparing both reverse logistics models in these countries would not only lead us to understand the overall reverse logistics system for each country but also allow us to identify best implemented practices.

3 Recovery of End-of-Use Fashion Products

End-of-use apparel and footwear (A&F) recovery involves the following sequential activities: collecting used items; 1st stage sorting for taking out re-wearable items, 2nd stage sorting for determining the potential for the product's reuse, cleaning, recycling processes, various treatments, re-distribution and disposal as municipal solid waste in incineration or landfill. This study will follow the investigation module shown in Figura 1.

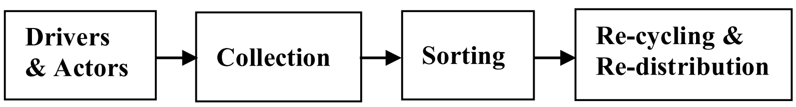

Fig.1
Investigation module for describing the case studies (Own development).

Identifying the drivers and actors for product recovery will address the question of who is recovering used textile and why? On the other hand, identifying the collection, sorting and recycling schemes along with the reverse distribution channels would address the question of: How is it done? By answering those questions, we can investigate later to improve and design efficient and valuable reverse logistics network. The framework we put forward in Figure 1 has been used for analyzing the case studies developed in Sections 4 and 5. In those case studies we research the take-back system for apparel and footwear in two European countries. Using a common framework for analysis enables us to develop a comparative analysis that is presented in Section 6 Discussion and Conclusions.

4 Comparative Case Studies: the French System

Drivers and Actors

In France, the Extended Producer Responsibility (EPR) policy for the apparel industry was introduced by the *Article L-541-10-3 of the Code de l'Environnement,* which came into force on 1st of January 2007. Since that date, according to the new legislation, all legal entities introducing in the French market new textile apparel products, i.e. garments, footwear and household linen, are hold responsible for the recycling or proper disposal of the waste generated by those products. Those entities (which include manufacturers, importers and distributors) can accomplish this legal obligation through two distinct ways: either by financially contributing to an accredited Producer Responsibility Organization (PRO) or by setting-up an individual take-back program approved by the French public authorities.

As a result, a PRO for textile, footwear and linen was created in December 2008, Eco TLC (*Eco-organisme du textile, du linge et de la chaussure*), which is for the moment the only PRO accredited by the French public authorities to cover the sector. Eco TLC is a non-for-profit private company initially constituted by 29 associates (*associés*). The associates represent the whole textile value chain and are organized in five “colleges”: (a) general large retailers (e.g. Auchan, Carrefour, Monoprix); (b) fashion retailers (C&A, Galeries Lafayette, Etam); (c) direct sales and mail/online retailers (Damart, Groupe 3SI); (d) manufacturers and wholesalers (LVMH, Cotonflor-linge du lit); (e) apparel industry associations (Federation Nationale de l’Habillement, Union des Industries Textiles). The Board of Directors of EcoTLC is made up of 12 representatives chosen among the associate companies.

Apparel manufacturers, importers and distributors can register as members (*adhérents*) of EcoTLC in order to fulfill their EPR liability. Membership involves paying an annual contribution to EcoTLC, based on the last year’s volume put on the market, and transferring the member companies’ responsibility to the PRO. Eco TLC members currently represent 93% of the industry and they are listed in the PRO web site (http://www.ecotlc.fr/).

The funds raised by members’ contributions are used by EcoTLC for covering the operating costs of the product recovery system, for funding R&D projects on the field of used apparel collection and recycling, and for supporting awareness-raising campaigns organized by local authorities to encourage apparel waste sorting at household level.

The tariffs for members’ contributions are recalculated every year, depending on the financial needs of EcoTLC. Members’ contributions are received in the first quarter of year *n* and are based on the number of units (and their size) put by each member company in the market during year *n-1*. Tariffs consider 4 different sizes for garments and linen (very small, small, medium and large items) and 2 sizes for footwear (small and medium items). In order to incentivize the use of recycled fibers by member companies, products that have a proven minimum of 15% of post-consumer recycled fibers can benefit for the “Eco-Module Tariff”, which represents a 50% discount over the normal tariff (Table 1). Member companies that have sold less than 5,000 items in year *n-1* or whose revenue is under €750,000 are entitled to contribute a fixed tariff of €33 plus VAT.

Table 1
EcoTLC tariffs for 2015 members contribution
(*n-1=2014*) (Eco TLC, 2014).

Garments & Linen	**Examples**	**Regular Tariff (€)**	**Eco-module Tariff (€)**
Very Small Item	Socks, kids underwear	0,00121	0,00060
Small Item	Shirts, leggings, lingerie	0,00484	0,00242
Average Item	Pijamas, nightdress	0,00726	0,00363
Large Item	Adult’s jacket, coat	0,0484	0,0242
Footwear			
Small Item	Slippers, mules	0,00484	0,00242
Average Item	Shoes, boots	0,00726	0,00363

Collection

EcoTLC is outsourcing logistics companies for collecting the used products from consumers by using three schemes: door-to-door collection from households, collection from partner charities, or from distributed containers. The volume collected through containers is about 46%, whereas charities and door-to-door collection represent 36% and 18% respectively (La Fédération de la Maille & de la Lingerie, 2014). The collected products are then transferred to a sorting center.

Sorting

EcoTLC is financially supporting sorting and recycling businesses fulfilling the required standard and work conditions. Enterprises should report to Eco TLC the amount collected and how have dealt with it. The first stage of sorting will separate the re-wearable clothing and shoes and re-useable linens manually from the ones which need further treatment. So that the re-useable products will be either locally re-sold in second-hand shops or re-sold to developing countries. The second stage will involve removing the hard particles from the products and sorting according to the fiber length and quality for recycling or energy recovery.

Recycling and Re-distribution

Mechanical recycling is widely used technique in France. Recycling of textile will include one of the following different processes: *un-raveling, grinding, de-fibration, and cutting*. The residual of the recycling is taken to incinerators which are mostly produce and recover energy from the textile waste.

5 Comparative Case Studies: the German System

Drivers and Actors

Germany is one of the top five European countries in terms of textiles and clothing production (WRAP, 2012). It is also ranked the first in Europe in term of collecting the largest quantity of textiles per year and it is the first in the world in terms of collecting the maximum quantity of textile per person per year (WRAP, 2012). Germany is practicing the collection since many decades ago collaborating with charities, churches, and commercial enterprises. The waste hierarchy of prevent, recover, and dispose was introduced and recognized for different products, including textiles, in the 80s decade, under the Closed Substance Cycle and Waste Management Act, which finally came into force in 1996. According to this Act, owners and generators of waste are responsible for waste avoidance, recovery, and disposal. However, although Germany has EPR programs for some products, clothing and footwear are not included in the legislation.

In this study, one commercial enterprise in Germany, SOEX Group, will be investigated because of their innovative partnerships programs for textile recovery. The company was established in 1977 as a private company intending to become a global market leader in collecting, marketing, re-use and recycling of used textile maintaining ecologically-sustainable practices. SOEX currently employs 2100 people working world-wide and exports used textile to around 90 countries in Asia, Africa, Europe, and North and South America.

Collection

The unique collection system hold by SOEX Group has attracted shareholders, charities, and fashion retailers. SOEX aimed to collect more used apparel and decided to integrate with well-established logistics companies to handle the reverse distribution inside and outside of Germany. Many acquisitions and partnerships agreements took place with independent companies (e.g. EFIBA, Retextil, ERC, and NTA). Consequently, SOEX has established an innovative organization called I:CO which is working to lead the collection practices with fashion retailers globally.

I:CO, which stands for I:Collect, is a unique system for collecting garments in stores and then processing them for recycling. I:CO is marketing SOEX innovative sorting system and their utilization channels for used products to leading fashion retailers such as The North Face, H&M and many others, and establishing long-term partnerships with them. All fashion products, including leather clothing and furs, underwear and socks, belts and bags, bed, table and household linen and cushions, are collected in the designated I:CO boxes inside retailers' stores. Customers will obtain a reward shopping voucher depending on the total weight that has been scaled. When the box is full, the store seals the shipping box and brings it to the store shipping area to be ready for pick-up. Then, all collected items in Europe will be delivered to SOEX's Wolfen sorting facility for sorting and recycling.

Sorting

Wolfen plant, founded in 1998, is considered one of the largest sorting facilities for used textile and clothing in Europe. It has an area of 89,000 m^2 where 700 employees are working in 3 shifts to sort 400 tonnes of garments every day. All items will be scaled and registered before passing into sorting processes. The items are sorted in 3 stages: Separation (where shoes, residual waste, and bed feather are separated), presorting (garments are sorted per clothing type, e.g. pants, T-shirt, etc.), and fine sorting according to the quality of wearable clothing.

Recycling and Re-distribution

The recycling system is also mechanical which has re-distribution and utilization channels similar to the one in France. Single color t-shirts and sweatshirts no longer can be worn are converted into wiping cloths in-house. In addition, SOEX owns two second-hand clothing businesses to sell high quality used clothing: Cash4brands and Modemarkt Freestyle GmbH. Cash4brands is an innovative online platform for selling name-brand and designer clothing while Modemarkt Freestyle GmbH has branches in Hamburg, Munich and Berlin offering a large selection of second-hand clothing and trendy vintage fashions from the 60's, 70's and 80's.

6 Discussion and Conclusion

France has obligated the fashion producers to recover used clothing implementing EPR policy to encourage more collection of used textile and footwear. Unfortunately, the collection rate per year in France is still very low comparing to other European countries. The collection rate in France is only 2 kg/inhabitant/year while in Germany the collection rate is 8.5 kg/inhabitant/year (*La Fédération de la Maille & de la Lingerie*, 2014). The key success of German collection has been achieved by long term effective plan that allowed shareholders and charities to participate in this trend to turn the waste into valuable resources. In addition, the reverse distribution system seems to be an important factor for the success of SOEX Group and Germany which will be investigated in the next stage of our study. The SOEX Group practice for apparel recovery is the best in Europe in terms of the number of fashion retailers involved and the unlimited type and quality of used apparel collected and recycled.

This paper represents qualitative exploratory study which is part of intensive study of RL in fashion industry. This exploratory study characterizes the current practices of the reverse supply chain channels in France and Germany. Actors and drivers as well as sorting, recycling and re-distribution have been identified for clothing recovery. In fact, sustainability in fashion industry has attracted both researchers and practitioners lately and it is one of the most complicated fields that require more studies and improvements in order to close the loop of the supply chain. The scarcity of scientific contributions (so far) has encouraged us to investigate and briefly write all aspects of product recovery in fashion industry with highlighting some research gaps for future studies. Framework and measurement of the sustainability of fashion industry, for instance, would be one of the future research studies for further contribution.

7 References

American Apparel and Footwear Association, AAFA (2015) Accessed: 1 May 2015, available at: https://www.wewear.org/industry-resources/we-wear-our-mission/

Beasley J, Georgeson R (2014) Advancing resource efficiency in Europe indicators and waste policy scenarios to deliver a resource efficient and sustainable Europe. Brussels: European Environmental Bureau. Available at: http://www.eeb.org/EEB/?LinkServID=4E9BB68D-5056-B741-DBCCE36ABD15F02F. Accessed 15 October 2014

Caniato F, Caridi M, Crippa L, Moretto A (2012) "Environmental sustainability in fashion supply chains: An exploratory case based research", International Journal of Production Economics, Vol. 135, pp. 659-670

Caro F, Martínez-de-Albéniz V (2014). "Fast Fashion: Business model overview and research opportunities", Retail Supply Chain Management: Quantitative models and empirical studies, 2nd Edition, Springer, New York, NY

De Brito M, Carbone V, Blanquart CM (2008) "Towards a sustainable fashion retail supply chain in Europe: Organisation and performance", International Journal of Production Economics, Vol. 114, No. 2, pp. 534-553

Govindan K, Soleimani H, Kannan D (2015) "Reverse logistics and closed-loop supply chain: A comprehensive review to explore the future", European Journal of Operational Research, Vol. 240, No. 3, pp. 603-626

La Fédération de la Maille & de la Lingerie. (2014) "On the textile recycling road", available at: http://www.la-federation.com/data/evenements_4c4be/fiche/5486/leaflet_recyclage_bf06f.pdf. Accessed 3 November 2014

Palm D, Elander M, Watson D, Kiørboe N, Salmenpera H, Dahlbo H, Moliis K, Lyng K, Valente C, Gislason S, Tekie H, Rydberg T (2014) Toward a Nordic textile strategy: Collecting, sorting, reuse and recycling of textiles. Norden

Toffel MW (2004) "Strategic Management of Product Recovery", California Management Review, Vol. 46, No. 2, pp. 120-141

Waste and Resource Action Programme, WRAP (2012) Valuing our clothes: The evidence base. Technical Report. Available at: http://www.wrap.org.uk/sites/files/wrap/10.7.12%20VOC-%20FINAL.pdf

Performance measures of Reverse Logistics: a survey in Brazilian companies

Giuriatto NT[1], Chaves GL[2], Ferreira KA[3]

Abstract: The purpose of this research was to determine the most frequently used performance measures for the evaluation of reverse logistics in Brazilian companies. Furthermore, we sought to verify whether a correlation exists between certain performance measure dimensions (cost, asset management, customer service, and productivity) and company size and their sectors of the economy. Therefore, a survey of 125 Brazilian companies from different industrial sectors was conducted. According to statistical analysis, it was found that large-sized companies are those that most frequently adopt performance measures to assess reverse logistics in Brazil; especially to evaluate productivity levels. However, no correlation was verified between the performance measure dimensions evaluated and company size. In addition to determining the major measures used, this study is expected to provide information to support decision making in companies, resulting in improvements in reverse logistics and competitiveness.

Keywords: performance measures, reverse logistics metrics, survey.

1 Introduction

Although many companies recognize the importance of reverse flow, most of them have difficulties or show unwillingness to adopt performance measures or evaluate their performance. Thus, it is difficult to measure the outcome or the impact of product and/or material return, and therefore reverse flow has become one of the major concerns to businesses in several countries today (Rogers & Tibben-Lembke, 1999; Langman, 2001; Chaves, 2009; Lopes et al, 2014). Measuring the performance of the activities that control product return and managing reverse flow are of great importance and relevance to ensure a more effective reverse logistics performance and cost reduction Accordingly, this study aimed to identify, through a survey, the performance measures frequently used to evaluate reverse logistics in Brazilian companies from different sectors. Furthermore, the correlation between certain performance measure dimensions (cost, asset management, customer service, and productivity) and company size and their sectors of economy will also be investigated.

The studies reviewed provide good justification for the present research since those authors show the savings and benefits related to good management and to the measurement of the reverse logistics results such as: company image enhancement, customer satisfaction improvement, cleanliness in distribution channels, profit margin protection, value recapture and asset recovery (Rogers & Tibben-Lembke, 1999; Leite, 2009; Lambert, Riopel & Abdul-Kader, 2011; Genchev, Richey & Glaber, 2011; Bai & Sarkis, 2013).

This paper was divided into 5 sections. Following this introduction, section 2 presents a summary of the literature review on performance measurement of reverse logistics and the hypotheses tested in this research. Section 3 addresses the research methods. Section 4 analyzes the main results obtained, and section 5 presents the final considerations.

1 **Naiara Tomazelli Giuriatto** (naiaragiuriatto@hotmail.com)
2 **Gisele de Lorena Diniz Chaves** (giselechaves2@yahoo.com.br)
Dept.of Engineering and Technology, Federal University of Espírito Santo,
Rodovia BR 101 Norte, Km 60, Bairro Litorâneo, 29.932-540, São Mateus – ES, Brazil.
3 **Karine Araujo Ferreira** (karine@em.ufop.br)
Dept. of Production Engineering, School of Mining, Federal University of Ouro Preto,
Campus Universitário - Morro do Cruzeiro, 35400-000, Ouro Preto – MG, Brazil.

2 Reverse Logistics, measurement, and performance measures

Reverse logistics can revert flows from the point of consumption to the point of origin for the purpose of recapturing value or proper disposal. Due to the growing concern about environmental issues, reverse logistics has become one of the most important concerns for many industries nowadays (Ho, Lam & Wong, 2012; Bai & Sarkis, 2013). Reverse logistics, part of business logistics, is responsible for planning, managing, and controlling the flow of products, materials and products' packaging, and their corresponding logistics information through the reverse distribution channels, adding economic, legal, and logistics value and improving corporate image among other things (CSCMP, 2013; Leite, 2009).

This process can be divided into two categories: post-sale and post-consumption reverse logistics. The first one can be understood as the area of reverse logistics that deals with the planning, control, and allocation of goods that had little or no use and return to the distribution chain for several reasons: warranty returns and related warranty claims, goods damaged during transportation, excess inventory, and past expiration dates among others. On the other hand, post-consumption reverse logistics deals with assets at the end of their useful life, potentially reusable assets, and industrial waste (Leite, 2009).

These concepts have been widely considered to deal with environmental issues (Ho, Lam & Wong, 2012) and minimizing economic, financial, health, legal, and social related problems (Guarnieri et al., 2011). Measurement is an inherent necessity in any activity planning and monitoring process. According to Barbosa and Musetti (2011), there is no single definition of performance measurement, which makes the literature on the topic varied and abundant. An interesting definition was provided by Neely, Gregory and Platts (2005), who define performance measurement as the process to quantify the efficiency and effectiveness of actions. These authors added that performance measurement is a metric used for quantification.

In recent decades, a large number of studies have been published on performance measurement and the development of frameworks and models. Among these models is the World Class Logistics (WCL), proposed by The Global Logistics Research Team at Michigan State University (GLRT, 1995), which addresses the basic factors to achieve best practices in logistics resulting in attaining the status of leading company, which includes performance measurement as one way to achieve excellence. A performance measurement system should consider that the measurement can be performed on activities and processes, and it can be internal and external. With regard to performance metrics, the WCL model highlights that the performance measures used by world-class companies revolves around 4 dimensions: (1) costs, (2) customer service and quality; (3) productivity, and (4) asset management (GLTR, 1995).

In the present study, a comprehensive literature review on performance measurements to evaluate Reverse Logistics was carried out. In addition to the study conducted by Chaves, Barboza & Alcantara (2011), who grouped together the performance measures for the adoption of reverse logistics up to the year of 2010, other studies were reviewed, such as Shaik Abdul-Kader & (2012); Lambert, Riopel & Abdul-Kader (2011); Skapa & Klapalová (2010), and Genchev, Richey & Gabler (2011). These measures were grouped under the WCL dimensions and the strategic, tactic, and operational levels, as shown in Table 1 in section 4.3.

The field research focused on identifying, among those found in the literature, the measures that are or have the potential to be adopted in practice and the existence of measures other than those reported in the literature. Additionally, whether a correlation exists between certain reverse logistics performance measure dimensions and company size and their sectors of the economy were also investigated based on the following hypotheses:

Hypothesis 1: There is a relationship between the reverse logistics dimensions (cost, asset management, customer service, and productivity) and the size of a company.
Hypothesis 2: There is a relationship between the use of performance measures and sectors of the economy.

3 Research Method

A descriptive study with a quantitative approach was carried out in the form of a survey conducted in all regions of Brazil by administering questionnaires, prepared using Google Docs tool, to employees of companies in this area.

Initially, associations and federations that include companies working with reverse logistics were contacted and invited to participate, but since the response rate was low, different approaches were adopted. The questionnaire was transmitted electronically via Linkedin, through which the best response rate was obtained. A total of 125 companies participated during the eight month-period of research (from November 2013 to June 2014). Data analysis was divided into two parts. The first one, descriptive analysis, involves general characteristics of the participating companies such as performance measurement systems adopted to evaluate the reverse logistics and the identification of performance measures adopted. The second included the statistical tests used to confirm the hypotheses suggested in this study.

4 Results

4.1 Characterization of the companies participating in the research

Eighty one percent of the companies participating in the present study are located in the Southeast region (the most developed region in the country, including the highest number of industries), 11% in the South, 4% in the Midwest, 3% in the Northeast, and 1% in the North regions. With regard to their size, it was found that most companies (57% , 71 companies) are large (based on the following classification: more than 500 employees for industries and more than 100 employees for service and trade), 17% of the companies are small, 15% are considered micro enterprises and 11% are medium-sized enterprises.

Although most companies in Brazil (63%) are considered as micro-sized enterprises, 57% of the responses were received from large companies. This was possibly due to the fact that companies of this size have a more effective RL, and thus information is effectively provided to different hierarchical levels. Another important point to be discussed concerns the sector of activity of the participating companies. The respondent companies belong to the following sectors: transport and storage (32%), manufacturing industries (21%), trade, vehicle repair, personal and household goods (12%), other community, social and personal services (11%), and other sectors (24%).

4.2 Adoption of reverse logistics and performance measurement

With regard to the use of Reverse Logistics (RL) performance measures, none of the companies seems to use a structured performance measurement system that includes RL. In spite of this, it is important to mention that, in most cases, these companies evaluate their RL using performance measures indicators.

The results obtained show that most companies use resale, recycling, and repair as processes associated to their reverse logistics. These results indicate that these companies, in general, adopt this strategy for economic recovery. However, recycling is a process used less frequently because of its lower economic return compared to that of the other activities, which is due to lack of technology and resources in Brazilian companies, making impossible to use expensive processes such as reprocessing. Another important finding was that 17 companies dispose of their waste in landfills, which, although being the least often adopted approach, is a prohibited activity in Brazil. A total of 53% of these processes are outsourced. Moreover, as for the the quality of reverse logistics systems used by these companies, most of them consider their reverse logistics activities as having fair and a good level quality. This result demonstrates that even not having a standard RL system implemented, as discussed above, the reverse logistics performance in companies cannot be considered low if taken as an average result; although only 11% is considered excellent. This classification results from factors that hinder the implementation of reverse logistics.

4.3 Adoption of performance measures for reverse logistics

According to the responses obtained, it was possible to draw up a table presenting the use of performance measures (%) for each dimension of the WCL previously identified in the literature and verified in practice. These results are shown in Table 1.

Table 1
Performance Measures for reverse logistics (RL).

PERFORMANCE MEASURES - COSTS	USED (%)	NOT USED (%)
Total cost of RL	65	35
ABC costs	57	43
RL profitability	53	47
Cost of variations with respect to the RL budget	50	50
Annual sales of returned products RL	48	52
Net profit RL versus Productivity index of RL activities	45	55
Rate of return on RL investment	44	56
Financial investment in RL	44	56
Returns prevention cost	44	56
Internal cost of failure	43	57
External cost of failure	43	57

Table 1 (continued)

PERFORMANCE MEASURES - COSTS	USED	NOT USED
Cost of returned goods	42	58
Costs in service failure	42	58
Costs in logistics gaps	41	59
Litigation costs	40	60
Stock level costs (for manufacturers)	40	60
Management and planning costs	38	62
Warranty costs	38	62
Cost of receipt and storage of returned product	37	63
Return processing cost	34	66
Cost incurred to correct the failure recovery	34	66
Transport costs	32	68
Cost of stock movement	31	69
Packing costs	30	70
Administrative cost with the LR	26	74
Order processing cost	26	74
Labor costs	24	76
Bad Products costs	24	76
Inspection of returned products costs	22	78
Costs of material used in repair operations	22	78%
PERFORMANCE MEASURES – ASSET MANAGEMENT	USED	NOT USED
Inventory obsolescence	54	46
Stock level	54	46
Inventory turnover	53	47
Inventory management accuracy	50	50
Number of days of inventory	50	50
Inventory amount	41	59
PERFORMANCE MEASURES – CLIENT SERVICES	USED	NOT USED
Delivery in time	60	40
Consumer satisfaction	60	40
Service quality	58	42
Damage	57	43
Delivery reliability	54	46
Information system supporting LR	52	48
Shipment quality	52	48
Input methods for returned product services	46	54
Return reasons	44	56
Type of products returned	42	58
Percentage of periods of *backlogs*	40	60
Return amounts	39	61
RL cycle time	38	62
Complaints (absence or presence)	38	62
Waste generation rate	36	64
Quantity / volume of recyclable material disposed and capable of	35	65
Rate of products with defects	33	67
Return speed	33	67
Dock-to-stock time	32	68
Quality of documentation delivery	26	74
Recovery efficiency rate	26	74

PERFORMANCE MEASURES - PRODUCTIVITY	USED	NOT USED
Process technology and innovation capacity	47	53
Adjustment capability (flexibility)	36	64
Network capacity	30	70
Transport capacity	30	70
Accuracy of forecasting techniques	29	71
Reuse of materials	27	73
Labor productivity in the transport of RL	26	74
Energy use	23	77
Diagnostic accuracy	21	79

As seen in Table 1, contrary to what was found in the literature (only financial measures are fairly evaluated), it was possible to note that non-financial measures were also properly implemented in some dimensions. As an example, it is possible to mention the following measures: inventory obsolescence, inventory levels and inventory turnover (asset management dimension); on-time delivery, customer satisfac-tion, service quality, delivery damage and reliability (customer service); process technology, and innovation and adjustment capability (productivity).

5 Hypotheses Testing and Final Considerations

In order to verify the existence of a correlation between the use of performance measures dimensions and the size of the companies (hypothesis 1) and the sectors of the economy (hypothesis 2), these hypotheses were formulated and tested using a questionnaire that was applied before the survey was conducted. Homogeneity tests were carried out to evaluate the correlation between the variables mentioned above. In the cases in which correlation was statistically proven, tests (qui square) for the proportion of two samples were conducted in order to identify the most significant sector of the economy. Based on the statistical tests carried out for Hypothesis1 and 2, it was found that the large-sized companies evaluate productivity more frequently than the small and medium-sized companies. This could be explained due to the fact that this performance dimension requires a more fully implemented reverse logistics system in order to be better evaluated. In addition, it is expected that large-sized companies have properly implemented RL practices and widely share them with their staff, which enables them, even low hierarchical level employees, to use relevant information to assess this dimension.

As for hypothesis 2, no significant difference was found in the tests. i.e., no market sector influenced these companies in terms of the use of the different performance measures. Finally, it is important mentioning that although these companies are concerned about implementing more efficient logistics processes in the distribution of their products through a direct channel, they should express the same level of concern about the goods distributed through the reverse channel. This study presents a list of measures for this assessment in different industrial segments, which is a first step towards reverse logistics performance measurement. However, there are other studies on reverse logistics performance that are also of great importance as theoretical contribution and to the improvement and increase the use this activity in practice.

6 References

BAI, C. ; SARKIS, J. (2013) 'Flexibility in reverse logistics: a framework and evaluation approach', Journal of Cleaner Production, vol.47, pp.306-318.

BARBOSA, D.H.; MUSETTI,M.A. (2011) 'The use of performance measurement system in logistics change process', International Journal of Productivity and Performance Management, vol. 60, no.4, pp. 339 - 359.

CHAVES, G. L.D. (2009) 'Logística reversa de pós-venda para alimentos derivados de carnes e leite: análise dos retornos de distribuição',Thesis, Universidade Federal de São Carlos, São Carlos, Brazil.

CHAVES, G; BARBOZA, J.R.; ALCÂNTARA, R.L.C. (2011) 'Medidas de Desempenho para Avaliação da Logística reversa', in paper presented at Encontro Nacional de Engenharia de Produção, 23, ENEGEP, Belo Horizonte. Available at: http://www.abepro.org.br/ biblioteca/enegep2011_TN_STO_135_857_18209.pdf (accessed ago.2013).

CSCMP - COUNCIL OF SUPPLY CHAIN MANAGEMENT PROFESSIONALS (2013). Supply chain and logistics terms and glossary. Available at: http://www.cscmp.org/Terms/glossary03.htm (accessed dez.2013).

GENCHEV, S.E., RICHEY, R.G., GABLER, C.B. (2011) 'Evaluating reverse logistics programs: a suggested process formalization', International Journal of Logistics Management, vol.22, no.2., pp.242-263.

GLRT (GLOBAL LOGISTICS RESSEARCH TEAM), (1995) World Class Logistics: the challenge of managing continuous change. Michigan State University: Council of Logistics Management.

GUARNIERI, P. (2011) Logística Reversa: Em busca do equilíbrio econômico e ambiental. Recife:1 ed., Clube dos autores.

HO, G. T. S., LAM, C. H. Y., WONG, D. W. (2012) 'Factors influencing implementation of reverse logistics: a survey among Hong Kong businesses', Measuring Business Excellence, vol.16, no.3, pp.26-46.

LAMBERT, S.; RIOPEL, D.; ABDUL-KADER, W.A (2011) 'A reverse logistics decisions conceptual framework', Computers & Industrial Engineering, vol.61, no 13, pp. 561-581.

LEITE, P. R. (2009) Logística reversa: meio ambiente e competitividade. São Paulo: Practice Hall, 2ed.

LOPES, D. M. M et al (2014). 'Improving post-sale reverse logistics in department stores: a Brazilian case study', Journal of Transport Literature.Rio de Janeiro, vol.8, no.2, pp.325- 348.

NEELY, A.; GREGORY, M.; PLATTS, K. (2005) 'Performance measurement system design - a literature review and research Agenda', International Journal of Operations & Production Management, v. 25, n. 12, pp. 1828-1863.

ROGERS, D. S.; TIBBEN-LEMBKE, R. S. (1999) 'Going Backwards: Reverse Logistics Trends and Practices', Reno: University of Nevada.

SHAIK, M.; ABDUL-KADER, W. (2012) 'Performance measurement of reverse logistics enterprise: a comprehensive and integrated approach', Measuring Business Excellence, vol.16, no.2, pp. 23-34.

SKAPA, R.; KLAPALOVÁ, A. (2010) 'Reverse Logistics in Czech Companies: Increasing Interest in Performance Management', in paper presented at International Conference on Logistics and SCM Research, Bordeaux.

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Effectiveness of Holt Winter Models as aid to Production Alignment

Pinto J[1], Benitez GB[2], Furtado JC[3], Nara EOB[4], Siluk JCM[5]

Abstract: The research aimed to investigate and assess the use of holt-winters model through NCSS (Number Cruncher Statistical System) in the planning process optimization of industrial manufacturing production, evaluating the production of a product in a business accessories manufacturer for motorcyclists. Aimed up align demand forecast using historical sales data that were implemented in NCSS statistical tool. The construction of modeling was based on the method proposed by Armstrong (2001), and from statistical modeling been generated scenarios demand forecast, the results found evidenced the effectiveness level of methods adopted.

Keywords: Forecasting, NCSS, Holt-Winter Models.

1 Introduction

Despite the uncertainties of the global market, management looks the best demand forecasts to support decision-making processes, it is necessary to acquire raw materials, equipment, invest, training and adjustments to the establishment plan. The ability to handle demand characteristics and its variations, brings advantages for production systems, for example, low cost, simplicity and speed to generate results. Therefore, statistical techniques to demand and data modeling have demonstrated its importance and deserves the attention of organizational managers.

Changes on processes, products and technologies generally require high investments, which makes the high-risk processes. In this context, information technology in manufacturing and business processes are becoming popular as provided increments in the optimization of control systems efficiency (Bakhtadze, 2004).

Another point of using these tools is given in the possibility to predict the results and whether it is possible to carry them, with the advantage of needing not produce a single piece to learn the outcome assessed in advance, making way for a wide range of applications of these techniques in industrial environments.

In this context, we highlight the use of demand forecasting as a tool that uses data to predict future scenarios in search of minimizing risks taken operational decisions of process programming, minimizing potential losses arising from uncertainties.

With the use of demand forecasting, several studies have been developed using historical data to forecast future scenarios looking for minimizing risks faced by organizations, such as the studies of Sandanayake, Oduoza and Proverbs(2008), Montevechi *et al.*(2009), Mahfouz, Hassan and Arisha(2010), among others.

From the foregoing considerations, this study examined the use of statistical and computational tools in planning the optimization process for a manufacturer of accessories for motorcyclists, from sales time series. It has been used as a computational tool the NCSS software.

The work is organized as follows: section 2, the theoretical basis is presented; in section 3, materials and methods, in section 4, the results and in section 5 the conclusions are exposed.

1 **Jander Pinto** (jpjanderjp@yahoo.com.br)
2 **Guilherme Brittes Benitez** (guilherme.benitez@hotmail.com)
3 **João Carlos Furtado** (jcarlosf@unic.br)
4 **Elpidio Oscar Benitez Nara** (elpidio@unisc.br)
5 **Julio Cezar Mairesse Siluk** (jsiluk@ufsm.br)
Dept. of Production Engineering. University of Santa Maria.
Santa Maria, Avenue Roraima 1000, Brazil.

2 Theoretical basis

Planning is a common activity to any company and demand forecast (or forecasting) is the basis for preparation of this planning is required to help determine the necessary resources, in the programming of existing resources and the acquisition of additional resources (Ritzman, 2008; Moreira, 2009; Danese and Kalchschmidt, 2011).

The methods can be classified into quantitative and qualitative, the first, is based on the characterization of historical time series and forecasting future events, since the qualitative, involves subjective estimates, will and considerations of experts or consumers (Arnold, 2006; Boyer and Verma, 2009; Anzanello, Lemos and Echeveste, 2009).

The demand forecasts can be used in various types of business and according to several methods. Among others, the literature cited were: Werner *et al*. (2006) who applied the simple exponential smoothing to forecast demand for agricultural products and produce an estimate of the area to be planted; Antonio (2005), who used computer simulation to predict demands in the supply chain.

Among the generic statistical packages, stand out from the NCSS, Statgraphics, and SPSS that with similar characteristics, require user degree of statistical knowledge to use both in the selection of the forecasting.

3 Materials and methods

The development of this research took place by the use of statistical and computational tools with the use of quantitative demand forecasting methods for exponential smoothing techniques.

The NCSS software (Number Cruncher Statistical Systems) version 9.0 was chosen and used to plot the data and determine the predictors (Hintze, 2004; Bolding *et al.*, 2009).

As a structure for forecasting was used Armstrong (2001) following a structure around tasks: (i) formula-ting the problem; (ii) data collection; (iii) select forecasting methods; (iv) apply the methods; (v) evaluate the results, and; (vi) use the forecasting.

This proposed methodology was then applied to a case study in plastics industry, covering a family of products.

3.1 Defining the Problem

This study was conducted in a plastics company in South of Brazil, which offers to customers a product mix accessories for motorcyclists: chaps, boots, bags, reflective vests, motorcycle cover, cover for motorcycle seat, jackets, among other products.

There are problems in production system and the question is: The use of appropriate demand forecasting techniques can make production programming more efficient?

3.2 Data Collection

In the data collection planning, for modeling and construction of temporal interval predictions were determined variables of products through the historical sales information.

One product, denominated "Speed", was chosen among all the mix of products manufacturing by the company. The period of 2009-2013 was selected for the study and the demand forecasting model was implemented. The Figure 1 shows the demand between 2009 and 2013.

Speed Set					
Month	Year_2009	Year_2010	Year_2011	Year_2012	Year_2013
Jan	391	540	450	104	75
Feb	502	282	714	102	143
Mar	764	2155	655	375	419
Apr	690	1276	569	220	20
May	910	1130	1036	242	52
Jun	482	606	291	45	168
Jul	1054	1004	464	40	80
Aug	1549	2782	454	130	19
Sep	1467	1191	643	164	150
Oct	1017	1155	579	201	51
Nov	381	274	366	40	0
Dec	714	318	206	0	0

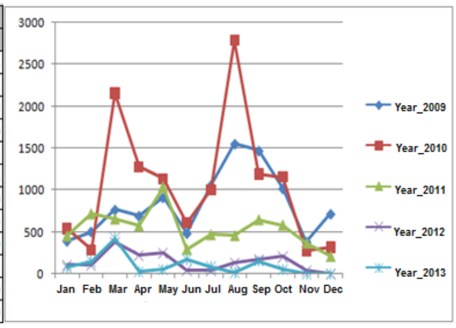


Fig.1
Sales Information/demand of the product called “Speed”.

3.3 Predictive method determination

After defining the time series and its plot (as seen in Figure 1) with the intention of collecting evidence that could generate data about how best to use quantitative model, has been opted for the Exponential Smoothing method.

Exponential smoothing is divided into: (i) Single Exponential Smoothing ; (ii) Linear Exponential Smoothing and Holt; (iii) Holt-Winters method. Being adopted the model of Exponential Smoothing through multiplicative Holt-Winters method and additive, because the dice shows seasonal variation and the possibility of applying smoothing equations to estimate the level, trend and seasonality of the time series analyzed in the process of forecast.

The multiplicative model in Pellegrini and Fogliatto (2007) is presented with the following mathematical equations:

$$F_{t+m} = (L_t + b_t m)S_{t-s+m} \tag{3.1}$$

$$L_t = \alpha \frac{Y_t}{S_{t-s}} + (1-\alpha)(L_{t-1} + b_{t-1}) \tag{3.2}$$

$$b_t = \beta(L_t - L_{t-1}) + (1-\beta)b_{t-1} \tag{3.3}$$

$$S_t = \gamma \frac{Y_t}{L_t} + (1-\gamma)S_{t-s} \tag{3.4}$$

The explanation of the mathematical models, according Samohyl, Rock and Mattos (2001):
F_{t+m} = forecast for period $t + m$;
m = the forecast horizon;
L_t = estimate of time series level in period t;
b_t = trend estimate of the time series for period t;
Y_t = observed demand;
s = length of seasonality;
S_t = seasonal component;
α, β and γ = exponential straighteners parameters, level, trend and seasonality respectively;
Have the additive, according to Pellegrini and Fogliatto (2007) are given by:

$$F_{t+m} = L_t + b_t m + S_{t-s+m} \tag{3.5}$$

$$L_t = \alpha(Y_t - S_{t-s}) + (1+\alpha)(L_{t-1} + b_{t-1}) \tag{3.6}$$

$$b_t = \beta(L_t - L_{t-1}) + (1-\beta)b_{t-1} \tag{3.7}$$

$$S_t = \gamma(Y_t - L_t) + (1-\gamma)S_{t-s} \tag{3.8}$$

3.4 Choose and proposal of validation

The biggest advantages of smoothing methods are low cost and simplicity, as in the case of need for predictability for thousands of items or in the case of inventory control systems. Such methods have quickly to generate results and to compose an effective demand forecasting system.

4 Results

The resulting methods of application information are shown in Figures 2, 3 and 4.

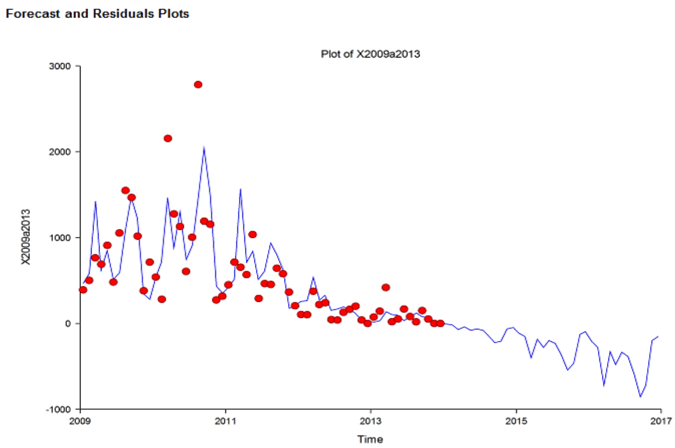


Fig.2
Demand graph.
Source: prepared by the author.

In Figure 2 is possible to see the plot of actual demand graph (in red) and predictions in blue) and the actual demand for the next three years. It can be seen also from the graph, that by the year 2015 the product had "dead", that is, after that date, if it continues as it is the product will no longer generate profit for the company. So the chart is pointing down, so the demand forecast permitted viewing a fall for this product, and leaves the criteria that can be done a thorough study of possible changes to the product, if there is interest in keeping the product on the market.

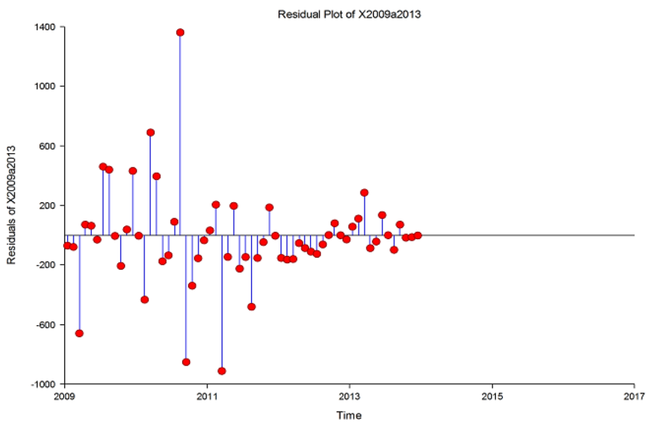


Fig.3
Demand level chart.
Source: prepared by the author.

Figure 3 shows the plot chart the level of demand for verifying noise, seasonality and amplitude of the seasonal value, which showed a strong seasonal pattern (seasonal cycle of five years) where the multiplicative model was adequate.

In the Figure 4, the model used was the Holt-Winters additive compared to the multiplicative effect, finding an R-Squared Pseudo adjustment 0.611418 medium.

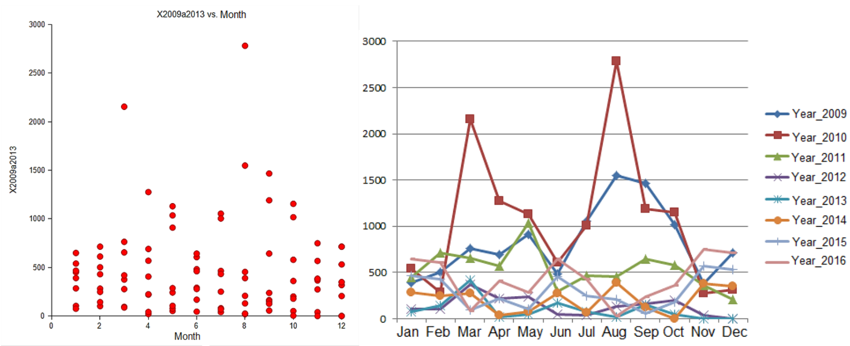


Fig.4
Shows the comparison of forecast charts generated by the NCSS and the Excel where we can see that the two methods showed identical results.

5 Conclusions

Analyzing the results of the comparison between the multiplicative and additive methods, we can see that the simulation data forecasts performed with NCSS, had results of Pseudo R-Squared below of 0.75.

For the product, the percentage of correct answers in the simulated predictions was not satisfactory because it is not at a high level of accuracy, which creates uncertainty in the application of credibility of the computational method demand forecasting with the NCSS software.

In order to get a higher coefficient of correlation and more accurately, we compared the results of the method used and the graph generated by Excel. Thus, came to the conclusion that the tested forecasting models showed very similar results, as seen by the graphs and the values of Pseudo R-Squared.

According to the results of analyzes to validate the demand forecasting method applied, it was also possible to conclude that the use of this statistical tool can be applied to support the optimization process of the company's planning and help you find the best condition programming by selecting the most appropriate method.

Therefore, we can conclude that the use of demand forecasting techniques can make programming more efficient production, as through NCSS software simulations was possible to see future predictions, which reduce the risks eminent decision-making processes, as forecasts show a certain degree of accuracy resulting increase in accuracy of prediction which leads to decrease in losses due to uncertainties in the decision making process, and this method have low cost.

As future work is suggestion of the use of multi-criteria analysis for selecting the most suitable tool for performing demand forecast.

References

Antonio D, Pires S (2005) Uma análise da Gestão da Demanda na Cadeia de Suprimentos através de simulação. Anais do XXV Encontro Nacional de Engenharia de Produção, ENEGEP, Porto Alegre-RS, Brazil.

Armstrong JS (2001) Principles *of forecasting: a handbook for researchers and practitioners.* USA: Kluwer Academic Publishers.

Anzanello MJ, Lemos FO, Echeveste ME (2009) Aprimorando produtos orientados ao consumidor utilizando desdobramento da função qualidade (QFD) e previsão de demanda. *Produto & Produção*, Porto Alegre, v.10, n. 2, p. 01-27, Quadrimestral, Jun.

Arnold JRT (2006) *Administração de Materiais.*São Paulo: Atlas. 521 p.

Bakhtadze NN (2004) Virtual analyzers: Identification approach. *Automation and Remote Control*, v. 65, n 11, p. 1691-1709.

Bolding MC, Chad TD, Loren DK (2009) Productivity and costs of an integrated mechanical forest fuel reduction operation in southwest Oregon. *Forest Products Journal*.

Boyer KK, Verma R (2009) *Operations and Supply Chain Management for the 21st Century.* Mason, Ohio: Cengage Learning.

Danese P, Kalchschmidt M (2011) The role of the forecasting process in improving forecast accuracy and operational performance. *International Journal of Production Economics*, v. 131, n. 1, p. 204-214.

Hintze J (2004) NCSS and PASS.*Number Cruncher Statistical Systems*. Kaysville, UT.

Mahfouz A, Hassan SA, Arisha A (2010) Practical simulation application: Evaluation of process control parameters in Twisted-Pair Cables manufacturing system. *Simulation Modelling Practice and Theory*, v. 18, p. 471–482.

Montevechi JAB, Costa RFS, Leal F, Pinho AF, Jesus JT (2009) *Economic evaluation of the increase in production capacity of a high technology products manufacturing cell using discrete event simulation*. In: PROCEEDINGS OF THE WINTER SIMULATION CONFERENCE, Austin, USA.

Moreira, DA (2009) *Administração da produção e operações*. 2. ed. rev. e ampl. São Paulo: Cengage Learning.

Pellegrini FR, Fogliatto FS (2007) Estudo comparativo entre os modelos de Winters e de box-jenkins para previsão de Demanda sazonal. Revista produto e produção.

Ritzman LP, Krajewski LJ (2008) *Administração da produção e operações.*São Paulo: Pearson Prentice Hall.

Samohyl RW, Rocha R, Mattos VLD (2001) Utilização do método de Holt-Winters para previsão do leite entregue às indústrias catarinenses. *Enegep – Encontro Nacional de Engenharia de Produção*, Rio de Janeiro.

Sandanayake YG, Oduoza CF, Proverbs DG (2008) A systematic modelling and simulation approach for JIT performance optimization. *Robotics and Computer-Integrated Manufacturing*, v. 24, p.735-743.

Werner L, Ribeiro JLD (2006) Modelo composto para prever demanda através da integração de previsões. *Produção*, v.16, n.3, p.493-509.

The Pressures of the Brazilian Pre-Salt Production on the National Refining Sector

Yabiko R[1], Chicata F[2], Bone R[3]

Abstract: The objective of this article is to analyze the current production capacity of the Brazilian refining sector and how much it should be increased in order to process the oil from the pre-salt layer. The variables considered were refining capacity, refined volume, and utilization factor of refineries, production profile and domestic demand for petroleum products. We conclude that oil production will exceed domestic consumption. However, the refined volume is short of demand, even with the investments announced by Petrobras. To achieve self-sufficiency by 2030, it would be necessary the implementation of two refineries with the refining capacity of 350 thousand barrels of oil per day each.

Keywords: Brazil; Pre-Salt; Oil Derivatives; Self-Sufficiency; Refining.

1 Introduction

The refining process involves transforming crude oil into derivatives. In other words, the oil is separated into fractions according to molecular weight in order to achieve a final product for consumption (KIMURA, 2005). Currently the Brazilian national refining complex consists of 17 oil refineries. In 2013, these refineries hit the throughput capacity of 2.2 million oil barrels per day (MMbbl/d) and in 2014 the Abreu e Lima Refinery (Rnest) started production, adding to 230 thousand oil barrels per day (Mbbl/d), according to the National Agency of Petroleum, Natural Gas and Biofuels (ANP). Petrobras owns 13 of the 17 existing refineries and 4 are from the private sector. In 2013, the utilization factor of all refineries in national territory was 98.2%. This information, linked to the other factors mentioned below, highlights the urgency of expansion projects to the national refining capacity.

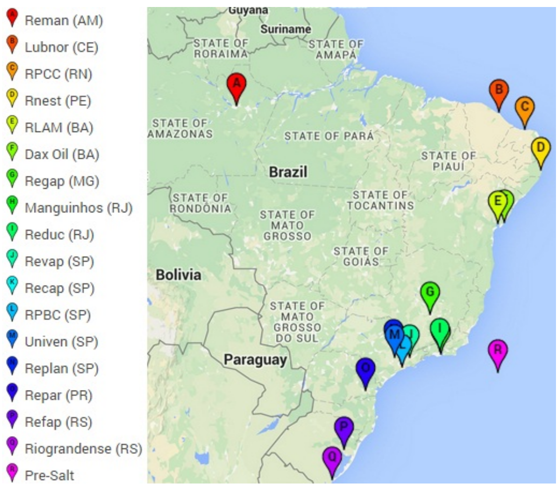
Since 2008, the Brazilian pre-salt began its production at an accelerated pace. From the year 2012 to 2013 there was a 76.9% increase in the volume extracted from these fields. There are many blocks in the region waiting to be auctioned, causing positive production prospects. Nowadays, Brazil produces about 2.4 MMbbl/d and consumes about 3 MMbbl/d (ANP, 2013).

The purpose of this paper is to analyze the national refining capacity upon the expanding Brazilian oil production scheduled for the years to come. The specific goal is to verify if the domestic demand for oil will be met and, therefore, whether it will decrease in its imports expenditure, as well as an increase in revenue from the export of high value-added products.

2 Refining Plants in Brazil

An important feature of the Brazilian refining sector is its high spatial concentration. The construction of the refinery network was aimed to maximize economies of scale in production and minimize diseconomies of scale in distribution. Map1 situates the Brazilian refining park and the pre-salt area.

1 **Raíssa Fernandes Yabiko** (rayabiko@poli.ufrj.br)
2 **Fabíola Siomara Liboreiro Chicata** (fabiolachicata@poli.ufrj.br)
Petroleum Engineering,
Polytechnic School of Federal University of Rio de Janeiro, Brazil.
3 **Rosemarie Bröker Bone** (rosebone@poli.ufrj.br)
Department of Industrial Engineering - DIE,
Polytechnic School of the Federal University of Rio de Janeiro



Map 1
Location of Brazilian refineries and the pre-salt.
Source: GoogleMaps 2015

Throughout the years, the refineries were built in locations close to the main centers of consumption and production: 8 of the 17 refineries are in the Southeast, the largest consumer base of oil products. Since the Brazilian refining scenario is different to the refineries from the private initiative and Petrobras, initially it will be analyzed the refineries of the private sector.

2.1 Private Sector Refineries

The first Brazilian oil refinery was the Oil Refinery Riograndense, opened in Rio Grande do Sul, in 1937. Its refining process is prepared to handle domestic oil, including those from the pre-salt. In 1954, with the beginning of oil exploration in Brazil, the Petroleum Refinery Manguinhos was created in the city of Rio de Janeiro. The raw material used by the refinery goes from light oil (greater than 30°API) to heavy (less than 22°API), which allows great operational flexibility. The pre-salt brings a window of opportunity to Manguinhos considering its performance of desalting and dehydration (removal of salt and water) of the oil operations to avoid the commonly named 'dead freight’, which is the transport of water instead of petroleum during the exportation – a vital operation for Petrobras' partners to efficiently export the oil produced from these fields.

Recently, two more refineries began operations. In 2009, Univen Oil Refinery started its activities in the metropolitan region of São Paulo. In 2010, the Dax Oil Refinery began operating in the state of Bahia. Both refineries buy oil from marginal fields producers and from importation, but its facilities can work mostly with national oil. The introduction of the pre-salt production in the market will facilitate these private companies to gain access to the national feedstock and improve their use factor, which was only 31.3%, on average, in 2013 (ANP, 2014).

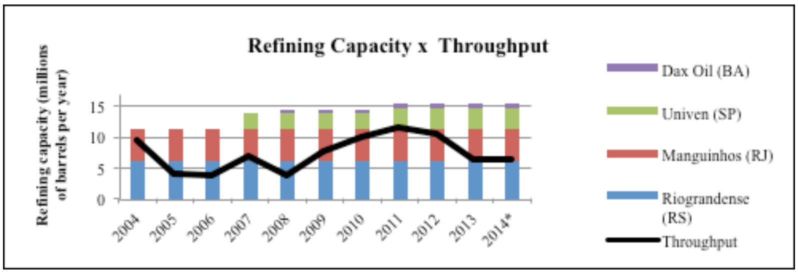
2.1.1 Evolution of the Private Refineries

A problem faced by all the refineries in the private sector is to obtain the raw material and to maintain the competitiveness of their products regarding the production of Petrobras refineries. In collaboration with government policy, the state does not pass all charges involved in the refining of fuels to the final consumer. Thus, in order to overcome this structure of costs and prices of derivatives, private refineries need to be highly technological and produce high value-added products. Figure 1 and Table 1 show a sector outlook.

Table 1
Utilization Factor (%) of Private Refineries.
Source: ANP

Utilization Factor (%) of Private Refineries									
2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
87.5%	37.8%	33.7%	51.1%	26.4%	55.2%	73.1%	78.7%	72.3%	43.2%

Chart 1
Refining capacity x throughput of the private refineries
Source: ANP *Preliminary results



In chart 1, there are three moments of decreased productivity. The first one is related to the closing of Manguinhos – during the years 2006 to 2009, this refinery left the business due to the lack of competitiveness of its final product in detriment of Petrobras products. The second moment corresponds to the oil crisis and the third to the crisis faced by all private refineries to obtain raw materials and produce competitive products. As aforementioned, these refineries present idle capacity and are potential targets for the coming of pre-salt production, which appears promising for the sector.

2.2 Petrobras Refineries

There are four Petrobras refineries installed in the state of São Paulo. The Paulínia Refinery (Replan) is the largest in oil processing capacity: 415 Mbbl/d. Its production is responsible for 20% of all oil refining in Brazil and its feedstock is 80% national, mainly from Campos Basin (ANP, 2014). The Capuava Refinery (Recap) was the first to process the pre-salt oil from Santos Basin, in 2009. The Presidente Bernardes Refinery (RPBC) produces final high value-added derivatives such as podium gasoline, petroleum coke, petrochemical naphtha and fuel for ships (bunker). These derivatives are of high market value and produced according to international standards. Most of the raw material used comes from the Santos Basin. The Henrique Lage Refinery (Revap) is the third largest refinery in the country and its feedstock is 80-90% national (Petrobras, 2015).

Still in the Southeast, there is the Duque de Caxias Refinery (Reduc) in Rio de Janeiro. Currently, this refinery uses about 60% of domestic oil from Campos Basin (ANP, 2014). Located in Minas Gerais, the Gabriel Passos Refinery (Regap) is able to refine 150 Mbbl/d, with a perspective to increase 10% of its volume within the next few years, on account of an expansion project of processing units focusing on diesel production. This investment aims for the pre-salt production, considering that the refinery has already been working with the oil from Campos Basin.

In the South, there are two refineries: the Alberto Pasqualini Refinery (Refap) and the Presidente Getúlio Vargas Refinery (Repar). Both utilize a mixture of domestic oil and imported as a feedstock, with greater participation of Brazilian oil.

Located in the Reconcavo Baiano, Landulpho Alves Refinery (RLAM) is the second largest in the country. Still in the Northeast, the Potiguar Clara Camarão Refinery (RPCC) is located in Rio Grande do Norte. This state became the only in the country to be self-sufficient in the production of all types of oil products (ANP, 2014). Both of them work with the heavy crude oil from the post-salt and the light crude oil from the pre-salt layer, originated in the Campos Basin.

All the aforementioned refineries are able to process the oil from the pre-salt. However, some of them do not fit this profile. The Isaac Sabbá Refinery (Reman), for example, is located in the Amazonas state, deep in the Amazon forest. The oil used in the refinery presents high API gravity (about 30 ºAPI), different from the pre-salt oil. Furthermore, there would be an insurmountable logistical problem in the transportation of raw material from the pre-salt. On the other hand, the Lubrificantes e Derivados do Nordeste Refinery (Lubnor), in the Ceará state, works with extra heavy oil from the state itself and Espírito Santo. Thus, the oil coming from the pre-salt is not a priority for this refinery, because the properties of this oil hinder the production of derivatives, including high value-added lubricants for noble use. In the same operation line, the Abreu e Lima Refinery (Rnest), located in Pernambuco, began operations in December 2014, with the main objective to produce diesel using as raw material a heavy crude oil (around 16 ºAPI) from Rio Grande do Norte.

2.2.1 Evolution of the Petrobras Refineries

The problem faced by Petrobras in the refining business is the high utilization factor of its refineries. This positive background is explained by an easy access of raw material, given the company also acts in the exploration and production sector (E&P) and utilizes economies of scale inherent of the sector. Chart 2 and Table 2 demonstrate this scenario.

Chart 2
Refining capacity x throughput of the Petrobras refineries.
Source: ANP *Preliminary results

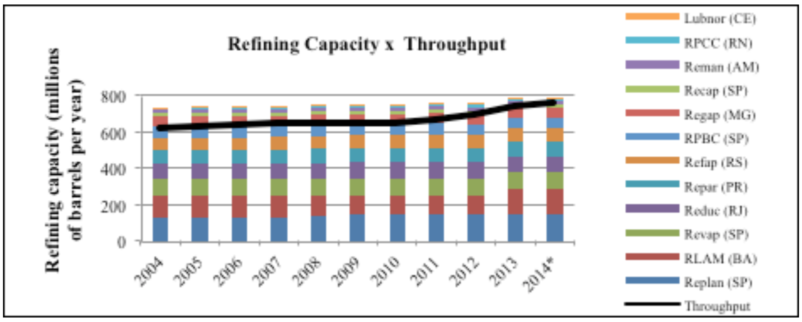


Table 2
Utilization Factor (%) of Petrobras Refineries.
Source: ANP

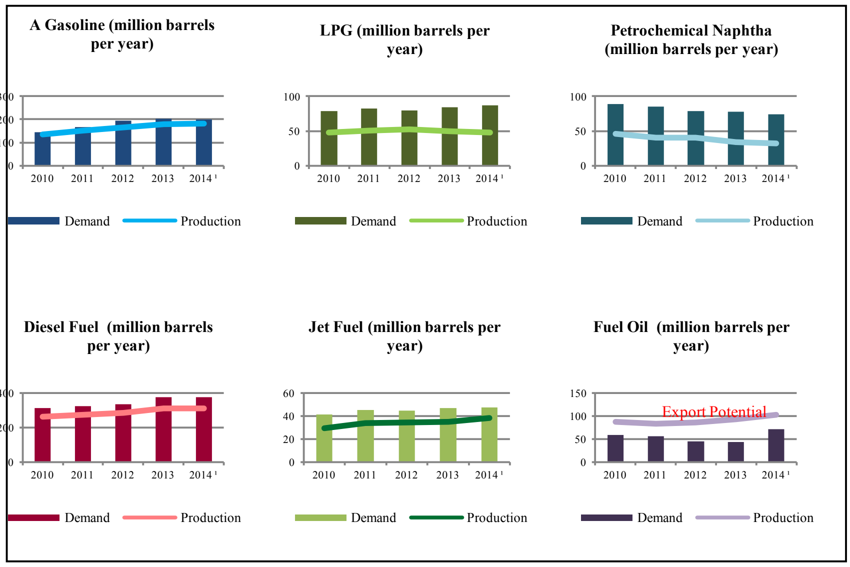
Utilization Factor (%) of Petrobras Refineries									
2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
90.3%	90.4%	91.1%	91.9%	91.4%	91.8%	91.6%	93.0%	97.1%	99.3%

Since 2008, the utilization factor of refineries only increased as shown in table 2. According to Chart 2, even with the global economic crisis, the refined volume did not show a significant fall. The production of Petrobras refineries reached 2.17 MMbbl/d in 2014, which represents a growth of 2.1% compared to 2013. This record is due to the Medium and Gasoline Production Program (Promega), implemented by the company to maximize the volume of petroleum derivatives produced from medium fractions of oil, through the updating and improvement of the refineries (PORTAL BRAZIL, 2014).

3 Domestic Demands and Production of Oil and Derivatives

The refineries profile reveals in which products they are specialized. This also shows which derivatives are more demanded by the domestic market. The graphs (3) below display the quantity produced from a set of derivatives, chosen according to their relevance, and the consumption of each one.

Chart 3
Domestic demand x national production.
Source: Ministry of Mines and Energy - MME (2014).
[1]Considering the average value for December/2014



According to the graphics (3), among the important group of derivatives, Brazil exports only fuel oil, characterized as a strong importer. The strategic plan until 2030 published by Petrobras, in 2014, affirm that the demand for derivatives in Brazil will grow 20% by the year 2020, always ensuring a stimulating refining sector. In addition, based on data provided by the ANP, in 2013, the country had an expenditure of US$ 19,600,385,382.00 with importation of petroleum derivatives and revenue of US$ 9,941,619,795.00 with export of these, leading to a deficit of US$ 9,658,765,587.00.

Despite the unfavorable scenario presented above, Brazil has the potential to be self-sufficient in derivatives in the years to come. According to the Organization of the Petroleum Exporting Countries (OPEC) cited in MME (2014), in 2025 the oil production in Brazil will reach its maximum of 1.7 billion barrels per year.

In consonance with this information, it follows that the greatest obstacle to the Brazilian self-sufficiency in relation to petroleum products is the total capacity of the national refineries. Some measures to solve this issue are already being provided, such as: (a) investments in new refineries and (b) expansion of the existing ones.

4 Brazilian Refining Sector Investments

By 2020, Petrobras plans to supply the totality of the Brazilian derivatives products market, achieving self-sufficiency in relation to petroleum derivatives. To fulfill this goal, two investments are already underway. The first is finishing the construction of the Abreu e Lima Refinery (Rnest), so the refinery can operate at 95% of its capacity – currently the maximum is 64%. And the second is building the Petrochemical Complex of Rio de Janeiro (Comperj), which will have as final products diesel fuel, naphtha, jet fuel, coke and LPG. The forecast for starting operation of the first refining train is in August 2016, with an installed refining capacity of 165 Mbbl/d. The company also intends to continue with the Promega, which has already shown results by increasing the refineries efficiency.

However, with the recent withdrawal of two more Petrobras investments, the Premium I and Premium II Refineries, which would have had the capacity to process at 600 and 300 Mbbl/d respectively, this goal, will be difficult to reach. Considering the perspective of growth for the internal demand, even with the possible retraction of the Brazilian economy, in 2020 it will arrive at 3.5 M Mbbl/d. Brazil will need to add more 695 Mbbl/d to its existing refining capacity, which would correspond to an implementation of two more refineries in the same technical scheme of Landulpho Alves Refinery – with main final products the derivatives at the top of the Brazilian import list: gasoline, diesel, naphtha and jet fuel – and installed capacity of approximately 350 Mbbl/d to achieve the expected self-sufficiency.

As for the private refineries, there are still no concrete investments plans. However, the best way to increase the refined volume will be the full use of its installed capacity, which can reach up to about 40 Mbbl/d, meaning more than twice the volume of the year 2013.

5 Conclusion

The pre-salt production expands at an accelerate pace, as well as consumption. According to ANP, domestic demand grew by 5.6% in 2014 and it is expected to increase between 3 and 5% in 2015, despite the possible downturn in the national economy, since the growth of demand is linked to the performance of the Gross Domestic Product (GDP). This setting is ideal for Brazil to avoid what happens to countries like Mexico and Iran, which are crude oil exporters and petroleum derivatives importers. Nevertheless, investments in the refining sector have being encountering many obstacles along the way.

The 2030 Strategic Plan by Petrobras announced a self-sufficient Brazil in gasoline and diesel by 2020, when the country's refining capacity would reach 3 MMbbl/d. However, with the annulment of the Premium I and Premium II, this optimistic scenario is distant. In the current scenario, the inauguration of the Petrochemical Complex of Rio de Janeiro (Comperj), the completion of works in Abreu e Lima Refinery (Rnest) and the increase of the utilization factor of private refineries will not be enough for the country to achieve its self-sufficiency in relation to petroleum derivatives. Investments such as the construction of new refineries, expanding the existing ones and the efficient use of private refineries will be necessary.

References

Ministry of Mines and Energy (2014) Relatório do Mercado de Derivados de Petróleo N 108. (portuguese) Brasilia: Secretary of Petroleum, Natural Gas and Renewable Fuels, Petroleum Fuels Department. Available in PDF

National Agency of Petroleum, Natural Gas and Biofuels (2015) ANP. Available via <www.anp.gov.br>. Cited 20 Jan 2015

Petrobras (2015) Refineries. Available via <www.petrobras.com.br/pt/nossas-atividades/principais-operacoes/refinarias>. Cited 03 Sep 2014

Portal Brasil (2014) Promega contribui para os recordes de refino. (portuguese) Available via <www.brasil.gov.br/economia-e-emprego/2014/04/promega-contribui-para-os-recordes-de-refino>. Cited 30 Nov 2014

Kimura RM (2005) Indústria Brasileira de Petróleo: Uma Análise da Cadeia de Valor Agregado. (portuguese) IE/UFRJ

Conceptual Framework for applying Internet of Things in Production Systems for Sensing Enterprises

Boza A[1], Cortes B[2], Alemany MM[3], Cuenca L[4]

Abstract: Sensing Enterprise is a new concept, which appears with the Internet of Things (IoT) application in industry. This technology applied in production systems provides many benefits like better transparency or real time information. This approach proposes a conceptual framework for IoT application in Production Systems. The aim of this framework is helping enterprises to identify the main elements to apply IoT in Production Systems. To create this framework, a literature review has been made and the main components of IoT in Sensing Enterprise in production proposals have been identify. Thus, these elements and its relations have been the source for the conceptual framework proposed.

Keywords: Internet of Things, Sensing Enterprise, Production System, Information System, Conceptual Framework.

1 Introduction

According to FInES (2012) the next decade is expected to see a big change in the way enterprises operate, because to the Future Internet and the huge development achieved by enterprises in adopting new technical solutions. The FInES Cluster, in its Roadmap, proposes 9 *Qualities of Being* (QB) that are considered strategic for the enterprises of the future. One of these *Qualities of Being* is Sensing Enterprise. There is a need to decentralize intelligence, moving to a scenario where the enterprise is seen as a smart complex entity capable of sensing and reacting to (business) stimuli (FInES, 2012). This concept emerges with the evolution of IoT.

Although no universal definition exists for Internet of Things, the core concept is that everyday objects can be equipped with identifying, sensing, networking and processing capabilities, which will allow them to communicate with one another, and with other devices and services, over the Internet to achieve some useful objective (Atzori, Iera and Morabito, 2010). Miorandi et al. (2012) briefly resume the three main system-level characteristics of the Internet-of-Things as follows: Anything communicates, anything is identified and anything interacts.

This paper focus on Sensing Enterprise and IoT applied in production systems. Thanks to the new information technologies, production processes can be optimized; the entire lifecycle of objects, from production to disposal can be monitored; and greater transparency can be gained about the status of the shop floor, the location and disposition of lots, and the status of production machines (Bandyopadhyay and Sen, 2011). Enterprises could take these advantages and improve their production system applying IoT. To this end, this paper shows key concepts to implement IoT application in Production System. Section 2 shows a literature review with the application of IoT in production; section 3 includes the conceptual framework proposed to identify and organize these key concepts; and finally, section 4 includes the conclusions drawn from this research.

1 **Andrés Boza García** (aboza@cigip.upv.es)
2 **Beatriz Cortés Santamaría** (beacorsa@cigip.upv.es)
3 **María del Mar Alemany Díaz** (mareva@cigip.upv.es)
4 **Llanos Cuenca González** (llcuenca@cigip.upv.es)
Research Centre on Production Management and Engineering (CIGIP),
Universitat Politècnica de València, Cno. De Vera s/n, 46022, Valencia, Spain

2 Applications of IoT in literature

It is possible to find general proposals useful for a wide range of industrial sectors, but also a specific proposal for given industrial sectors (Boza et al., 2015). For example, Cao, Li and Song (2011) present a proposal based on IoT for the toy sector, Castro et al. (2011) for chemical industries, Hu, Zheng and Zhu (2011) in the meat sector, Liu and Xu (2013) for aerospace industries and Qu et al. (2012) and Wang and Liu (2014) for the agricultural sector.

The most proposal are general proposals useful for a wide range of industrial sectors. Cuiyun and Yuanhang (2010) study the influence of an IoT application on production and logistics in an enterprise. Houyou et al. (2012) design an automation system in manufacturing to support flexibility and agility in manufacturing. Isenberg et al. (2011) research about suitability and cooperation in collaborative production environments for autonomic and agile processes based on IoT. Lvqing (2011) presents a mechanical production monitoring system based on IoT technology. Meyer et al. (2011) make an approach for a monitoring and control system to enable new ways in which disturbances can be dealt with in order to increase the robustness of overall plan execution. Wang and Chen (2013) design a manufacturing inventory management model based on IoT. Yuan et al. (2013) develop a system to verify that IoT promotes workshop process visualisation developments. Zhang et al. (2014) propose an Internet of Manufacturing Things like a tool to design an easy-to-deployment infrastructure to form a sensing manufacturing environment. Zhiliang et al. (2013) present a project that merges Personal Digital Assistant (PDA) in manufacturing shop with IoT. Zuehlke (2010) design Smart Factory KL, a multi-vendor research facility for smart production technologies.

With these applications founded in literature, the main concepts to apply IoT in production system have been extracted and joined to create the conceptual framework presented in this paper. These concepts allow knowing the main elements of IoT application for Sensing Enterprises in Production System.

3 Concepts of IoT in Production System

The aim of this research is to identify and organize the key concepts to implement IoT applications in Production System basing on literature review. In order to define a conceptual framework, the key concepts of IoT in Sensing Enterprise and IoT in production proposals have been identified. Thus, a conceptual framework for applying IoT in Production System has been proposed.

3.1 Internet of Things in Sensing Enterprise

The main characteristic of Sensing Enterprise is the promptness to react in front of disturbances due to detecting events in real time with the help of new technologies, mainly IoT. This is a new concept which allows any object communicates with others objects through Internet, and provide information in real time with new technologies, like RFID and sensors, to facilitate the exchange of goods and services in global supply chain networks (Gu et al., 2014; Tan and Koo, 2014; Wang, 2014; Whitmore et al, 2014).

Internet of Things is structured in three levels (Atzori et al., 2010; Bandyopadhyay and Sen, 2011; Gubbi et al., 2013; Gu et al., 2014; Singh, Tripathi and Jara, 2014). These levels provides all the elements to apply IoT:

- Edge level: this level is formed by the physical part of IoT. ID-technologies and Sensors below to these level (Tan and Koo, 2014). These level gives to the objects the physical part to store information and give them intelligence. This part is formed by RFID (Cao et al., 2011; Castro et al., 2011; Hu et al., 2011; Isenberg et al., 2011; Liu and Xu, 2013; Shengduo and Jian, 2012; Vossiek et al., 2010; Wang and Liu, 2014) and two dimensional code (Lee et al., 2012; Lvqing, 2011; Meyer et al., 2011; Stephan et al., 2010; Zhiliang et al., 2013). For reading these ID-technologies, there are sensors (Cao et al., 2011; Hu et al., 2011; Qu et al., 2012; Vossiek et al., 2010; Zhang et al., 2014) and cameras (Lee et al., 2012; Shengduo and Jian, 2012). There are also Object Memory Servers (Stephan et al., 2010), to store the information in each object and database servers with enterprise information (Cao et al., 2011; Cuiyun and Yuanhang, 2010; Liu and Xu, 2013; Meyer et al., 2011; Wang and Liu, 2014; Zhiliang et al., 2013).

- Access Gateway Level: objects need a network to send and receive information between these. The management of these network bellows to these level. The possible networks are Wireless Sensor Network (Castro et al., 2011; Shengduo and Jian, 2012), Mobile Communication Network (Lee et al., 2012; Qu et al., 2012), GPS (Liu and Xu, 2013; Meyer et al., 2011), Bluetooth (Zuehlke, 2010), 6LoWPAN (Castro et al., 2011) and Zigbee (Zhang et al., 2014; Zuehlke, 2010).

- Application Level: in this level, objects acquire intelligence through implemented software. These objects can communication also with an application in a computer or a smartphone. This application can be new software (Cao et al., 2011; Hu et al., 2011; Lvqing, 2011; Wang and Chen, 2013; Wuest et al., 2012) or an extended part of information system in enterprise (Houyou et al., 2012; Zhiliang et al., 2013).

In summary, Sensing Enterprises are based on Internet of Things, and IoT is structured in three levels: Edge, the physical part (RFID, sensor, etc); Access, the part carried out of object communication; and Application, which can be new application or a module to extend the present information system (Figure1).

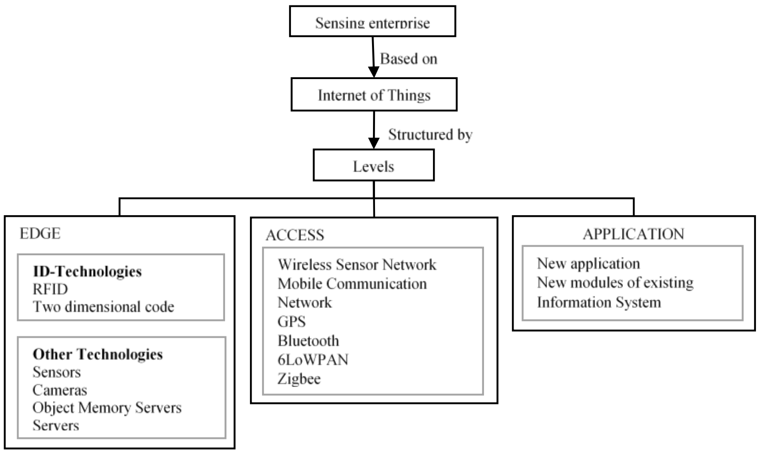


Fig.1
Main concepts of IoT Application.

3.2 Internet of Things in Production Proposals

Production system is a set of tasks to manage production in an enterprise. These tasks can be classified in three phases: Planning, Operations and Control (Cuatrecasas, 1994). To manage each phase, enterprise uses different information technologies. These technologies provides information to help managers making decisions (Simchi-Levi, Kaminsky and Simchi-Levi, 2003). IoT is one of these technologies which provides information (Cuiyun and Yuanhang, 2010).

In Production Planning, for example, inventory management application (Cuiyun and Yuanhang, 2010; Isenberg et al., 2011) to know the current inventory and to plan in base of this information; or tracking management system (Cuiyun and Yuanhang, 2010; Wuest et al., 2012) to know the times of transporting or production and planning with this information. In Operation Phases, IoT application allows factory automation (Houyou et al., 2012), product manufacturing workshop (Liu and Xu, 2013) or mechanical production with management system (Lvqing, 2011). The applications in this phase are also called Internet of Manufacturing Things (Zhang et al., 2014; Zhiliang et al., 2013). The largest number of IoT application in production system are for the Control Phase (Boza et al., 2015). In this phase, some applications are Resource Management Systems (Lee et al., 2012) , to control resources to accomplish the planning; Monito-ring and Control Systems for disturbances in production (Meyer et al., 2011; Yuan et al., 2013); tracking systems to control the necessary pieces of a product (Qu et al., 2012); or a management systems to control the environment of production like agriculture o food factory (Hu et al., 2011; Shengduo and Jian, 2012).

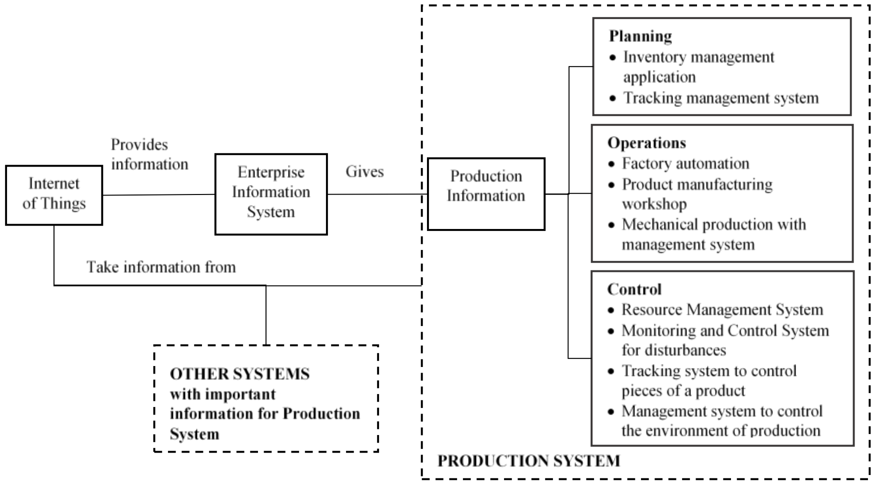


Fig.2
Main concepts of IoT in Production system.

In summary, IoT provides value information, taken from production system or other systems with relevant information for production, which enriches the Enterprise Information Systems. This information systems based on IoT improves the different phases of Production System: Planning, Operations and Control (Figure 2).

3.3 Proposed Framework of Internet of Things in Production System

In this section, a conceptual framework for Internet of Things Application in Production System of Sensing Enterprises is presented. Figure 3 represents the complete framework joining the concepts presented before. Sensing Enterprise has a production system that is improved with Information Systems. Information Systems are complemented by product information provided by IoT, which is structured in three levels: Edge, Access and Application.

Basing in this concepts, enterprise have to contemplate the phase whose information must to be improved (Inventory to plan, product localization to operate, production environment to control, etc). Then, enterprise should study the elements necessary in each level of IoT structure: Application (what kind of application is required? Will the application be new or an ERP extension?), Access network (How are objects going to communicate? How many objects will be?) and Edge (What ID-technologies are objects going use? Are sensors going to be necessaries?).

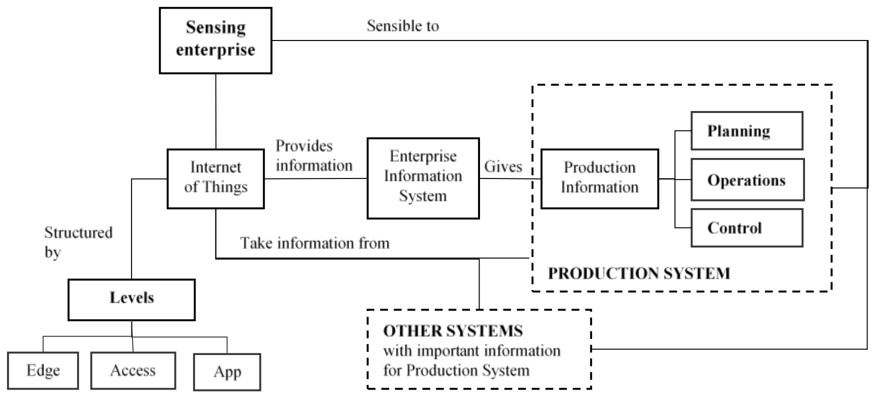


Fig.3
Conceptual Framework of IoT Application
in Production System for Sensing Enterprise.

4 Conclusions

This paper presents a conceptual framework about IoT in Production system inside Sensing Enterprise. To define this framework, a literature review about IoT applications in production System has been made. Even though there are few researches, main concepts of IoT applied in Production System has been extracted.

These elements help any enterprise of any sector to apply IoT and show examples of applications that improve the production system in each phase. This framework pretends to help enterprises to acquire sensibility in front of disturbances in the Production System. A possible future line will be proving this framework in a real company to see if these concepts help to apply IoT.

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References

Atzori, L., Iera, A., Morabito, G., (2010). The Internet of Things: A survey. Comput. Netw. 54.

Bandyopadhyay, D., Sen, J., (2011). Internet of things: Applications and challenges in technology and standardization. Wirel. Pers. Commun. 58, 49–69.

Boza, A., Cortés, B., Cuenca, L., Alarcón, F., (2015). Internet of Things Applications in Production Systems. Presented at the ICEIS - 17th Int. Conf. on Enterprise Information Systems.

Cao, Y.L., Li, W.F., Song, W., (2011). Research on Materials Tracking in Toy Production Based on the Internet of Things. Adv. Mater. Res. 314-316, 2439–2442.

Castro, M., Guillen, A., Fuster, J.L., Jara, A.J., Zamora, M.A., Skarmeta, A.F.G., (2011). Oxygen Cylinders Management Architecture Based on Internet of Things. 2011 ICCSA,271–274.

Cuatrecasas, L., (1994). Organización y gestión de la producción en la empresa actual. CPET.

Cuiyun, M., Yuanhang, H., (2010). Discussion on the Application of Internet of Things in Logistics Production Management, 2010 ICEE. 3901–3903.

FInES, F.I.E.S.C., (2012). FInES Research Roadmap 2025.

Gubbi, J., Buyya, R., Marusic, S., Palaniswami, M., (2013). Internet of Things (IoT): A vision, architectural elements, and future directions. Future Gener. Comput. Syst. 29, 1645–1660.

Gu, L., Wang, J., Sun, B., (2014). Trust management mechanism for Internet of Things. China Commun. 11, 148–156.

Houyou, A.M., Huth, H.-P., Trsek, H., Kloukinas, C., Rotondi, D., (2012). Agile manufacturing: General challenges and an IoT@Work perspective. 2012 ETFA, pp. 1–7.

Hu, T., Zheng, M., Zhu, L., (2011). Research Application of the Internet of Things Monitor Platform in Meat Processing Industry. Int. Conf. on Human-Centric Computing 2011 and Embedded and Multimedia Computing 2011, Lecture Notes. Springer Netherlands, 165–172.

Isenberg, M.-A., Werthmann, D., Morales-Kluge, E., Scholz-Reiter, B., (2011). The Role of the Internet of Things for Increased Autonomy and Agility in Collaborative Production Environments. Architecting the Internet of Things. Springer Berlin Heidelberg, 195–228.

Lee, C.K.H., Choy, K.L., Law, K.M.Y., Ho, G.T.S., (2012). An intelligent system for production resources planning in Hong Kong garment industry,IEEE Int. Conf. on Industrial Engineering and Engineering Management. 889–893.

Liu, J., Xu, W., (2013). Technical State Monitoring and Evaluation of Aerospace Product Manufacturing Workshop Based on Internet of Things. Presented at the GreenCom, 2013 iThings/CPSCom, IEEE Int. Conf. on and IEEE Cyber, Physical and Social Computing.

Lvqing, Y., (2011). The analysis and design of machinery production monitoring system based on Internet of Things. Presented at the 2011 Int. Conf. on Electronics, Communications and Control (ICECC), 3980–3983.

Meyer, G.G., Hans Wortmann, J.C., Szirbik, N.B., (2011). Production monitoring and control with intelligent products. Int. J. Prod. Res. 49, 1303–1317.

Miorandi, D., Sicari, S., De Pellegrini, F., Chlamtac, I., (2012). Internet of things: Vision, applications and research challenges. Ad Hoc Netw. 10, 1497–1516.

Qu, B., Jing, X., Wang, X., Li, Y., Liang, Y., (2012). Design on Cucumber Traceability System Based on the Internet of Things. Computer and Computing Technologies in Agriculture V, IFIP Advances in Information and Communication Technology. Springer Berlin Heidelberg.

Shengduo, L., Jian, Z., (2012). Research and Development of Management Platform for Precision Ecological Agriculture Based on the Internet of Things. Software Engineering and Knowledge Engineering: Theory and Practice. Springer Berlin Heidelberg, 387–393.

Simchi-Levi, D., Kaminsky, P., Simchi-Levi, E., (2003). Designing and Managing the Supply Chain. McGraw-Hill.

Singh, D., Tripathi, G., Jara, A.J., (2014). A survey of Internet-of-Things: Future vision, architecture, challenges and services. IEEE World Forum on Internet of Things 2014, 287–292.

Stephan, P., Meixner, G., Koessling, H., Floerchinger, F., Ollinger, L., (2010). Product-mediated communication through digital object memories in heterogeneous value chains.2010 PerCom.

Tan, J., Koo, S.G.M., (2014). A survey of technologies in internet of things. 9th IEEE Int. Conf. on Distributed Computing in Sensor Systems, DCOSS 2014, IEEE Computer Society.

Wang, H., Chen, X., (2013). Internet of Things Technology-Based Manufacturing Inventory Management. 2013 Int. Workshop on Computer Science in Sports. Atlantis Press.

Wang, X.F., (2014). Research on security issues of the internet of things. Presented at the 4th Int. Conf. on Materials Science and Information Technology, MSIT 2014, 4261–4264.

Wang, X., Liu, N., (2014). The application of internet of things in agricultural means of production supply chain management. J. Chem. Pharm. Res. 6, 2304–2310.

Whitmore, A., Agarwal, A., Da Xu, L., (2014). The Internet of Things-A survey of topics and trends. Inf. Syst. Front. 1–14.

Yuan, L., Guo, Y., Jiang, J., Nian, L., (2013). The Research on Monitoring of Discrete Manufacturing Process Based on Internet of Things. GreenCom, 2013 iThings/CPSCom, 1186–1191.

Zhang, Y., Wang, W., Liu, S., Xie, G., (2014). Real-Time Shop-Floor Production Performance Analysis Method for the Internet of Manufacturing Things. Adv. Mech. Eng. 2014, e270749.

Zhiliang, F., Xin, W., Guangrong, Y., Tao, D., (2013). PDA-Based Application and Research for Workshop Internet of Things. GreenCom, 2013 iThings/CPSCom.

Zuehlke, D., (2010). SmartFactory—Towards a factory-of-things. Annu. Rev. Control 34.

A multidimensional framework for the classification of stock-keeping units

Ferreira L M[1], **Arantes A**[2]

Abstract: Changes to an organization's internal and external environment may cause an increase in the number of stock-keeping units in inventory. Therefore a stock-keeping unit classification and corresponding grouping become highly important for improving the inventory management process. In this paper we propose a framework for stock-keeping unit classification in an industrial context considering a three-dimensional approach: value of usage; criticality and demand variability. This approach emphasizes the importance of stock-keeping units that despite their small value are of vital importance for the operations/production of the organization.

Keywords: stock-keeping unit; inventory management; framework.

1 Introduction

Companies cannot ignore the complexity of managing a large number of Stock-keeping Units (SKUs). As the size of the inventory increases, controlling those SKUs needs time and additional resources. One of the biggest challenge for inventory management that companies face is controllling a large number of items Grouping items together makes it easier for managers since the decisions are taken for a group of SKUs. As such, classifying SKUs can bring significant benefits (van Kampen et al., 2012). However, this requires that the problem be analyzed in a specific framework where the decision maker (expert)'s preferences are considered (Soylu and Akyol, 2014). When classifying SKUs companies need to have a clear understanding of the context and the aim of the company inventory management policy. Bacchetti et al. (2013) mention that the gaps between theory and practice show that empirical studies have not been properly validated. For that reason, some researchers have suggested that additonal studies are needed, which should look at ways of achieving more integrated solutions.

Another issue that increases the complexity of inventory management is the fact that reality is dynamic. This results from market changes, but also from internal changes in the organizations, which increases the cost of inventory control activities (Soylu and Akyol, 2014). As a result, it is important that organizations realize that an effective SKU classification could represent an important source of competitive advantage. Therefore, this paper proposes a framework for classifying SKUs, serving as a useful tool in supporting the decision making process in inventory management. The next section of the paper presents the framework, while the final section presents the conclusions and recommendations for future research.

1 **Luís Miguel D. F. Ferreira** (lmferreira@ua.pt)
Economics, Management and Industrial Engineering Department,
University of Aveiro, Aveiro, 3810-193, Portugal
2 **Amílcar Arantes** (Amilcar.arantes@tecnico.ulisboa.pt)
CERIS, CESUR, Instituto Superior Técnico, Universidade de Lisboa,
Av. Rovisco Pais, Lisbon 1049-001 Portugal

2 Proposed framework

In the management of organizations, not every SKU has the same level of importance. It is not wise to apply the same inventory management policy to every SKU; however, it is also true that managing SKUs individually is a very complex task (Soylu and Akyol, 2014). As a result, several researchers proposed different frameworks to help managers classify SKUs into groups and apply an adequate inventory management policy to each group (Bošnjaković, 2010; Cavalieri et al., 2008; Duchessi et al., 1988; van Kampen et al., 2012).

2.1 Methodology

The main aim of this paper is to develop and propose a framework for classifying SKUs. In this study, developed in collaboration with a large foundry operating in the automotive sector; we applied action research, which is a method of collaborative research that can be used to establish a link between companies and researchers. Sexton and Lu (2009) define action research as a "phenomenon-change" (or action) and critical learning that leads to a change and produce new knowledge (research) where researchers and practitioners intervene. Furthermore they say that action research generates a mutual development of know-that and know-how.

This choice of method was made as reflection and co-working were important for assessing the phenomenon and it was not necessary to control environmental elements. In any case, the focus of the research is to introduce changes in reality (Baker, 2012). Or, we might say that action research matches theory and practice through a change in a problematic situation.

Susman and Evered (1978) propose five steps for leading an action research project, which in the present case study we define as: 1) Diagnosis, 2) Dimension definition, 3) SKU classification, 4) Framework validation, 5) Defining inventory management policies.

2.2 Diagnosis

The diagnosis is an assessment step, where the main goal is to identify the context in which researchers will intervene, which problems are relevant and how they could affect the rest of the organization. This step was carried out over several meetings with the personnel of the foundry warehouse, purchasing, maintenance and other groups of interest. The researchers concluded that the main problem for the warehouse is related to the lack of physical space. Besides that, (unplanned) corrective maintenance activities raise problems related with the inventory management of spare parts and several stock-outs have been reported as a consequence. For this reason, maintenance personnel are relevant stakeholders in this research. It was observed that a large number of items are spare parts and so it is in the best interest of the company to define which SKUs should be more rigorously controlled.

2.3 Dimension definition

The major departments of the company should participate in the dimension definition step (Sexton and Lu, 2009) and the SKU classification aim should be clearly defined (van Kampen et al., 2012). This is a critical step, and it is not possible to move forward without collecting all the relevant data from the company's activity.

Choosing which dimensions to apply is something that must be discussed and adapted to the classification context and objectives. Several studies show that multidimensional approaches are the more effective way to assess spare parts and consumables management issues. Bacchetti et al. (2013) proposed a classification method with six dimensions (life cycle, lead time, number of orders, demand frequency, criticality and value). Bošnjaković (2010) presented a multicriteria framework with value, demand frequency and criticality. Childerhouse et al. (2002) built a classification based on life cycle, lead time window, volume and variability, which is named DWW^3. Flores and Whybark (1986) and Flores et al. (1992) presented multicriteria ABC analysis frameworks which included cost and noncost criteria for developing ABC categories for inventory management. Those models proved to be an effective tool for improving the efficiency of inventory management. Ramanathan (2006) remarks that multicriteria ABC analysis is a very effective approach for classifying SKUs.

Considering only the spare parts consumption makes the analysis limited, as many of those items are only used in very specific time periods it is thus very important to include other dimensions. As several studies have shown, one of the most important dimension to consider when analyzing spares is criticality (Cavalieri et al., 2008; Huiskonen, 2001; Jouni et al., 2011; Molenaers et al., 2012). But, because these items are characterized by an erratic consumption, it is also important to include demand variability (Heinecke et al., 2013). Therefore, this paper proposes a three-dimensional approach, using the following dimensions: (i) usage value; (ii) criticality; and (iii) demand variability.

2.4 SKU classification

2.4.1 Ranking demand value – ABC analysis

ABC analysis shows which SKUs have more impact on the company in terms of value. This analysis reveals that a small number of items are responsible for the most of the value. Likewise SKUs are usually classified into 3 groups – group A includes 5% of the items that represent 75% of value-usage, group C includes 75% of items representing only 5% of value-usage, the rest of items will be placed in group B, with 20% of items representing 20% of value-usage.

Cavalieri et al. (2008) says that this analysis is very important from different perspectives. Financially it provides data on which investments should be taken into account depending on whether they relate to durables or consumables. Logistically it provides information about whether inventory should be kept for an item or not. From a maintenance perspective it gives the basis for a balance between the availability of spares and consumables and the company maintenance policies, coordinating with purchasing the decisions of maintenance policies so that could they could minimize the effects of failures. However, this analysis is proven to be unsuitable when inventory is not homogenous, mainly when the major differences are not related to the value of the SKUs. In this case it is important to introduce other dimensions, but these must represent factors which are significant to the company (Flores and Whybark, 1986; Molenaers et al., 2012; Ramanathan, 2006).

2.4.2 Ranking criticality – VED analysis

Criticality is an important attribute when classifying spare parts and components (Huiskonen, 2001). Several authors (Cavalieri et al., 2008; Molenaers et al., 2012) have conducted criticality analysis, and used the VED analysis classification, which divides SKUs into 3 groups: Vital, Essential and Desirable. Although other techniques could be applied to conduct criticality analysis, most studies apply this technique.

The VED analysis allows SKUs to be ranked according to their criticality, allowing the most critical items to be quickly identified. Defining criticality is not an easy task, although this concept could be linked to the type of activity for which the SKU is used (Bošnjaković, 2010). This author assesses criticality through four attributes: criticality for plant production, criticality for safety, criticality for supply and criticality for inventory. Duchessi et al. (1988) claims that criticality is a function of the level of criticality of the equipment where the SKUs is installed.

In the present research, it was found that the company already distinguishes SKUs based on criticality. The company currently uses two attributes to measure criticality: one assessing the consequences for production and the other related to the safety of operators. This is an idea common in the literature, where criticality is measured as a function of the failure of equipment pieces (Duchessi et al, 1988; Huiskonen, 2001; Molenaers et al., 2012). Flores and Whybark (1987) reccommended that management should not only be concerned with the cost of keeping of an SKU item, but they should also consider the consequences of not keeping it. This concern was also expressed by the company maintenance managers during the action research meetings.

Assessing criticality is very hard because it is mainly based on subjective judgments and opinions of managers (Botter and Fortuin, 2000). To achieve a more systematic measure of criticality we decided to use an Analytic Hierarchy Process (AHP) (Saaty, 2008), which presents several advantages: it allows the application of qualitative criteria; numerous real world applications dealing with complex issues have proved AHP to be a valuable tool because it allows the hierarchical decomposition of the decision problem to its constituent parts. This is a procedure used in Cavalieri et al. (2008), Flores et al. (1992) and Moleanaers (2012) with the purpose of establishing a ranking of criticality.

2.4.3 Ranking demand variability

Bošnjaković (2010) claims that the frequency distribution of demand is an important dimension when selecting the inventory management policy. Nevertheless the frequency distribution of demand does not account for erratic demand, as the annual average consumption does not show peaks of consumption (Heinecke et al., 2013; Syntetos and Boylan, 2005).

Calculating of the coefficient of variation (CV – a measure that establishes a ratio between standard deviation and average demand) reveals the variability that exists between SKUs, showing how they differ in volume and distribution of demand. Although the CV does not have an intrinsic meaning, D'Alessandro and Baveja (2000) presents an example which illustrates how this measure can be used for analyzing demand.

The boundary between high and low variability SKUs is determined by using the procedure of D'Alessandro and Baveja (2000), where the Pareto principle is applied to assess the cut-off between SKUs. Potentially when calculating the CV, some singularities may occur with some SKUs that are not consumed or when their demands are so stable that the standard deviation is almost zero.

2.4.4 Ranking model

More dimensions could be considered, but Flores et al. (1992) remark that the main purpose of SKU classification is to simplify the inventory management. These authors argue that although it is possible to include more than three dimensions, the analysis could become excessively complex (Flores et al., 1992). Hence, the authors recommend that the framework should only include those dimensions that are really relevant to management.

After selecting the classification dimensions, SKUs were brought together to create groups of homogeneous items. Next, weights were given to the three dimensions presented – value, criticality and demand variability – in order to rank the SKUs. These weights were achieved using the AHP technique. The importance placed by the company managers on criticality dimension justified the achieved weight of 40%. A 40% weight was also assigned to the value dimension, and the demand variability received the remaining 20%. This approach is aligned with Flores et al. (1992) and Ramanathan (2006) recommendations. The outcome resulted in a scheme of classification that weights the three dimensions.

The main purpose of this step is to decide which SKUs deserve closer attention by management. The resulting ranking of the SKUs showed that a considerable number of SKUs changed class, when comparing the classic and the multidimensional approach of ABC analysis (Table 1). This confirms the relevance of using a multidimensional approach to SKU classification. For instance, 172 SKUs were reclassified from "C" to "A" and 230 SKUs from "A" to "C".

In addition to these results, the company experts claimed that this approach allowed them to identify many unchanged SKUs. These SKUs were considered to be candidates for removal from the inventory, either through selling or through disposal. This decision allowed a substantial reduction in the total inventory value, which was in line with the company's strategic guidelines regarding total inventory value.

Table 1
Results of the application of the multidimensional approach of ABC analysis.

Class	Classic ABC	Reclassified SKUs	Multidimensional ABC
		35	A
A	348	83	B
		230	C
		141	A
B	901	261	B
		499	C
		172	A
C	11622	557	B
		10893	C

2.5 Framework validation

Once the SKUs were classified and ranked it was necessary to validate the framework by the managers. A meeting was held with researchers, purchasing, warehouse, financial and maintenance personnel and senior managers to present the results achieved. This meeting had as objectives to assess if the framework was relevant tool for the decision-making process and if adjustments were necessary. The participants agreed that the proposed framework was considered as a valuable and effective tool to classify and manage the existent and future SKUs. However, it was raised the issue how often should the application of the framework be revised.

2.6 Defining inventory management policies

The final step of the proposed framework is to identify SKUs that potentially share the same inventory management policies and group them together. For instance, these policies may determine that: there is either "no need to stock", or there is a need to maintain a "safety stock", or that the traditional models of periodic/continuous review policies should be applied.

3 Conclusions

This paper proposes a three-dimensional framework grounded in a multicriteria ABC analysis for classifying SKUs. This framework proved to be an effective tool for supporting the inventory management decision process: it was able to handle a situation with a large number of SKUs to be managed in inventory; and in addition it took into consideration the decision maker (expert)' s preferences.

The three-dimensional framework has revealed that the traditional ABC classification of SKUs, that uses only one dimension, is not completely satisfactory as it ignores other relevant dimensions for the organization. This is particularly significant in industrial contexts where dimensions of criticality or demand variability are relevant to the operations of the company.

The application of the framework showed that a considerable number of SKUs changed class. In this case some SKUs, which previously were placed in groups of low importance, emerged as critical SKUs. Therefore, this confirms that multicriteria ABC analysis is a very effective approach for classifying SKUs.

In future research the last step of the methodology – defining inventory management policies – could be applied and the necessary adjustments included in the management of inventories. It could also be of interest to apply the proposed framework to other types of organizations and contexts.

4 References

Bacchetti A, Plebani F, Saccani N, Syntetos A (2013) Empirically-driven hierarchical classification of stock-keeping units. Int. J. Production Economics 143: 263–274.

Baker T, Jayaraman V (2012) Managing information and supplies inventory operations in a manufacturing environment. Part 1: An action research study. International Journal of Production Research 50(6): 1666-1681.

Bošnjaković M (2010) Multicriteria inventory model for spare parts. Tehnički vjesnik 17 (4): 499-504.

Botter R, Fortuin L (2000) Stocking strategy for service parts–a case study. International Journal of Operations & Production Management 20(6): 656-674.

Cavalieri S, Garetti M, Macchi M, Pinto R. (2008) A decision-making framework for managing maintenance spare parts. Production Planning & Control 19(4): 379-396.

Childerhouse P, Aitken J, Towill DR (2002) Analysis and design of focused demand chains. Journal of Operations Management 20(6): 675-689.

D'Alessandro AJ, Baveja A (2000) Divide and conquer: Rohm and Haas' response to a changing specialty chemicals market. Interfaces 30(6):1-16.

Duchessi P, Tayi GK, Levy JB (1988) A conceptual approach for managing of spare parts. International Journal of Physical Distribution & Logistics Management 18(5): 8-15.

Flores BE, Whybark, D C (1986) Multiple criteria ABC analysis. International Journal of Operations & Production Management 6(3): 38-46.

Flores BE, Whybark DC (1987) Implementing multiple criteria ABC analysis. Journal of Operations Management 7(1): 79-85.

Flores BE, Olson DL, Dorai VK (1992) Management of multicriteria inventory classification. Mathematical and Computer Modelling 16(12) : 71-82.

Heinecke G, Syntetos AA, Wang W (2013) Forecasting-based SKU classification. International Journal of Production Economics 143(2): 455-462.

Huiskonen, J. (2001) Maintenance spare parts logistics: special characteristics and strategic choices. International Journal of Production Economics, 71 (1–3) : 125–133.

Jouni P, Huiskonen J, Pirttilä T (2011) Improving global spare parts distribution chain performance through part categorization: A case study. International Journal of Production Economics, 133(1) : 164-171.

Molenaers A, Baets H, Pintelon L, Waeyenbergh G. (2012) Criticality classification of spare parts: A case study. Int. J. Production Economics 140: 570–578.

Ramanathan R. (2006) ABC inventory classification with multiple-criteria using weighted linear optimization. Computers & Operations Research 33 (3): 695-700.

Saaty, L.T. (2008). Decision Making with the Analytic Hierarchy Process. International Journal of Services Sciences 1(1): 83-98.

Sexton M, Lu SL (2009) The challenges of creating actionable knowledge: an action research perspective. Construction Management and Economics 27(7): 683-694.

Soylu B, Akyol B (2014) Multi-criteria inventory classification with reference items. Computers & Industrial Engineering 69: 12–20.

Susman GI, Evered RD (1978) An assessment of the scientific merits of action research. Administrative Science Quarterly 23(4): 582-603.

Syntetos AA, Boylan JE (2005) The accuracy of intermittent demand estimates. International Journal of Forecasting 21(2): 303-314.

van Kampen TJ, Akkerman R, van Donk DP (2012) SKU classification: A literature review and conceptual framework. International Journal of Operations & Production Management 32(7): 850-876.

The Reverse Logistics on Companies' Perspective - Case Studies

Gonçalves M[1], Silva A[2]

Abstract: The Reverse Logistics is a research area that has received special attention by academic community (researchers, students and teachers) and this is the reason to improve the understanding of this issue. The aim of this paper is, based on a study made in a previous work, to emphases the results obtained by the analysis of the evolution of the papers about Reverse Logistics, published in scientific journals in 2004 – 2014, to analyze and characterize the Portuguese companies' perspective, based on three aspects: the concept, the returns and the environmental impact. This is a working paper that pretends to present and describe the methodology used to study the perspectives of different Portuguese companies.

Keywords: reverse logistics, literature review, case-study methodology.

1 Introduction

The Reverse Logistics is actual and very attractive field of research due to potentials of value recovery from the used products, legislations and directives about environmental and consumer laws and social responsibilities (Pokharel & Mutha, 2009). As today's consumers are more and more concerned with the environmental impacts of products and services they buy, enterprises have been more and more concerned with ''green operations'' because the rapid increase of the industrial activities and uncontrolled consumption of natural resources cause environmental problems (Alfonso-Lizarazo, et al. 2013, Akdoğan and Coşkun, 2012).

Many authors have suggested many definitions for this concept and the proposal of the European Working Group on Reverse Logistics, REVLOG, appears to be the most complete definition. This research group defines Reverse

Logistic as "the process of planning, implementing and controlling backward flows of raw materials, in process inventory, packaging and finished goods, from a manufacturing, distribution or use point, to a point of recovery or point of proper disposal always with the purpose of capturing value" (Rubio et al, 2008).

Reverse Logistic refers to the distribution activities involved in product returns, source reduction/ conservation, recycling, substitution, reuse, disposal, refurbishment, repair and remanufacturing (Akdoğan and Coşkun, 2012).

Rubio, Chamorro and Miranda (2008), Lambert, Riopel and Abdul-Kader (2011) and Reddy (2011) are some examples of relevant publications on Reverse Logistics with emphasis to determine the areas of research on reverse logistics: concept, product returns and environmental impact.

Based on these studies, the aim of this working paper is to understand the concept of Reverse Logistics and its role in the manufacturing industry, focuses on learning different aspects of the reverse logistics and how these aspects affect the decisions made by manufacturing firms.

1 **Mélodine Gonçalves** (melodine_05@hotmail.com)
2 **Ângela Silva** (d1279@fam.ulusiada.pt)
Faculdade Engenharia e Tecnologias. Universidade Lusíada.
Largo Tinoco de Sousa, 4760-108 Vila Nova de Famalicão. Portugal.

2 Analysis of the Research on Reverse Logistics (2004-2014) – Overview

The first goal of this research is present the results of the research development of Reverse Logistics area. A systematic review of literature was done where the principal goal was to analyse the articles published in database Elsevier Science (ScienceDirect) since 2004 until 2014 (Gonçalves & Silva, 2014).

Therefore, the following terms were used for the research: Reverse Logistics, in the title, abstract or keywords of the papers during the period of analysis. Other terms could be used to perform this research but it was decided to focus the object of this research, the objective is to investigate which is related and focused with this specific term. The reference work and books are excluded, in that way only journals were select. 89 articles were analyzed: Year of publication; Type of journal; Origin; The number of authors; The methodology; Areas of research and the Local of the research. These 89 articles were then classified in the following areas: Supply Chain Management and Environment. Each member classified each paper in one of these areas. For environmental issues concern recycling industry/products, environmental laws, waste management, sustainability, end-of-life products and others issues and the supply chain management concerns products returns, cash flows, supply planning, production planning, remanufacturing and others issues. All the articles were examined by the title, abstract, keywords and main body of the paper. It is important to emphasize that, not all articles on reverse logistics published during the period of analysis have been published in impact factor journals. There are other prestigious scientific publications, not included in Elsevier Science database, however in future work it should be considered the access to others databases and others terms of research (Gonçalves & Silva, 2014).

Each article was analysed for the following topics (Table 1) and all the decisions were taken mutually by the research team. None software was used to support these decisions, only EXCEL was used to organize the data (Gonçalves & Silva, 2014).

Table 1
Results of relation to analysis of topics.

Analysis of Topics	Results
Number of the publications per journal	The International Journal of Production Economics was the scientific journal with more publications.
Concept Evolution in the period 2004-2014	There was an increase in the number of papers published in journals, more precisely since 2010 until 2013.
The research area evolution over the years	Over the years, the "Supply Chain Management" topic has attracted more attention than "Environmental". However, it is noticed an increase in the topic "Environmental" in the period of 2010 to 2013
Research methodology	It was observed that the mathematical model applied in case studies was the methodology more used, followed by study case.
Number of the authors per articles	It was observed that 92% of the articles have two or more authors and the most of them have authors from different countries.
The origin of the articles and the local of research	USA leads with 17 publications and the principal local of research is in Universities with 70%.

Throughout this first stage of the work, the development of research on reverse logistics over the recent years was analyzed, by examining the scientific articles appearing in the international journals. Our principal goal was to analyze the evolution of the papers on Reverse Logistic published in 2004 until the present time, describe the current situation of the research and provide the support for those who begin the development of this topic.

In accordance with the findings, it can point out the following conclusions: although, there were some earlier works focusing on the Reverse Logistic, this research is recent and over the next years everything points to an incredibly interest by the researchers. This increasingly interested in the field, as demonstrated the last four years the progressive growth in the number of the papers (the peak was reached in 2013).

The previous literature review gave the support to understand and analyze the strategies applied in each area: Products returns and Environment.

Effective reverse logistics focuses on the backward flow of materials from customer to supplier (or alternate disposition) with the goals of maximizing value from the returned item and/or assuring its proper disposal (Rogers &Tibben-Lembke, 1999; Stock, 1998 apud Autry, 2005).

This may include product returns, source reduction, recycling, materials substitution, reuse of materials, waste disposal, refurbishing, repair and remanufacturing (Stock, 1998 apud Autry, 2005).

Reverse logistics processes–and reverse logistics research–has traditionally emphasized green logistics, i.e., the use of environmentally conscious logistics strategies (Carter & Ellram, 1998; Green, Morton, & New, 1998; Murray, 2000; Stock, 1998; van Hoek, 1999 apud Autry, 2005). While environmental aspects of reverse logistics are critically important, many firms are also recognizing the economic impact of reverse logistics (Klausner & Hendrickson, 2000; Ritchie, Burnes, Whittle & Hey, 2000).

Effective reverse logistics is believed to result in improved firm outcomes. Firms that effectively manage the reverse flow of goods benefit through decreased resource investment levels and cost reductions, i.e., storage and distribution (Andel, 1997; Giuntini & Andel, 1995a).

Once a product enters the reverse logistics flow, the logistics manager has to decide where the product has to be sent: either return to vender, to the landfill, or to the secondary market. There are several reasons why a product enters the reverse logistics flow. Customers return the products for several reasons, for example products once bought may be returned due to physical damage, some of them are returned because the customers are unhappy with the functionality of the product (expectations not met), sometimes customers return products because they discover an alternative product with better functionality after they have made the purchase and others reasons Reddy (2011). Rogers and Tibben-Lembke (1998) apud Reddy (2011) mention seven channels for disposing the products that have been returned to the manufacturer. They are the return to vendor, sell as new, sell via outlet or discount, sell to secondary market, donate to charity, remanufacture/refurbish and materials reclamation/recycling/landfill.

Based on the condition of the returned product, contractual obligations with the vendor, and the demand for the product, the manufacturer has one or more of the above options to dispose the returned product

The author Autry (2005) emphasizes a quick and efficient handling of returned product can also be critical in sustaining relationships and creating repeat purchases. For this reason, firms are more willing than ever to accept returns from customers. Reverse logistics allows companies an opportunity to differentiate them-selves, builds consumer confidence in the company brand, and positively influences customer satisfaction (Blumberg, 1999 apud Autry, 2005).

As a result, liberal return policies have become a standard marketing practice and a major component of the corporate image for many firms in both business-to-business and business-to-consumer markets. The complexity of managing damaged or defective merchandise, product recalls, maintenance and repairs, and recycling should make reverse logistics programs a high priority (Autry, 2005).

Concerning the environment impact, in recent years, the interest has increased for a number of reasons. Firstly, as a result of the important negative environmental impacts that company products and processes are producing (Azzone & Noci, 1998 apud González-Torre & Belarmino Adenso-Díaz, 2006). Secondly, due to the pressure that society is exerting on its institutions to address environmental issues (Murphy & Poist, 2003 apud González-Torre & Belarmino Adenso-Díaz, 2006), which translates as new legal demands (for example, European Union laws require manufacturers to collect and reuse many types of products). Thirdly, managers appreciate the benefits to their company image of adopting environmentally concerned programs (van Hoek, 1999 apud c). Lastly, consumers have changed their preferences, which are transferred the entire value chain (Lampe & Gazda, 1995 apud González-Torre & Belarmino Adenso-Díaz), modifying the responsibilities of suppliers and manufacturers with regards to the products they place on the market (Bloemhof-Ruwaard et al., 1995 apud González-Torre & Belarmino Adenso-Díaz).

As a result of the aforementioned pressure, environmental practices have been adopted by companies that consist of both increased investment in clean technologies as well as the redesigning of processes and organization (González-Torre & Belarmino Adenso-Díaz, 2006).

Given that an impact on the environment is produced in all the phases of the life cycle of products (elaboration, transport, use or destruction), the integration of environmental questions consequently influences the choice of process technologies, the management of the supply chain or the development of new products (Angell & Klassen, 1999 apud González-Torre & Belarmino Adenso-Díaz, 2006). Accordingly, total quality environmental management, life cycle analysis, green supply chain management and ISO 14000 standards are becoming more and more widespread practices (González-Torre & Belarmino Adenso-Díaz, 2006).

The aim of this environmental strategic viewpoint is to revalue products once they have been thrown away by the end consumer, thus closing/extending their life cycle. Diverse alternatives exist to do so:

reutilization, repair, renovation, reprocessing, cannibalization or recycling (Thierry, Salomon, van Nunen, & Van Wassenhove, 1995 apud González-Torre & Belarmino Adenso-Díaz, 2006). To put any of these alternatives into practice, companies need to define in collaboration with their customers the changes in their relationship with the goal of returning products at the end of their life span (Azzone & Noci, 1998 apud González-Torre & Belarmino Adenso-Díaz, 2006).

After this analysis of the different strategies adopted in the product returns and environmental impact, it is important to understand the connection between the literature and the real life, and understand if the companies follow some of these strategies.

3 Companies' Perspective - Methodology

The bibliographic research, made earlier, give a connection between the literature and all the elements that must be taken in field research (Real Oliveira & Ferreira, 2014). With this objective it was adopted the case-study's methodology using a semi-structured interview. The interview is one of the most important sources of information and essential in the case studies (Yin, 2005 apud Meirinhos & Osorio, 2010). Also, Fontana and Frey (1994) apud Meirinhos and Osorio (2010) focus the interview as one of the most powerful way to understand the others perspectives and it's a powerful tool to capture the diversity of descriptions and interpretations about what the people know on the field (Meirinhos & Osorio, 2010).

After getting somewhat of an idea about Reverse Logistics, a preliminary set of questions were formulated for the case studies. Most of the questions were either taken directly or inspired by the methodology developed by Reddy (2011), for its master thesis work "A study on Reverse Logistics". The methodology adopted was the case study, as proposed by Yin (1994) apud Silva et al (2013).

"Case study" means a close analysis of the practice, together with the circumstances and its characteristics leading to an understanding of the situation within its own context (Stake, 1995 apud Brito, 2004). Yin (2003) apud Subramoniam et al (2009) proposed an exploratory case study aimed at defining the questions and hypotheses of a subsequent study or defining the feasibility of the detailed research procedure.

This methodology was choose because the case study is used to assess the strategic factors from the literature review and to clarify the questions that require further research (Subramoniam et al, 2009).

The case study will be applied in different business sector and dimensions (national and multinational SMEs) Portuguese enterprises and it pretend to analyze and characterize these companies' perspectives, based on three aspects: the concept, the returns and the environment.

These exploratory case study started in the systematic literature review and then, it was delineated all the important questions to get answers from the different business sectors companies. The population of this study consists of supply chains/logistic managers in thirty Portuguese companies of different business sectors and dimensions, located at North of Portugal. A formal email was sent to these companies to explain the project and to request their collaboration. This study gets the collaboration of ten companies, three of them are multinational and seven are national companies and small and medium-size enterprise's (SMEs). Concerning business sectors, it will be focused on six different business sector: two companies are the automotive industry; two companies are the cutlery industry; one company is the food industry, one company is the drink industry, three companies are the aluminium industry and one company is the retail industry.

The case study will be conducted through semi-structured interviews with open-ended questions. This study was divided in three research areas and each area has a research question which results the interview questions (Table 2). This type of interview doesn't follow any previously established order about the questions designed and allow more flexibility because it is possible to put the questions in the appropriate time according to the interviewee's answers (Meirinhos & Osorio, 2010).

Table 1
Research areas and questions.

Research Areas	Research questions	Interview questions
Product Returns	What are the Reverse Logistics strategies used by Portuguese Companies on the product returns?	What are the principal reasons for returns?
		How is the returns process (flow) adopted by your company?
		What activity (ies) / strategy (ies) apply, in order to get value from your products returns?
Environment	What are the Reverse Logistics strategies used by Portuguese companies on the environment?	What are the Reverse Logistics strategies directed to the environment? Packages type? Planning routes, collection points and time? Correct disposal of waste? Recycling? Reuse materials, products, package? Materials recovery?
Concept	What is the company's perception about Reverse Logistics concept?	Have you heard about the term reverse logistics? If yes, what do you understand by it?
		In your point of view, what is the importance of reverse logistics in companies?

The interviews will be recorded, on audio format, and always with the agreement of the interviewees. It's very important to respect their space and if they want to remain anonymous or confidentiality of their information. Then, to analyze all the information by interviews the WebQDA or NVivo software will be used to support all this qualitative data analysis.

4 Conclusions

In this study the methodology selected to explore the perspective of different companies about the concept of reverse logistic, the strategies adopted by that companies and the value aided by this strategies, it is presented. It is also pretends to analyze their reality and how the multinational and small and medium-sizes enterprises manage their product returns and the environmental issues.
The case study methodology will allow the understanding of the companies' reality related to Reverse Logistics and the diversity of the companies sample will permit the comparison of different strategies adopted by different business sector and dimension.

References

Alfonso-Lizarazo EH, Montoya-Torres JR, Gutiérrez-Franco E (2013) Modeling reverse logistics process in the agro-industrial sector: The case of the palm oil supply chain. Applied Mathematical Modelling, Vol. 37, Nº 23, p. 9652–9664.

Akdoğan MŞ, Coşkun A (2012). Drivers of Reverse Logistics Activities: An Empirical Investigation. Procedia - Social and Behavioral Sciences, Vol 58, p. 1640–1649.

Autry, CW (2005) Formalization of reverse logistics programs: A strategy for managing liberalized returns. Industrial Marketing Management, 34(7), 749–757.

Brito, M (2014) Managing Reverse Logistics or Reversing Logistics Management? PhD Series Research In Management, University Rotterdam, Holland.

García-Rodríguez, FJ, Castilla-Gutiérrez, C, Bustos-Flores, C (2013) Implementation of reverse logistics as a sustainable tool for raw material purchasing in developing countries: The case of Venezuela. International Journal of Production Economics, 141(2), p. 582–592.

Gonçalves, M, Silva, A (2014) Analysis of the Research on Reverse Logistic (2004 – 2014). Proceedings International Conference IS2014 - Innovation for Sustanability Is your Responsibility, Universidade Lusíada do Porto, Porto, Portugal, 10 e 11 de Julho.

González-Torre, PL, Adenso-Díaz, B (2006). Reverse logistics practices in the glass sector in Spain and Belgium. International Business Review, 15 (5), 527–546.

Meirinhos, M, Osório, A (2010). Educação O estudo de caso como estratégia de investigação em educação. EDUSER: revista de educação, Vol. 2 (2), p.49–65.

Pokharel S, Mutha A (2009) Perspectives in reverse logistics: A review. Resources, Conservation and Recycling, Vol.53, Nº4, p. 175–182.

Oliveia, ER, Ferreira, P (2014) Métodos de Investigação Da Interrogação à Descoberta Científica. Vidaeconómica: Porto.

Reddy, D (2011) A study on Reverse Logistics. Master Program In Product And Process Development production & logistics, Malardalen University, Sweden.

Rubio S, Chamorro A, Miranda JF (2008). Characteristics of the research on reverse logistics (1995–2005). International Journal of Production Research, Vol. 46, p. 1099 –1120.

Silva, DAL, Santos Renó, GW, Sevegnani, G, Sevegnani, TB, Serra Truzzi, OM (2013) Comparison of disposable and returnable packaging: a case study of reverse logistics in Brazil. Journal of Cleaner Production, 47, 377–387.

Subramoniam, R, Huisingh, D, Chinnam, RB (2009) Remanufacturing for the automotive aftermarket-strategic factors: literature review and future research needs. Journal of Cleaner Production, 17(13), 1163–1174.

Integrating Value Stream Maps with Waste Identification Diagrams

Carvalho D[1], Ferrete L, Magalhães A, Ferreira J

Abstract: Value Stream Maps are the most common tools used to process mapping, but several limitation are recognized by professionals and academics. Another process mapping tool with more features and capabilities called "Waste Identification Diagrams" (WID) is being developed in the Production Systems Department of the University of Minho. Since both tools have their advantages and drawbacks, a new tool is proposed in this paper which includes features from VSM and WID hoping to grasp the best of both tools. The result is that this new tool becomes more complete in terms of availability of information and more effective in communicating information, but, on the other hand, is not able to represent layout and multiple roots as WID.

Keywords: Value Stream Mapping; Waste Identification Diagrams; Visual Effectiveness; Lean Manufacturing.

1 Introduction

Too often is believed that business processes are well known, but in reality most managers do not really understand what their processes are or whether they can be improved, simplified, or eliminated. Process mapping is a management and communication technique used by companies to help them understand how their systems work. This technique was initially developed and implemented by General Electric as part of their integrated "Work-out," "Best Practices," and "Process Mapping" strategy to improve significantly their bottom-line business performance by allowing their process improvement and reengineering teams to gain real understanding of their processes.

This exercise of understanding and documenting is essential for many process improvements such as Lean Manufacturing. It is from a well-structured map of the whole process that appears suggestions and points of action to improve the system. Thus, it can be said that the mapping helps the company to find their strengths, but mainly to identify wastes (transport, inventory, motion, waiting, over-processing, overproduction and defects) (Ohno, 1988) that translate into cost savings, reduction of work in process and final inventory, reduction of the operations times, improved production flow and improved the quality of the final product.

There are many tools that can be used to map a process such as, Flowcharts, SIPOC diagrams (Suppliers – Inputs – Process – Outputs – Customers), BPI, Value Stream Maps, Waste Identification Diagrams (Dinis-Carvalho et al, 2014a), and many others. So, the first step to use these techniques is to define the process and the purpose of the mapping, and then choose the right tool. After defining the limits of the process there is the need to determine the level of detail and information required to build the map. Once the map is built it is necessary to verify it to see if there are any errors or discrepancies and then validate the final version. This article proposes a process mapping approach that integrates the principles of VSM with various WID features with the purpose of increasing the effectives of process mapping. A small process unit with three processes will be used to illustrate the advantages of such integration. In order to compare the integrated approach with traditional VSM and WID, a list of criteria is used and assessed as an attempt to find the potential gains that may be achieved by this proposal.

1 **Dinis Carvalho** (dinis@dps.uminho.pt)
Dpto. de Produção e Sistemas. Escola de Engenharia.
Universidade do Minho. Campus de Azurém, 4804-533 Guimarães

2.1 Value Stream Mapping

Value Stream Mapping, commonly known as VSM (Rother and Shook, 1999 and Jones and Womack, 2002), is one of the most popular tools for process mapping. It aims at all the actions that are required from the time a customer makes an order to the time he receives it. Its methodology involves, in a first step, drawing up a map of the current state of the existing system, define a future state of how the system should be in the future and then define the needed steps in order to reach that future or desired state.

This tool has become quite important as it allows to represent the entire production flow and information (one can visualize all processes and not just one), where one can identify any existing change, especially overproduction and work in progress (WIP), which its elimination is essential for a lean implementation plan.

However, some authors have reported several limitations to this tool. Irani & Zhou (1999) identified key VSM limitations, such as that it cannot be applied when there are multiple items with different manufacturing routes, it does not provide layout visualization, it does not have unassociated economic indicator, and it does not reflect a products' Bill Of Materials. Lovelle (2001) referred that the transport is depicted with arrows between processes, but it is not quantified or measured in terms of impact. The same author also stated that waiting, over-processing and motion wastes are difficult to observe, virtually remaining "hidden" on the map.

Huang and Liu (2005) presented other VSM limitation which is the fact that the distances between the processes are not represented. The difficulty to represent production systems with large diversity of products and production routes is also identified by other authors such as Chitturi et al.(2007). Moreover, the VSM does not represent people related wastes, lacks of financial indicators such as income, operating costs, costs of stock, and graphics for the layout spatial visualization and material handling.

2.2 Waste Identification Diagram

The Waste Identification Diagram (WID) is a representation model for production units developed in the Production and System Department at University of Minho, Portugal (Dinis-Carvalho et al., 2014a). These diagrams aim to help identify most forms of waste related to flow of materials (inventory, overproduction, transport and defects) as well as forms of waste related the use of people (transport, motion, waiting, over processing) and provide information in a much more effective way. It is very easy to understand and allows a very fast diagnose of the most relevant locations of waste and can be used as a continuous improvement tool.

This tool consists in a network of blocks and arrows that visually show the throughput times, idle capacity, transport effort, changeover times and work-in-process levels. Each WID block represents a process, or a group of processes, where are represented four variables: Takt Time (TT), Cycle Time (CT), Work In Process (WIP) and Changeover time (C/O) and they are connected by transport arrows, that represent the effort needed to move the products from one process to the next. The transport effort measures the quantity of products transported from one station to another multiplied by the traveled distance.

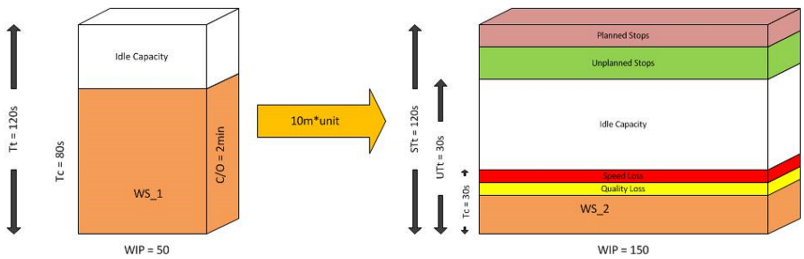

Fig.1
Example of blocks in a WID.

Two examples of processes are represented in Figure 1, one for each block, required in the process route of a product or family of products, thence having the same takt time for each process. As can be seen, several relevant information can be taken by just looking at the two blocks, being the most obvious the larger size of the station block 2, which is associated to a greater waste. Other information that can be visually seen is a greater capacity available at station 2, which has also increased WIP and, therefore, needs attention to find the reasons of such a large inventory. According to Little's law, throughput time can be obtained by multiplying takt time and WIP. Thus, even without seeing these values, just by looking at the front area of each block, it can be seen that station 2 has a larger throughput time than station 1.

It is also shown in Figure 1 the transport arrow, which, as already mentioned, represents the transport effort required to move products from one process to another. This effort will be greater the larger the width of the arrow, and can be expressed in parts * meter, kg * m, cost units (€) among others. In a continuous improvement context, companies should seek to reduce waste associated with transportation, making this arrow as thinnest as possible.

Other advantages associated with the WID are the ability to show the layout of the production system and the inclusion of Overall Equipment Efficiency (OEE) (Dinis-Carvalho et al, 2014b), an indicator that shows the efficiency using certain equipment. In the long term, a systematic analysis of the WID can visually check the system changes, allowing to act where necessary. One of the most recognized WID limitation is the inability in representing the flow of information which is one of the advantages of VSM.

3 WID integrated in VSM

In order to improve the effectiveness of VSM it is proposed, in this article, the integration of some WID features into VSM. Figure 2 presents a small example where the visual effectiveness of WID blocks as well as the Transport Effort information is embedded in a VSM diagram.

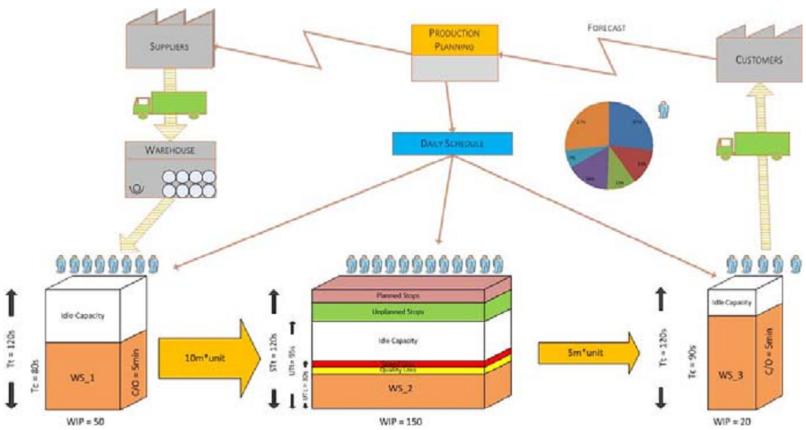

Fig.2
A VSM with some WID features.

This adaptation integrates the WID valuable features, while keeping the essence of VSM, which is showing the whole system value stream and information flow. The use of WID begins immediately to reduce some difficulty in analyzing the productive system, allowing withdraw immediately several information faster namely cycle times, WIP, throughput times, bottleneck, among others already mentioned in the previous chapter.

In this approach, the wastes related to people use of available time are also included as one may see in the small pie chart in Figure 2. This pie chart shows the percentage of people time spent in various forms of waste.

As an attempt to highlight the advantages of this proposed approach, a set of criteria is listed in Table 1 and an assessment was performed following the judgment of the authors.

Table 1
Insert description.

Criteria	VSM	WID	VSM+WID
Information flow	Yes	No	Yes
Production flow	Yes	Yes	Yes
Overproduction waste	Yes	Yes	Yes
Inventory waste	Yes	Yes	Yes
Transportation waste	No	Yes	Yes
People related wastes	No	Yes	Yes
OEE information	No	Yes	Yes
Visual relevance of values	No	Yes	Yes
Capacity to represent several routes	No	Yes	No
Capacity to represent layout	No	Yes	No

Table 1 shows that this integration of VSM and WID covers some of the limitations of VSM, like its inability to represent transportation waste, waste related to people utilization, OEE information and visual relevance of values which represents visual effectiveness. From the criteria covered in Table 1, the only VSM feature not covered by WID and now is covered by the VSM+WID approach is the information flow representation.

4 Conclusion

This paper proposes a way of improving the VSM capabilities and effectiveness, by including some important features imported from Waste Identification Diagrams. The most relevant gains obtained from that integration are: the ability to represent transportation waste, people related wastes and OEE information. Another interesting innovation is the inclusion of visual relevance of values in a way that, by simply looking at the diagram, many bits of information are rapidly grasped, such as available capacity in processes, bottlenecks, setup times, differences between station times, differences between transportation effort and information about people related wastes. This tool may be more effective for communicating with top managers about systems' current state, as well as improvement opportunities. Despite the gains, this new approach loses the ability to represent the layout and represent systems with wide range of products, a feature associated exclusively to WID.

References

Chitturi R M, Glew D J, Paulls A (2007) Value stream mapping in a jobshop. Paper presented at the Agile Manufacturing, 2007. ICAM 2007. IET International Conference.

Dinis-Carvalho J, Moreira F, Bragança S, Costa E, Alves A, Sousa R (2014a) Waste Identification Diagram, Production Planning & Control: The Management of Operations, Published online: 24 Mar 2014.

Dinis-Carvalho J, Guimarães L, Moreira F, Rodrigues J, Lima R M (2014b) Waste Identification Diagrams with OEE data, Proceedings of the CIO-ICIEOM-IIIE 2014, July 23-25, Malaga Spain, ISBN-13978-84-616-9935-3, pp. 313-320.

Huang C C, Liu S H (2005) A novel approach to lean control for Taiwan-funded enterprises in mainland China. International Journal of Production Research, 43(12), 2553-2575.

Irani S A, Zhou . (1999) Value Stream Mapping of a Complete Product. MS thesis, The Ohio State University, Columbus, OH.

Jones D, Womack J (2002) Seeing the whole: Mapping extended the value stream, The Lean Enterprise Institute, ISBN 0-9667843-5-9.

Lovelle J (2001) Mapping the value stream. IIE Solutions, 33(2), 26-32.

Ohno T (1988) Toyota Production System: Beyond large-scale production, Productivity Press, Portland, Oregon.

Rother M, Shook J (1999) Learning to see - value stream mapping to create value and eliminating muda, 1.2 ed. Brookline: The Lean Enterprise Institute.

Does Sustainable Supply Chains Practices Increase Companies Performance?

Pinto L[1], Borges Gouveia JA[2], Ferreira, L[3]

Abstract: The recent worldwide crisis, in finance and energy areas, is likely to reinforce the importance of sustainable development within strategic intents of states and firms. Companies have increasingly recognized the need to pursue not only economic but also environmental and social goals. Using a multiple case study, eight focal companies were investigated through semi-structured interview, how sustainable internal and external practices are being incorporated by industrial companies across the supply chain, as well as the performance measures used for evaluate the influence of sustainable practices on focal companies and the impact of those practices on the global performance. The paper contributes to understand the potential of sustainable practices on the company's performance explored through semi structured interviews on eight industrial companies. We identify through empirical evidence the environmental and social practices with larger application in business and their implications on economic, environmental and social performance. The paper draws useful lessons for companies and practitioners who seek sustainable practices.

Keywords: Sustainable supply chains; Performance; Case studies; Portugal.

1 Introduction

There is an increasing recognition that organisations must address the issue of sustainability in their supply chain as an essential element of firm strategies (Seuring, 2013). Due in large part to pressures from various stakeholders, especially government regulators, community activists, non-governmental organizations (NGOs), and global competition, many companies have adopted a certain level of commitment to sustainability practices. Sustainability is commonly defined as the use of resources to meets the needs of the present without compromising the ability of future generations to meet their own needs (WCED, 1987). Sustainable supply chain management (SSCM) is a critical and interdisciplinary field that derives from integrating the concept of sustainability with core business functions that fall within the domain of supply chain management, such as procurement, logistics and knowledge management (Morally & Searcy, 2013; Pagell & Wu, 2009).

The structure of this article is organized in five sections. In section two a brief review of the literature, the main characteristics of the framework and the research's objectives are provided. In section three the methodology of the study is introduced. The results of the empirical data analysis are presented in section four. Section five includes a summary of findings, conclusions and future research directions.

1 **Luisa Alexandra Pinto** (lpinto@estgl.ipv.pt)
School of Technology and Management of Lamego/ CI&DETS,
Polytechnic Institute of Viseu, Av. José Maria Vale de Andrade,
Campus Politécnico, 3504-510 Viseu – Portugal.

2 **Joaquim Borges Gouveia** (bgouveia@ua.pt)

3 **Luis Miguel Ferreira** (lmferreira@ua.pt)
Dept of Economics, Management and Industrial Engineering, University of Aveiro,
Campus Universitário de Santiago, 3810- 193 Aveiro,Portugal.

2 Research Objective and Framework

This paper aims to identify the relationships between sustainable supply chain practices and companies economic, environmental and social performance. Based on literature review, a research framework has been defined, encompassing two main elements: sustainable supply chain practices and performance.

The first element of the framework contains the sustainable supply chain practices identified by means of the literature review. Despite the many studies to date, that have been conducted on the relationship between environmental practices and economic performance (e.g., Azevedo et al., 2011; Eltayeb et al., 2011; Kleindorfer et al., 2005; Svristava, 2007; Seuring & Muller, 2008; Seuring et al., 2008), just a few examine the social and environmental practices with economic, environmental and social performance. Through literature review we identified environmental and social practices used in different studies.

Environmental Practices

The set of techniques, politics and procedures implemented by companies, whose consequences are the reduction and elimination of waste and pollution, elimination of hazardous materials, life cycle analysis of products, reduction of companies' operations environmental impact and preventive environmental problems are denominated as environmental practices (Montabon et al., 2007). Those environmental practices includes supply chain activities: from eco design, reverse logistics, distribution, green purchasing, internal environmental management, environmental information systems, green production focus on suppliers' process management of the focal firm (Azevedo et al., 2011; Eltayeb et al.,2010; Hervani et al., 2005; Zhu et al., 2008,2010).

Social Practices

The adoption of social practices in the supply chain is related to the social dimension of SSCM, incorpo-rating organization's internal and external social issues. Internal social practices are those related with the organization's internal environment, associated to human resources: recognition, valorization and promotion of the workforce capabilities with appropriate human resources politics, equity practices, development and wellbeing, creation and maintenance of a participatory and open environment for employees development, fair remuneration, decent work conditions, training and adaptation programs (Elkington, 2001) Concerning external social practices, those include: relationship between surrounding communities and manufacturing facilities in order to assure populations quality of life, relationship with other stakeholders through democratic and ethic decisions, responsibility for the products and services offered, considering the impacts on costumers and non-costumers affected by the negative externalities of other citizen's consumption (Pullman et al., 2009).

2.1 Framework

The framework has been formulated according to the literature review. More specifically, sustainable supply chain practices have been classified into internal and external environmental and social practices:

Environmental practices

– Internal environmental practices, includes a set of environmental practices: internal environmental management, eco-design, green purchasing and green production (Azevedo et al., 2011; Hervani et al., 2005; Rao, 2004; Rao & Holt, 2005;Tsoulfas & Pappis, 2008; Zhu et al., 2008, 2010;).

– External environmental practices, includes: environmental collaboration with customers and suppliers, green packaging and reverse logistics (Beamon, 1999; Carter & Rogers, 2008; Eltayeb et al, 2011; Hervani et al., 2005; Nair & Menon, 2008; Rao, 2004; Vachon & Klassen, 2006; Vachon & Klassen, 2007; Zhu et al., 2008).

Social practices

– Internal social practices, includes, top managers internal social commitment to manage social issues, labour practices and health and safety conditions (Gauthier, 2005; GRI, 2006; Hutchins & Sutherland, 2008; Sloan, 2010).

– External social practices, includes, social collaboration with suppliers and customers and community collaboration (Amaeshi et al., 2008; Gauthier, 2005; GRI, 2006; Hutchins & Sutherland, 2008; Sloan, 2010).

Performance

The second element of the framework includes the performance indicators used to measure sustainable supply chain practices impacts. We can only manage what we can measure, so measuring performance is critical to any organisation manage its activities and operations and an important requirement to its improvement process (Sink & Tuttle, 1989).

Based on GRI, environmental and occupational health management systems performance indicators and others key performance indicators (KPIs) identified on the literature review, performance indicators can be grouped in:

– Economic performance: measure the impacts of environmental and social practices on focal firm and on the supply chain: Sales; Earnings Before Interests, Taxes, Depreciation and Amortization (EBITDA);

– Environmental performance: measure the impacts of environmental and social practices adopted on focal firm and on the supply chain, in relation to raw material used, energy, water, air emissions and wastes;

– Social performance: measure the impacts of environmental and social practices on focal firm and on the supply chain considering injuries number, working hours lost due to illness, accident frequency and gravity index, absenteeism rate, overall staff turnover rate and training.

Figure 1, synthesizes the main components of the framework:

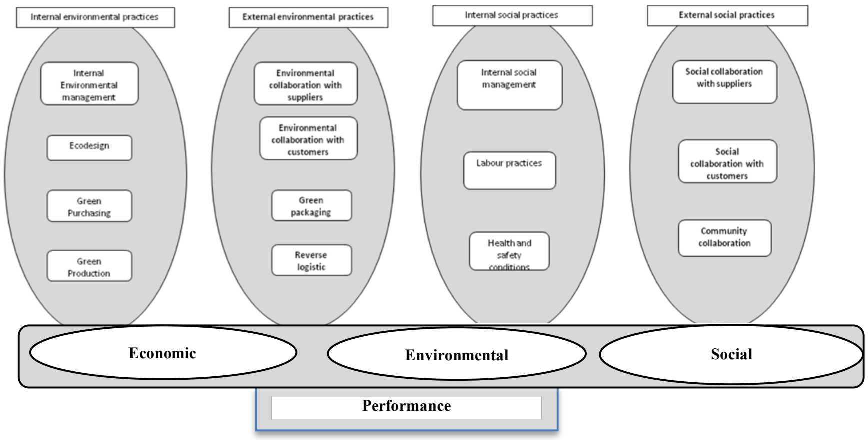

Fig.1
Research framework.

On the basis of the research framework, the research objective aims at analyzing the link between sustainable supply chain practices and performance.

In line with this the following main research question has been formulated:

RQ1: How supply chain environmental and social internal and external supply chain practices impact on the economic, environmental and social performance of the focal firm?

3 Methodology

This study adopt a qualitative approach, using a case study approach which was chosen as the most appropriate research method to describe and explore new phenomena and useful to explain the relationships between sustainable practices and organizations performance. Suggestions for the number of cases to use in multiple case study research vary, but Eisenhart (1989) suggests eight cases as the maximum that a person can mentally process, Yin (2009) is more circumspect in regards to hard numbers and instead suggests that data should be collected until theoretical saturation. For those reasons the sample is composed by eight companies. Those companies are highly committed to all dimensions of sustainability – economical, environmental and social - and have production plants in Portugal. They received third party certification and/or recognition, the attitude of transparency that characterizes their activities described in their websites, social reports and also through the newspaper articles, articles in the business press and presentations at sustainability conferences. Case studies have been developed by means of twenty two anonymous semi-structured face-to-face interviews on the basis of a semi-structured protocol (Cf. Table 1). Triangulation with secondary data collected from reports and websites, was conducted to enhance study validity and reliability.

Table 1
Characteristics of the sample.

Company	Industry	Annual Turnover (ME)	Number of employees	Number of interviews	Role of interviews
C1	Glass	95	350	3	General, Purchasing and Health & Safety Director;
C2	Cork	318	927	4	General, Purchasing and Human Resources Director; Environmental, Health & Safety Coordinator;
C3	Automotive components	84,4	348	4	General, Integrated Systems, Purchasing and Public Relations Director
C4	Wood based panels	1.321	177	3	General, Environmental, Health & Safety and Purchasing Director
C5	Office and commercial furniture	8,62	122	1	Quality, Environmental, Health & Safety Director
C6	Automotive assemblage	216	190	3	General, Human Resources and Purchasing Director
C7	Drinks	498	1500	1	Environmental, , Health & Safety Sustainable Director
C8	Automotive textile	44	182	3	General, Environmental, Health & Safety and Purchasing Director

4 Results and discussion

In this section the main results of the empirical analysis will be presented and discussed. We present, in table 2 the sustainable performance indicators used by companies and the impact of sustainable supply chain practices on economic, environmental and social performance.

Table 1
Performance indicators.

Key performance indicators		
Economic	**Environmental**	**Social**
Sales; EBITDA	Energy; Water Waste; Air emissions	Number of injuries ; Number of working hours lost due to illness; Accident frequency index; Accident gravity index Absenteeism rate; Overall staff turnover rate; Training hours per employee; Age profile; Break down by gender

Table 2 shows the indicators that companies´ have in common to measure sustainability performance. As we can see from the table, the typically economic indicators used to measure economic performance are sales and EBITDA. The assessment of environmental performance is determined by the impositions of the ISO 14000 certification, which these companies have obtained. From the social point of view, performance socials indicators include classic human resources and safety indicators. Even some of the companies do not have OSHAS 18001 certification, all of them measure health and safety indicators (Cf. Table 2). Customer satisfaction is also an indicator measured for all companies. The companies that do activities and collaborate to NGOs measure the number of activities.

We aim to identify the relationship between sustainable practices implemented and the economic, environmental and social. Regarding the relationship between the implementation of environmental practices and economic performance, concerning General and Health & Safety Directors opinions of the eight companies in the study, the relationship is positive , i.e, the application of environmental practices have a positive impact on economic performance.

Three of the study companies reveal difficulties in measuring the application (or the relation) of environmental practices and economic performance, due to the scope of the practices in question. Some of them have negative effects on economic performance, given the investments that are needed to accomplish.

Regarding the relationship between the implementation of internal social practices and economic performance, despite the existence of trade-offs applying social practices, for three of the companies, the effect on economic performance is positive in that it increases employee satisfaction which has effects on quality, productivity and profitability. With regard to the relationship between environmental practices and environmental performance, we find that for all of the companies the implementation of environmental practices have a positive and immediate impact on environmental performance. The relationship between social practices and environmental performance for companies in which it has been established this relation-ship exists and is positive however the relationship is difficult to establish. The relation between social practices and social performance is a win-win relation for all companies. This was reflected in the improvement of social performance indicators, such as, employee motivation and satisfaction, pride, absenteeism rate, turnover rate, work accidents. Beyond the internal effects, external impacts are evident in corporate recognition by the community through awards and establishing partnerships with NGOs and through the participation in different research projects with different stakeholders.

5 Conclusions

This paper aims at studying sustainability on different industries, considering supply chain practices, and performance. To chase this objective, a literature review has been carried out to identify sustainable supply chain practices and performance. In general we conclude, based on the eight companies analyzed, that the implementation of supply chain sustainable practices across the companies, have positive impacts on the overall business performance. These results might help practitioners to understand how to implement sustainable supply chain practices and identifying the impact that each practice has on the performance.

Nevertheless, this research suffers from some limitations. Even different industrial sector have been analyses, due to the limited number of companies involved, results may not be generalized to other contexts and broader samples. A wider sample of analysis is needed to support the results and to allow statistical validations as well.

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6 References

Amaeshi, K., Osuji, O. and Nnodim, P. (2008), Corporate Social Responsibility in Supply Chains of Global Brands: A boundaryless responsibility? Clarifications, exceptions and implications, *Journal of Business Ethics,* Vol. 81, Nº1, pp. 223–234.

Azevedo, S. G., Carvalho, H. and Machado, V. C. (2011), The influence of green practices on supply chain performance: A case study approach, *Transportation Research Part E,* Vol. 47, pp. 850–871.

Beamon, B.M. (1999), Measuring supply chain performance, *International Journal of Operations & Production Management*, Vol. 19, Nº3, pp. 275–292.

Carter, C. and Rogers, S. (2008), A framework of sustainable supply chain management: moving toward new theory, *International Journal of Physical Distribution & Logistics Management*, Vol. 38, Nº 5, pp. 360-387.

Eisenhart, K.M. (1989), *Building Theories from Case Study Research*, Academy of Management Review, Vol. 14, Nº4, pp. 532-550.

Eltayeb, T., Zailani, S. and Ramayah, T. (2011), Green supply chain initiatives among certified companies in Malaysia and environmental sustainability: Investigating the outcomes, *Journal of Resources Conservation and Recycling,* Vol. 55, Nº 5, pp. 495-506.

Elkington, J. (2001), The triple bottom line for 21st century business. Starkey, R. and Welford, R. Editions The Earthscan Reader in Business and Sustainable Development, Earthscan, London, pp. 20-43.

Gauthier, C., (2005), Measuring corporate social and environmental performance: the extended life-cycle assessment, *Journal of Business Ethics,* Vol.59, Nº 1, pp. 199–206.

Gimenez, C., Sierra, V. and Rodon, J. (2010), Sustainability through Supply Chain Management. *EBN 23rd Annual Conference of the European Business Ethics Network Proceedings.*

GRI (2006), Guidelines for Sustainability Reporting, Available from <https://www.globalreporting.org/resourcelibrary/Portuguese-G3-Reporting-Guidelines.pdf.>

Hervani, A., Helms, M., and Sarkis, J. (2005), Performance measurement for green supply chain management, *Benchmarking: an International Journal,* Vol. 12, Nº4, pp. 330–353.

Hutchins, M. and Sutherland, J. (2008), An exploration of measures of social sustainability and their application to supply chain decisions, *Journal of Cleaner Production,* Vol. 16, pp. 1688-1698.

Kleindorfer, P., Singhal, K. and Van Wassenhove, L. (2005), Sustainable Operations Management, *Production and Operations Management*, Vol.14, Nº4, pp. 482-492.

Miles, M., and Huberman, A. (1994), *Qualitative data analysis*, Thousand Oaks, CA: Sage.

Nair, S. and Menon, C. (2008), An environmental marketing system: a proposed model based on Indian experience, *Business Strategy and the Environment*, Vol. 17, Nº8, pp. 467–479.

Pagell, M. and Wu, Z. (2009), Building a more complete theory of sustainable supply chain management using case studies of 10 exemplars, *Journal of Supply Chain Management*, Vol. 45, Nº 2, pp. 37-46.

Pullman, M., Maloni, M. and Carter, C. (2009), Food for thought: social versus environmental sustainability practices and performance outcomes, *Journal of Supply Chain Management*, Vol. 45, Nº 4, pp. 38-54.

Rao, P. (2004), Greening production: a South-East Asian experience. *International Journal of Operations & Production Management*, Vol. 24, Nº 3, pp. 289-320.

Rao, P. and Holt, D. (2005), Do green supply chains lead to competitiveness and economic performance? *International Journal of Operations Management*, Vol. 25, Nº 9, pp. 898-916.

Seuring, S. (2013), A review of modeling approaches for sustainable supply chain management, *Decision Support Systems,* Vol. 54, pp. 1513–1520

Seuring, S. and Müller, M. (2008), From a literature review to a conceptual framework for sustainable supply chain management, *Journal of Cleaner Production,* Vol. 16, Nº 15, pp.1699–1710.

Seuring, S., Sarkis, J., Müller, M. and Rao, P. (2008), Sustainability and supply chain management – an introduction to special issue, *Journal of Cleaner Production*, Vol.16, pp. 1545-51.

Sink, D. and Tuttle, T. (1989), *Planning and measurement in your organization of the future,* Georgia: Industrial Engineering and Management Press.

Sloan, T.W. (2010), Measuring the sustainability of global supply chains: current practices and future directions, *Journal of Global Business Management,* Vol. 6, Nº1, pp. 92–107.

Tsoulfas, G. and Pappis, C. (2008), A model for supply chains environmental performance analysis and decision making, *Journal of Cleaner Production,* Vol.16, 1647–1657.

Vachon, S. and Klassen, R. (2006), Extending green practices across the supply chain: The impact of upstream and downstream integration, *International Journal of Operations & Production Management*, Vol. 26, Nº 7, pp. 795-821.

Application of Lean Accounting for production costs management in lean enterprises: a case study in an auto parts company

Soranso LM[1], Cavalcanti D[2], Meirelles JLF[3], Rossetti N[4]

Abstract: This study deals with the application of account reports, as proposed by the Lean Accounting (LA) methodology, as a management tool to evaluate the cost results in the lean manufacturing cells and also compares the deviation between the traditional cost per unit and the average cost per unit as in the Value Stream Costing (VSC) method. According to the unit managers of a Lean Manufacturing (LM) company, one of the greatest challenges, after the modifications in the production system, is the demonstration of the financial benefits achieved due to the lean changes. Mainly because of the conflict between the product cost calculation method and the production costs indicators. The encountered results corroborate with the literature in regarding of the need for adapting the cost controlling system adopted in Lean Enterprises.

Keywords: Lean Accounting, Value Stream Costing, Cost Management.

1 Introduction

In the latest decades, many companies have been migrate its production system from mass production to the Lean manufacturing system (Kennedy and Widener, 2008).

After adhering to the philosophy and implementing improvements that dramatically reduce waste and minimize inventory levels, managers have been facing a new challenge: to demonstrate financially all earnings and savings generated by the Lean Manufacturing. (Arbulo-Lopez and Fortuny-Santos, 2010; Maskell, 2011).

In order to align the information of the results obtained through the lean system and the production costs required for financial statements (Slavov et al., 2013), an interaction between Production and Accounting Management has been established.

The aim of this study is to demonstrate if a lean enterprise can keep using the traditional costing method to evaluate its production costs results. Can this traditional model, a system that seeks the lowest unit cost by the dissolution of the fixed costs into the highest possible production quantity, still demonstrate the performance of an one-piece-flow oriented system?

1 **Lígia Martinez Soranso** (ligia_sos@yahoo.com.br)
2 **Dalmo Cavalcanti** (cavalcanti.dalmo@bol.com.br)
3 **Jorge Luís Faria Meirelles** (jorgeluis@ufscar.br)
4 **Nara Rossetti** (nara@ufscar.br)
Dept.Production Engineering. Federal University of São Carlos.
Sorocaba. Rodovia João Leme dos Santos (SP-264), Km 110, Brazil.

2 Literature Review

2.1 Accounting Roles in Production Systems

Atkinson et al. (2000) state that:

> "Management accounting information is one of the primary informational sources for decision making, improvement, and control in organizations."

To Lere (1980) the responsibility for price definition and market value belongs to the Accountancy, others authors also claim that the Accounting systems should be able to fit into the various production systems in order to better serve its managers and evolve with the innovations in production systems (Granlund, 2001; Lere, 2001; Souza et al.., 2003).

2.2 Costing Methods and Lean Accounting

Regarding the function of Accounting systems as support for business management follows a major debate about which appropriate costing method can be considered more appropriated to each production system (Charles and Hansen,2008; Lere, 2001; Pong and Mitchel, 2006). Other important discussion in this regard is about the real need of a product cost per unit (Kaplan and Cooper, 1991) versus its importance as a pricing method (Noble and Gruca, 1999; Charles and Hansen, 2008).

The most widespread costing methods are:

• Absorption: the only one still recognized by the Brazilian tax authorities for balance sheet purposes and income statement. It is applied for this study case. In this model, every cost, direct or indirect, is absorbed into the product cost. Thus the higher the production volume, the lower the unit product cost, since the fixed costs are dissipated in the production volume. This effect leads to an overproduction and therefore inducing to inventory increase, what can compromise company´s cash flow (Womack et al., 1992).

• Variable Costing: avoids the arbitrariness of apportionment contained in the absorption method and allocate the fixed costs as overhead in the income statement (Martins, 2003).

• Activity Based Costing - ABC: here the activities consume resources and the cost objects consume the activities (Andrade et al., 2008). Similar to the Value Stream Costing, on ABC, the use of resources are measured and appointed for each activity and the costs will be only appropriate to the product if it consumes the activity (Kaplan and Cooper, 1991).

3 Research Methodology

1. The Company

   This case study was performed in a subsidiary of a large multinational European company, in the auto parts industry. The company has 170 locations in 49 countries and has approximately 80,000 employees. The Brazilian subsidiary is located in State of São Paulo, Brazil, counts with approximately 4,000 employees and has, for over 20 years, a strong lean program, leaded by the matrix, focused on the lean philosophy implementation.

2. Interview and Data Collection

   This empirical research uses the information obtained from the interviews with the Lean Office Manager and the Production Unit Manager and the data collection of the Value Stream Map and its costs after the lean cell implementation.

4 Project, Costs and Reports

After track and design the Value Stream Map of a product line, the Lean Office has identified an operation sequence that could improve the value stream performance if the layout of the machines could be modified.

The approximation of the equipments and the balance of the material flow created a dedicated cell and drove to savings in handling, intermediate stocks (WIP) and allocated employees, as follows:

Table 1
Comparative between push (before) and lean concept (after).

		Before				After	Δ
Cycle Time		Grinding	Finishing	Washing	Assembly	Line	
Component A	[min/pc]	0,180	0,160	0,160	-		
Component B	[min/pc]	0,120	0,120	0,007	-	0,168	-16%
Final Product	[min/pc]	0,000	0,000	0,000	0,180		
Concept	-	Individial Machines				Cell	-
Employees	-	18				10	-44%
WIP [1]	[pcs]	16.000				6.012	-62%
Batch Size	[pcs]	100.000				25.000	-75%
Lead Time [2]	[days]	1,6				0,8	-50%
Handling	[m]	2500				60	-98%
OEE [3]	[%]	68				76	12%
Area	[m^2]	213				180	-15%
Cost per Unit [4]	[BRL]	1,30				1,47	13%

[1] WIP = ΣWIP ÷ Daily Customer Demand

[2] LeadTime = ΣQeueT + ΣSetupT + (Batch Size x ΣCycleT) + ΣWatingT + ΣHandlingT

[3] OEE= Availability x Performance Efficiency x Quality

4Cost per unit = (Setup Time/Batch Size + Cycle Time) x Cost Minute

As demonstrated in Table 1, by applying the new concept, many performance indicators have been improved. The cycle time reduction was achieved substituting an upgraded grinding tool in the bottleneck machine. This is important to highlight, because, even with this improvement, the final calculated cost per unit has been increased. This occurs basically because of the batch size effect (see Cost per Unit equation).

The handling distance between the machines almost does not exist anymore and the logistic labor to movement the components from one station to another has been eliminated, what has also influenced, associated to the WIP reduction, savings in utilized area.

Due to this new layout, 8 employees were released to work at other sectors that were in lack of manpower. The company´s policy is not to dismiss any employee, but avoid new hires.

Going forward on the cost analysis, it is necessary to understand the cost per minute structure and how the company analyses its production costs results.

Table 2 shows all the allocated costs for machinery and operation cost. Summing not only the production costs, but also all costs of support areas, sales and company´s overhead, the production unit absorbs costs that are not related to its activity, because of the apportionment method. This total amount applied to the machine center cost is divided by the total available minutes per month, or year, so the cost per minute is created.

Table 2
Cost per Minute Structure and Operations
Costs before Cell Implementation.

Cost per Minute Structure	Profile Grinding	Finishing / Washing	Grinding / Finishing / Washing	Assembly
Customer Service	R$ 90,62	R$ 36,14	R$ 210,72	R$ 143,24
Purchasing	R$ 326,76	R$ 134,16	R$ 502,86	R$ 243,08
Production Cell	R$ 36.616,99	R$ 46.334,69	R$ 65.909,45	R$ 20.111,04
Cell reloading	R$ 2.941,62	R$ 2.157,30	R$ 2.922,54	R$ 1.629,23
Quality Assurance	R$ 3.969,47	R$ 3.046,01	R$ 3.494,02	R$ 2.345,26
Unit Administration	R$ 7.389,99	R$ 4.539,74	R$ 8.201,43	R$ 6.808,85
Accounting	R$ 55,46	R$ 53,88	R$ -	R$ -
Information Systems	R$ 90,62	R$ 9,74	R$ -	R$ 84,41
Design Engineering	R$ 2.227,25	R$ 1.709,11	R$ 1.960,48	R$ 1.315,92
Technical Support	R$ 7.249,21	R$ 1.041,83	R$ 8.914,12	R$ 205,02
Area	R$ 202,48	R$ 75,92	R$ 263,03	R$ 32.082,19
Overhead	R$ 1.972,67	R$ 783,36	R$ 2.617,69	R$ 2.607,39
Total Cost	R$ 63.133,15	R$ 59.921,88	R$ 94.996,33	R$ 67.575,65
Available Time [min/month]	28.762	37.710	33.988	41.662
$Cost_{per\ minute}$	R$ 2,20	R$ 1,59	R$ 2,80	R$ 1,62
Setup	300	200	400	70
Cycle Time	0,180	0,160	0,120	0,180
Batch Size	100.000	100.000	100.000	100.000
$Cost_{per\ unit}$	R$ 0,40	R$ 0,26	R$ 0,35	R$ 0,29

Further, by applying the company's cost rule to the new production condition, within the cell implement-tation, following results, demonstrated in Table 3, were obtained:

Table 3
Individial Machines and Cell Total Costs and Manufacturing Costs.

Cost per Minute Structure	Individial Machines	Cell
Customer Service	R$ 480,72	R$ 480,72
Purchasing	R$ 1.206,86	R$ 1.206,86
Production Cell	*R$ 168.972,18*	*R$ 151.325,95*
Cell reloading	R$ 9.650,69	R$ 9.650,69
Quality Assurance	R$ 12.854,77	R$ 12.854,77
Unit Administration	R$ 26.940,01	R$ 26.940,01
Accounting	R$ 109,34	R$ 109,34
Information Systems	R$ 184,76	R$ 184,76
Design Engineering	R$ 7.212,76	R$ 7.212,76
Technical Support	R$ 17.410,19	R$ 17.410,19
Area	*R$ 32.623,62*	*R$ 27.569,26*
Overhead	R$ 7.981,11	R$ 7.981,11
Total Cost	R$ 285.627,01	R$ 262.926,41
Available Time [min/month]	*see Table 2*	32.832
Cost per minute	*see Table 2*	R$ 8,008
Setup	*see Table 2*	400
Cycle Time	*see Table 2*	0,168
Batch Size	*100.000*	25.000
Operation Cost per unit	R$ 1,30	R$ 1,474

For Maskell et al. (2011), the average cost per unit would be R$ 2,856 / piece, in other words, R$ 285.627,01 divided by 100,000 produced pieces. Thus, *a priori*, some managers would consider this cost unfeasible for the business. That is why the Lean Accounting affirms that this simplistic cost per unit analysis is a wrong view for cost management and should not to be used by lean enterprises.

Evidencing the literature, even with the total production cost reduction of 7,9%, the company did not use the cost per unit metric to decide for cell implementation since, as shown in Table 4, the product cost per unit has been increased,

Converging with Maskell et al. (2011), Árbulo-López and Fortuny-Santos (2010) and Slavov et al. (2013) it is found that a differentiated approach in the cost presentation changes the viewer's perspective regarding the obtained results. This alternative approach is also necessary for the production system evolution.

The next table presents the results according to a Lean Account suggestion for Financial demonstration and shows that, to enable the complete business management overview, it is also necessary to include the sales revenue of the Value Stream and the inventory level.

Table 4
Financial Statement for Value Stream
Mapping according to Lean Accounting.

	Before Lean	After Lean	Improvement
Sales Revenue	R$ 1.158.750,00	R$ 1.158.750,00	R$ -
Conversion Costs	R$ 285.627,01	R$ 262.926,41	-R$ 22.700,60
Material Costs	R$ 627.000,00	R$ 627.000,00	R$ -
Value Stream Profit	R$ 246.122,99	R$ 276.804,70	R$ -
ROS	21%	23%	2%
Inventory	R$ 121.104,00	R$ 45.504,83	-R$ 75.599,17
Average Cost per Unit[1]	R$ 9,13	R$ 8,90	-R$ 0,23

[1] Average Cost per Unit = (Conversion Costs + Material Costs) ÷ 100,000 pcs (produced)

In this report, the inventory reduction is clearly demonstrated. Here the stocks variance is treated separately while in Table 5, the current company´s report, the inventory variance is carried into the *unit credit* and leads to a controversial impact, once inventory increase affects positively the performance of the unit production costs.

Table 5
Current Financial Statement.
Behavior of Inventory Variation.

Inventory	Reduction	Increase
(=)Production Credit[1]	R$ 912.627,01	R$ 912.627,01
(±) Δ Inventory	-R$ 75.599,17	R$ 75.599,17
(=) Total Unit Credit[2]	R$ 837.027,83	R$ 988.226,18
(+)Processes Costs	R$ 285.627,01	R$ 285.628,01
(+) Material Costs	R$ 627.000,00	R$ 627.000,00
(=) Total Costs	R$ 912.627,01	R$ 912.628,01
(=) Production Cost Deviation	-8,3%	8,3%

[1] Production Credit = Cost per unit x delivered quantity at Expedition
[2] Unit Credit = Delivering Credit +/- change of stock

That is why, more than apply the lean method, the enterprise must understand the informational impact of the figures on its managers actions and decisions.

5 Final Conclusion

It was considered that the analyzed figures results combined with the unit management reports confirmed the literature proposition of the need for an adequate accounting system that better supports the management decisions in lean enterprises.

Since this is a private company, the access to information and staff was limited, not allowing the verification of the real raw material and selling price values and the apportionment rules. Thus those values were given after multiplied by an unknown factor, not higher than 10%, only for an approximated calculation statement.

Finally, seeking the evolution of the lean culture spread, it is suggested to other researchers to verify whether companies that adopted lean manufacturing system are also presenting deficiencies in their management accounting, how those divergences are handled and if they are aware about the existence of Lean Accounting as a management tool.

References

Andrade MC , Pessanha Filho RC, Espozel A M, Maia LOA , Qassim RY (1999) Activity-based costing for production learning. Int. J. Production Economics 62:175-180

Arbulo-Lopez PR, Fortuny-Santos J (2010) An accounting system to support process improvements: Transition to lean accounting. J of Industrial Engineering and Management : 576-602

Atkinson AA, Banker RD, Kaplan RS, Young M (2000) Contabilidade gerencial. Atlas.São Paulo.

Charles SL, Hansen DR (2008) An evaluation of activity-based costing and functional-based costing: A game-theoretic approach. International Journal Production Economics 113:282-296

Cooper R, Kaplan RS (1991) Priorities from Activity-Based-Costing. Harvard Business Review 130-135

Kennedy FA, Widener SK (2008) A control framework: Insights from evidence on lean accounting

Granlund M (2001) Towards explaining stability in and around management accounting systems. Management Accounting Research 12:141-166

Lere JC (1980) Observable differences among Prime, Variable, and Absorption Costing Firms. Journal of Business Research:371-387

Lere JC (2001) Your Product-costing System Seems to Be Broken: Now What?. Industrial Marketing Management 30: 587–598

Martins, E (2003) Contabilidade de Custos. Atlas.São Paulo

Maskell, B, Baggaley B, Grasso L (2011) Practical Lean Accounting: A proven System for Measuring and Managing the Lean Enterprise. CRC Press. New York

Noble PM, Gruca TS (1999) Industrial Pricing: Theory and Managerial Practice.Marketing Science Vol.18 3:435-454

Pong C, Mitchel F (2006), Full costing versus variable costing: Does the choice still matter? An empirical exploration of UK manufacturing companies 1988–2002. The British Accounting Review 38:131-148

Slavov TNB, Faria AC,di Serio LC, Pereira AN (2013) Contabilidade Enxuta (Lean Accounting) na Indústria Automobilística: o caso FIAT. Gestão e Regionalidade Vol. 29 - 86: 88-103

Souza MA, Lisboa LP, Rocha W (2003) Práticas de Contabilidade Gerencial adotadas por subsidiárias brasileiras de empresas multinacionais.Revista Contabilidade e Finanças - USP 32:40-57

Womack J, Jones, D, Roos D (1992) A máquina que mudou o mundo. Translated by Ivo Korytowski. Campus. Rio de Janeiro

Industrial Vertical Portals: Influence of Cluster Membership on Participants' Perceptions of Future Value Creation, Motivations and Expectations

Santos S[1], Barros AC[2], Campos P[3]

Abstract: Increasingly, web-based portals are used as a vehicle to meet the needs of both Business-to-Consumer (B2C) and Business-to-Business (B2B) markets. Several authors have highlighted the importance of companies' participation in clusters as a way to foster networking and relationships among networks of organizations towards the identification of new business opportunities. And yet, studies about the motivations and expectations of companies to actively participate in web-based portals as means of networking and opportunity search are scarce in literature. This paper, based on a case study of the Portuguese Manufacturing Technologies Cluster (PRODUTECH), investigates how cluster membership affects the perception of future value creation, motivations and expectations of companies to participate in the cluster web-based portal. The results showed that perceptions of future value creation, motivations and expectations for participation and/or search in the industrial portal are in fact related with being a member or not of PRODUTECH.

Keywords: Clusters, Industrial Vertical Portal, Case Study.

1 Introduction

Currently, companies, associations and clusters have been engaging in projects for the creation and implementation of vortals (vertical industry portals) in the hope of increasing their competitive advantage by perceiving the opportunities that arise from cooperation networks. Indeed, industrial vertical portals or vortals are an useful instrument because they provide access to online platforms for data sharing and other forms of cooperation (Haupt and Kalyanasundaram, 2007). Examples of industrial vertical portals are the one developed by the Portuguese Information Technology, Communication and Electronics Cluster (tice.oobian.com), the plastics and packaging portal (www.plastech.biz) and the FindLaw portal (www.findlaw.com). However, to the best of our knowledge, until now, there are only scientific studies investigating the importance of value creation, motivations and expectations in B2B e-commerce, and not in industrial vertical portals. Similarly, we were not able to find scientific evidence that demonstrates that the membership of clusters has a differentiating effect on value creation, motivations and expectations in industrial vertical portals. Therefore, this paper aims to fill this gap, by means of a case study on the vertical portal of the Portuguese Production Technologies Cluster - PRODUTECH.

1 **Sara Santos** (120418032@fep.up.pt)
2 **Ana Cristina Barros** (acbarros@inesctec.pt)
3 **Pedro Campos** (pcampos@fep.up.pt)
INESC TEC and Faculty of Economy, University of Porto.
Rua Dr. Roberto Frias, 4200-464 Porto, Portugal

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2 Literature Review

The cluster concept, defined by Porter (1998), is based on the geographical concentration of companies and institutions in a specific area of uncommon competitive success. Being part of a cluster allows companies to operate productively, to access to information, technology and institutions, and to achieve coordination and complementarity with related parties. Furthermore, the close relationships builds trust between the actors in the cluster, therefore promoting cooperation and learning through the exchange of knowledge between companies (Podolny and Page, 1998; Kajikawa et al., 2012). With the development of ICT tools, cluster managers seek to implement web-based systems to potentiate the interaction and collaboration among cluster members. Still, as to the best of our knowledge, there are no previous studies exploring the value creation, motivations and expectations in industrial vertical portals, we based our research on the ones identified in B2B e-commerce, which we revise in the following sub-sections.

2.1 Value Creation in E-Business

New information and communication technologies allow the collection and exchange of information between parties, thus improving the development of value creation networks and better communication between the parties (Kothandaraman and Wilson, 2001). In the context of e-business, Amit and Zott (2001) identified four sources of value creation: efficiency, complementarity, lock-in and novelty.

Efficiency: The greater efficiency of a transaction, the lower the costs. The electronic markets allow efficiency gains because they allow the improvement of information on products and services, minimizing the effort, money and time that consumers invest.

Complementarily: The internet allows to sell products or services, which may increase the value that the consumer is willing to pay. In addition, there may be a complementarity between the business offline and online.

Lock-in: The e-business provides tools that contribute with customer retention, as intangible factors - the brand and the company's reputation influence the valuation that the consumer conceives of what the company has to offer; and tangible factors related with the quality of products or services, their personalization and customization.

Novelty: The novelty is related to innovation. The Internet allows companies to create new business models, penetrate new markets, and create new products and services according to the needs of consumers.

In short, the information made available from a single source, the complementarities between the online and offline, the opportunity to create new businesses, products and services and the efficiency allow companies to take a strategic position in the online world.

2.2 Motivations in E-Business

Yoon et al. (2002) consider that the motivation for the use of a web portal is an important factor in the continued growth of e-commerce. There are four motivating factors (function, customization, familiarity, search) correlated with confidence and satisfaction. While function corresponds to the portal's utility, customization maintains users, allowing adaptation of the content of web portals and users can select news and information they want. The familiarity factor is associated with the relational concept of intimacy or knowledge, in which users are accustomed to while using portals and therefore it does not change from on to another (Yoon *et al*., 2002). The search for information is also a motivating factor. Katz and Aspden (1997) found, through the study of motivation on the web, that "obtaining information about specific interests" is the main reason for using the Internet, followed by "communicating with people "and "keeping up".

If organizations have an active participation in the digital market or are merely passive observers it will depend on their motivations. These may be related with improving efficiency, reducing the cost of doing business, demonstrate a technological sophistication of image or utility, customization portal, familiarity and seeking information. The motivation for the use of a web portal allows a continued growth of e-commerce.

2.3 Expectations in E-Business

Expectations are the perceptions of the future product or service performance that are commonly thought to reflect what the customer believes or anticipates will likely to happen (Olson and Dover, 1979). Thus, after buying a product or using a service, customers evaluate their satisfaction based on their initial expectations, and the actual perceptions of service performance, comparing expectations with performance. It is with expectations in mind that customers decide whether or not to be present or search an e-business market.

Lankton and Wilson (2007) have combined the expectations from online services with the influence of previous history of personal needs and past experience. This study was applied in a B2C website linked to health services. **Personal needs** are essential conditions for the psychological, social or physical well-being of the customer. Information is the main supply in many online sites, and many clients access to them, especially to meet their information needs (Stafford, 2003). For example, a person who realizes the need for social interaction is likely to anticipate a service will be useful or pleasing to answer that need. People look for different types of information, including new information, clarify information or confirm information. **Past experience** includes previous exposures to products or services that are relevant (Zeithaml, Berry and Parasuraman, 1993).

The expectation is considered a multi-attribute construct (Hsu and Chiu, 2003). The authors Lankton and Wilson (2007) identified the following dimensions of expectations: utility, ease of use and enjoyment, showing that search for information and previous satisfaction with the service are significant antecedents of expectations, and expectations have a positive influence on satisfaction.

In our case study we analyzed the expectations set out by Lankton and Wilson (2007): utility and ease of use (we excluded the enjoyment of the portal because it is not yet in operation and therefore we are not able to review this attribute in advance) and their relationship prior to the request for information and previous satisfaction with the service. This proposal follows the one suggested by Lankton and Wilson (2007) that future research should investigate if the influence of information-seeking preference varies with the duration of the relationship between customer and supplier as well as deepening research in other sectors.

3 Research Methods

The research question driving this study is: Does cluster membership affect the perception of future value creation, motivations and expectations of companies to participate or search in the cluster web-based portal? In order to investigate this research question a survey was developed following the review of the literature above and administrated both to members and non-members of a cluster. The Portuguese Production Technologies Cluster (PRODUTECH) was chosen as context to develop this research, because of the heterogeneity of its members' profiles and the current implementation of a web-based portal for the cluster. PRODUTECH has 89 members covering the whole Portugal but with higher concentration in the north, as follows: 60 companies (44 manufacturers and 16 productions technologies users), 16 research institutions, and 13 other entities and associations. The development of the survey instrument was also supported by four exploratory interviews with members of the PRODUTECH Board of Directors. The sample used in this study is described in Table 1. The survey was administered in July 2014. In the case of cluster members, phone contacts were made to increase the companies' participation in the study. A list of 3500 Portuguese companies (production technologies and end users) of various sectors, such as furniture, construction, molds, cork, footwear, automobile, among others, was used for reaching out to cluster non-members.

Table 1
Sample composition.

	Cluster Non-members	Cluster Members
Number of companies contacted	3500	89
Number of valid responses	266	69
Response rate	7,5%	77,5%

The industrial vertical portal of PRODUTECH shall work as a tool to potentiate exports increase and imports reduction (increasing the level of information to national and international companies so that they buy machinery and equipment from Portuguese companies). It will also help to identify opportunities for cooperation and for the promotion of companies and organizations belonging to the sector and its major products, services, jobs and markets.

4 Conceptual Model and Hypothesis Formulation

The proposed conceptual model (Figure 1) depicts the variables under study and how it is suggested that these relate to each other. It is assumed that the membership of PRODUTECH network has a differentiating effect on the perception of value creation (efficiency, complementarities, lock-in and novelty), motivations (function, customization, familiarity and search) and expectations (utility and ease of use) for the participation or search in the portal of production technologies. Similarly, it is expected that personal needs (the need for information), and past experience (previous satisfaction with the service) have an effect on expectations.

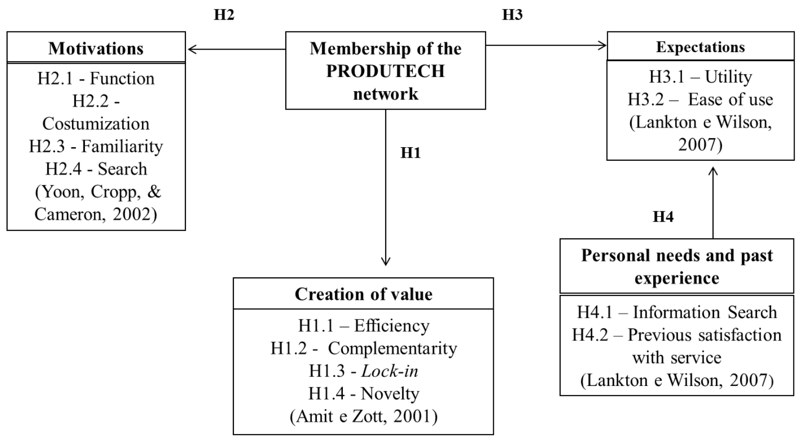


Fig.1
Conceptual Model.

5 Results

The results in Table 2 show that membership of PRODUTECH is linked to the perception of value, motivations and expectations for belonging to the portal of production technologies, according to the t-test for comparing means in independent samples (the two groups of independent samples considered are members and non-members of PRODUTECH).

The conclusion of the test was made using a p value of 5% to measure the perceptions of future value creation we used the sources identified by Amit and Zott (2001) in the context of e-business: efficiency, complementarities, lock-in and novelty. From the results, we can see that being a member of the PRODUTECH network has a differentiating effect on the perception of the companies on creating value through the portal of production technologies only according to sources of value "lock in" and "novelty". So we cannot conclude that the membership of the PRODUTECH network is connected to the perception of value creation in the portal of production technologies but that significant differences exist between belonging and not belonging to the cluster in the value sources of "lock-in" and "novelty".

In terms of motivation, we followed Yoon *et al*., (2002) who identified four motivating factors for the use of e-commerce: function, customization, familiarity and search. Our results point out that being a member of PRODUTECH network has a differentiating effect on the motivations of the companies in participating in the production technologies portal according to the motivations "function", "customization" and "search". Our results do not show statistical evidence that supports a differentiating effect on being a member of PRODUTECH for the motivation factor "familiarity". Therefore, there was no confirmation of the H2.

Table 2
Hypothesis verification.

Hypotheses	Measurement	Results	Confirmation
H1) Membership of the PRODUTECH network has a differentiating effect on the perception of the companies on creating value through the portal of production technologies.	1.1 – Efficiency	H0 Not rejected	No
	1.2 - Complementarity	H0 Not rejected	
	1.3 - Lock-in	H0 Rejected	
	1.4 – Novelty	H0 Rejected	
H2) Membership of the PRODUTECH network has a differentiating effect on the motivation of companies on belonging to or research in the portal production technologies.	2.1 – Function	H0 Rejected	No
	2.2 - Customization	H0 Rejected	
	2.3 - Familiarity	H0 Not rejected	
	2.4 - Search	H0 Rejected	
H3) Membership of the PRODUTECH network has a differentiating effect on the expectations of the companies belonging to or research in the portal production technologies.	3.1 - Utility	H0 Rejected	Yes
	3.2 - Ease of use	H0 Rejected	
4) The expectations for participation and research in the portal production technologies are related to:	4.1 - Utility versus Personal needs: Information Search	H0 Rejected	No
	Utility versus Past experience: previous satisfaction with the service	H0 Not rejected	
	4.2 - Ease of use versus Personal needs: Information Search	H0 Not rejected	No
	Ease of use versus Past experience: previous satisfaction with the service	H0 Not rejected	

The expectations identified by Lankton and Wilson (2007) combined expectations (utility and ease of use) from online services with the influence of the background of personal needs and past experience. The results show that the expectations "utility" and "ease of use" are connected to being a member of PRODUTECH having a differentiating effect on both. Therefore, there is a confirmation of the H3. Regarding the expectation “utility”, over 95% of PRODUTECH members consider the portal a useful tool for national and international dissemination of the sector of manufacturing technology while 76% of non-members share the same opinion. With regard to the "ease of use" 61.2% of the non PRODUTECH companies considered one of the three most important factors in the portal, however, the same factor is considered by most cluster members (55%) as the minor importance (between level 8-12).On the other hand, is it evident that only the expectation "utility" for participation and research in the production technologies portal is related to personal needs (information search).

6 Conclusion

This research sought to examine to what extent the perception of future creation of value, motivations and expectations for participation in the web-based portal of production technologies have a connection to being a member or not of the PRODUTECH cluster. The empirical survey carried out among members and non-members of the PRODUTECH cluster allowed to introduce interesting reflections and helped to deepen the knowledge about how the entities perceived value creation, motivations and expectations in relation to the portal of production technologies, and the differences between belonging or not to PRODUTECH.

The single case study design is the main limitation of this study. The research was carried our prior to the web-based portal launch. Future research may evaluate the perceptions of cluster members after using the portal.

7 References

Amit R and Zott C (2001) Value creation in e-business. *Strategic Management Journal*, 22: 493–520.

Kajikawa Y, Mori J and Sakata I (2012) Identifying and bridging networks in regional clusters. *Technological Forecasting and Social Change*, 79(2): 252–262.

Katz J and Aspden P (1997) Motivations for and barriers to Internet usage: results of a national public opinion survey. *Internet Research*, 7(3):170 – 188.

Kothandaraman P and Wilson DT (2001) The Future of Competition: Value-Creating Networks. *Industrial Marketing Management*, *30*(4), 379–389.

Lankton N K and Wilson E V (2007) Antecedents and Dimensions of Online Service Expecta tions. *IEEE Transactions on Engineering Management*, 54(4): 776–788.

Olson J C and Dover P A (1979) Disconfirmation of consumer expectations through product trial. *Journal of Applied Psychology*. 64(2): 179-189

Podolny J M and Page K L (1998) Network Forms of Organization. *Annual Review of Sociology*, 24(1): 57–76.

Porter M (1994) Construir as vantagens competitivas de Portugal. In *Forum para a Competitividade.* Lisboa

Porter M E (1998) Clusters and the new economics of competition. *Harvard Business Review*, 76(6): 77–90.

Porter M E (2001). Strategy and the Internet. *Harvard Business Review,* 79(3):63–78.

Yoon D, Cropp F and Cameron G (2002). Building relationships with portal users: the interplay of motivation and relational factors. *Journal of Interactive Advertising*, 3(1): 1–11.

Zeithaml V, Berry L and Parasuraman A (1993). The nature and determinants of customer expectations of service. *Journal of the Academy of Marketing Science*, 21(1): 1–12.

Activity-Based Cost Equations Systems: Extending the Predictive Power of TDABC

Santana A[1], Afonso P[2]

Abstract: Activity Based Cost Management (ABCM) systems have been presented in the literature as the most sophisticated approaches for cost management and costing purposes. Nevertheless, the theoretical relevance and practical applicability of both ABC and Time-driven ABC models is still an open question. The aim of this paper is to propose Activity-Based Cost Equations Systems (ABCES) as an extended and more powerful tool for decision making in the context of ABCM. A critical analysis of the literature on TDABC has been made in order to contextualize and discuss which developments on ABCM have been proposed recently or may be expected in the near future. ABCES is intended to be an extended version of TDABC with a focus on minimizing the problems encountered in the latter and with a particular concern in terms of applicability and a predictive vocation. A specific problem in a real context is used to illustrate the proposed approach. ABCES may support more complex mathematical formulations, cost models and algorithms for cost modelling, simulation and optimization.

Keywords: Cost Management; Costing Systems; Activity Based Costing (ABC); Time-Driven Activity Based Costing (TDABC); Activity-Based Cost Equations Systems (ABCES).

1 Introduction

Despite the advantages, TDABC has several limitations and it does not represents the ultimate solution for cost management systems. Some problems have been detected (e.g. related with measurement error) and several authors have been proposing different activity based cost models which represent extensions and developments of the initial ABC. For example, Activity Based Performance Management, Resource Consumption Accounting (Tse & Gong, 2009), Feature Based Cost Management, Efficiency Based Absorption Costing (Benjamin et al. 2009), Fuzzy Activity-Based Costing (Chansaad et al. 2012), Fuzzy Performance Focused Activity based Costing (PFABC) (Sarokolaei et al. 2013).

Indeed, the relevance and applicability of ABCM systems, in general, and TDABC, in particular, should be improved. Therefore, the aim of this article is to present and discuss the concept of Activity-Based Cost Equations Systems (ABCES) proposed by the authors as an extended and powerful tool for decision making in the context of ABCM.

ABCES extends mathematical models for cost accounting which have been proposed by scholars in the 1970s namely, by Robert Kaplan who has purposed, a few years later, ABC and more recently TDABC. It relies on several concepts such as cost matrices, cost equations and cost equations systems, among others. ABCES is analytically explained in this paper and a specific problem in a real context is used to illustrate it.

ABCES intends to complement and extend TDABC with a higher level of applicability and predictive power. Thus, take into account that the ABCES is proposed as an extension and development of TDABC, a critical analysis of the literature on the latter has been made. This literature review contextualize ABCES in terms of TDABC and highlights which developments on ABCM have been recently proposed or may be expected in the next years. The comprehensive literature review on TDABC that has been conducted resulted in a total of more than seventy papers which have critically analyzed.

1 **Alex Fabiano Bertollo Santana** (afbsantana@hotmail.com)
2 **Paulo Sérgio Lima Pereira Afonso** (psafonso@dps.uminho.pt)
Production and Systems Department. School of Engineering.
University of Minho. Campus de Azurém, 4800-058 Guimarães, Portugal.

This paper is organized as follows. Firstly, the comprehensive literature review on TDABC that has been undertaken is briefly presented and discussed. Secondly, the concept of ABCES proposed by the authors is explained. A real problem is used to illustrate its application. Several opportunities for future research are presented at the end of the paper.

2 Literature Review

A critical analysis of the literature is often used to survey the quantity and quality of articles on a topic that is considered relevant to a particular area. This type of study is important because it maps the topics and the authors involved, and in turn, researchers may contribute with their own systematization of the ideas offering new perspectives and a new understanding of the different phenomena involved.

In this case, the study that was undertaken can be considered as a critical and descriptive analysis with a qualitative and exploratory approach. According to Cassel & Symon (2004), this approach is especially relevant for cases in which the themes are emerging, in order to discuss matters with a great degree of intensity. The research was driven by theoretical pre-considerations and followed a clear process, as this allows conclusions to be drawn from the reviewed literature. Such research strategy may be classified as an archival research method within the framework for conducting and evaluating research suggested by Searcy & Mentzer (2003). The process of analysis comprised the following steps: a) Definition of the unit of analysis: the unit of analysis has been defined as a single research paper. We further delimited the material (i.e. papers) which should be analyzed considering the research scope; b) Collecting publications and delimiting the field: our literature review focused upon papers and journal articles only. To establish a time span, a starting point was set at 2004. This seems justified, as the beginning of the debate on TDABC can be traced to this period. Some important keywords such as 'TDABC, 'Time-Driven ABC', 'Time-Driven Activity Based Costing' have been used in this process but also cross-reference analysis and complementary and indirect searches have been made.

From a first final set of more than 80 articles they were selected finally a few more than 70 in order to avoid redundancies and valueless contributions. For example, some of Kaplan's and Anderson's papers were excluded because they essentially present parts of their best-seller book (Kaplan and Anderson, 2007). This work integrates and carries forward the literature on TDABC since its conceptualization. Because space limitations only a few of these papers will be mentioned in this paper but the complete list can be assessed directly from the authors.

It is important to notice that the examples of the application of TDABC presented in the literature are mainly in the domain of logistics with approximately 25 articles, followed by health related works and, finally, by the services sector. Theoretical papers just represent 14% of the total.

The review and analysis of the selected literature permitted to highlight that TDABC may offer several benefits in terms of cost management practices as it is described below, which partially corroborate Kaplan & Anderson (2007). However, also problems and limitations have been detected and are presented in the literature which ask for contributions in terms of extensions and improvements of the TDABC model.

The benefits listed in the literature justify the role that TDABC can play for the strategic management of organizations' costs. Kaplan & Anderson (2007) reported that it is an easy and simple cost model, making managers more aware of the relevant cost data for decision making. Managing costs is no longer a competitive advantage, it represents a fundamental and unavoidable activity in modern companies.

The main benefits can be summarized as follows: a) it offers speed and flexibility in the design of costing models; b) it has a broader and easier applicability, particularly in complex organizations; c) it permits a timely reporting, enabling faster feedback to managers; d) it is easy to integrate it within integrated management systems; e) it has a low cost of implementation and maintenance; f) it is for companies with complex production systems and a higher variety of products and other cost objects such as, customers, suppliers, distribution channels, etc.; g) it has a particular focus on the unused capacity.

Although there are many potential advantages and benefits related to the application of TDABC, not all the case studies presented in the literature have emphasized such positive aspects. Inversely, in some cases, authors have preferred to highlight possible problems and limitations. Most of them, represent challenges for more developed costing models based on or related to TDABC.

After ten years of TDABC, some problems and challenges have been encountered. Essentially, they are the following six aspects: there are problems in terms of measurement error, TDABC relies on the existence of homogeneous and repetitive activities, it can be biased by subjective information, time equations may be hard to be designed or too complex, it asks for structured information systems to supply the costing model, it may imply a constant review. The measurement error occur mainly in terms of time measurement accuracy due to the large volume of data that is needed to estimate time equations. On the other hand, TDABC tends to be limited to the cases characterized by pre-determined routines and activities. For some authors, TDABC may be as subjective as ABC if there is a strong overestimation bias when employees provide their time estimates for the activities performed. Furthermore, the application of TDABC in organizations characterized by several and different processes, products and activities, may be complicated as well as measuring and identifying the parameters for the time equations may be particularly difficult. TDABC demands for structured information systems and robust databases. Large companies have powerful ERP systems and the data is updated periodically. Nevertheless, in small and medium enterprises, the process of data recording and analysis is much more complicated and time consuming. Finally, this costing model asks for constant reviews and regular maintenance over time what may turn it expensive;

These problems are really important, especially because they contradict in some extent what Kaplan and Anderson (2007) have claimed. Measurement errors, subjectivity and dependence on homogeneity are the most cited problems of TDABC. Indeed, they reflect issues which are also presented in the ABC method. Yet, despite these problems, TDABC continues to be the recognized by its simplicity.

3 Activity-Based Cost Equation Systems

Cost equations represent a powerful tool for decision making and operational and strategic management particularly, in organizations characterized by complex production and business processes and those operating in very dynamic, competitive and uncertain markets, as well as public companies and large companies where cost management is critical for planning and budgeting processes – e.g. Wu et al. (2011). ABCES will allow both academics and practitioners to answer several important questions including, the cost of products, processes and activities undertaken by the company, information for the decision making related with what/if problems, make or buy decisions, the analysis of more efficient alternatives for the allocation of resources, performance analysis of the activities, minimization of costs, maximization of margins and profits, pricing strategies, budgeting exercises, etc.

To build the concept of "cost equation" we have considered the principles of both ABC and TDABC. In ABCES, the cost of products is presented through an equation where the cost of cost objects is a function of the available resources.

$$CstEq_A = \alpha_{A1} * X_1 + \alpha_{A2} * X_2 + \alpha_{A3} * X_3 + \alpha_{Ap} * X_p + \varepsilon \qquad (1)$$

$CstEq_A$ – cost equation of the cost object A (e.g. product, order, client, activity)
Xp – resource p (e.g. resource, activity) used in the production of cost object A
α_{Ap} – driver of the consumption of the resource p by the cost object A
when α_{Ap} is a normalized driver, Xp is the total amount of resource
when α_{Ap} is not a normalized driver, Xp corresponds to the resource cost driver
p – number of resources needed to produce the cost object A
ε – measurement error

Cost equations can be designed for all different types of resources behind a cost object. Thus, using the nomenclature of ABC we will have cost equations for the resources, activities, processes, products, orders, clients, etc. Cost equations are interrelated which means that a cost equations system may be developed to present a specific context namely, a production system, a business process, a company, etc. Cost equations systems translate the company in terms of costs and relationships among the different resources involved. In an ABCES model, we just have resources and cost objects and cost objects can be resources of other cost objects. Established the cost equations for the different activities and for the cost objects (e.g. products) a series of proprieties can be used to establish a direct relationship between products and resources. This happens because products consume activities and these can be expressed in terms of resources.

In a generic ABCES model of J Resources (R), I activities (A) and K Products (P), the set of equations of α_{Ap} and X_p elements is represented as follows.

$$R = \sum_{j=1}^{J} R_j \;; \qquad A = \sum_{i=1}^{I} A_i \;; P = \sum_{k=1}^{K} P_k \tag{2}$$

$$A_i = \sum_{j=1}^{J} r_{ij} \times R_j \;; \;\; P_k = \sum_{j=1}^{J} \sum_{i=1}^{I} a_{ki} \times r_{ij} \times R_j \tag{3}$$

$$\text{If } x_{kj} = \sum_{i=1}^{I} a_{ki} \times r_{ij} \text{ then } P_k = \sum_{j=1}^{J} x_{kj} \times R_j \tag{4}$$

$$\sum_{k=1}^{K} x_{ki} = 1, \ \forall i \;; \sum_{i=1}^{I} r_{ij} = 1, \ \forall j \;; \sum_{k=1}^{K} a_{ki} = 1, \ \forall i \tag{5}$$

Substituting activity costs in product cost equations, by their equivalent cost equations, we can present product cost equations in terms of resources consumption instead of activities (i.e. through the drivers $a_{ki} \times r_{ij}$). Such model can be represented as follows.

$$\begin{bmatrix} x_{11} & \cdots & x_{1J} \\ \vdots & & \vdots \\ x_{K1} & \cdots & x_{KJ} \end{bmatrix} * \begin{bmatrix} R_1 \\ : \\ \vdots \\ R_J \end{bmatrix} = \begin{bmatrix} P_1 \\ : \\ \vdots \\ P_K \end{bmatrix} \tag{6}$$

If prices and margins are included, this model can be extended as it is explained below.

$$\begin{bmatrix} x_{11} & \cdots & x_{1J} \\ \vdots & & \vdots \\ x_{K1} & \cdots & x_{KJ} \end{bmatrix} * \begin{bmatrix} R_1 \\ : \\ \vdots \\ R_J \end{bmatrix} * \begin{bmatrix} \frac{1}{Q_{P_1}} \\ : \\ \vdots \\ \frac{1}{Q_K} \end{bmatrix} * \begin{bmatrix} -1 \\ : \\ \vdots \\ -1 \end{bmatrix} + \begin{bmatrix} Price_{P_1} \\ : \\ \vdots \\ Price_{P_K} \end{bmatrix} = \begin{bmatrix} Margin_{P_1} \\ : \\ \vdots \\ Margin_{P_K} \end{bmatrix} \tag{7}$$

The cost equations represented by these matrixes show the flexibility and the potential application range of ABCES which can be used to calculate and relate product costs, margins, consumption patterns of resources and activities, etc. For example, the cost of unused capacity can be easily introduced and computed in the model considering unused capacity as a fictitious cost object. On the other hand, cost equations turn simpler the association between resources and cost objects. In this model, intermediate products can be treated as cost objects firstly and, after, be included in the cost equations of final products. Then, optimization strategies can be designed and possible scenarios and simulation exercises may be made and compared using simple heuristics or optimization methods. Next section presents an application of the ABCES and discusses the results and potential of such cost modelling approach.

4 Application

ABCES has been applied in a real context to validate its potential as decision-making tool. Thus, a case study was conducted in a medium-sized textile company located in the north of Portugal. This company has more than three decades in the market, has 75 employees and exports almost all of its products, exports are mostly to European markets, including Spain, Belgium, The Netherlands, Germany and England. The production process starts with the conversion of raw materials in an intermediate product (knitted fabrics) which is used to obtain four different categories of final products (summer pyjamas, winter pyjamas, polo shirts and undershirts). In this paper, we have opted to present the resources considering their variability, i.e. Variable Costs (VC) and Fixed Costs (FC) – respectively X_1 and X_2. Variable costs are essentially materials and fixed costs are equivalent to conversion costs. The intermediate Product (X_3) is also an input for the other products. The corresponding set of normalized equations is the following.

$$\begin{aligned} \boldsymbol{CstEq_{P1}} &= \mathbf{0,03} * \boldsymbol{X_1} + \mathbf{0,08} * \boldsymbol{X_2} + \mathbf{0,15} * \boldsymbol{X_3} \\ \boldsymbol{CstEq_{P2}} &= \mathbf{0,06} * \boldsymbol{X_1} + \mathbf{0,16} * \boldsymbol{X_2} + \mathbf{0,40} * \boldsymbol{X_3} \\ \boldsymbol{CstEq_{P3}} &= \mathbf{0,06} * \boldsymbol{X_1} + \mathbf{0,18} * \boldsymbol{X_2} + \mathbf{0,26} * \boldsymbol{X_3} \\ \boldsymbol{CstEq_{P4}} &= \mathbf{0,05} * \boldsymbol{X_1} + \mathbf{0,19} * \boldsymbol{X_2} + \mathbf{0,19} * \boldsymbol{X_3} \\ \boldsymbol{CstEq_{PI}} &= \mathbf{0,80} * \boldsymbol{X_1} + \mathbf{0,39} * \boldsymbol{X_2} + \mathbf{0,00} * \boldsymbol{X_3} \end{aligned} \tag{8}$$

Products P_1 to P_4 are, respectively, summer pyjamas, winter pyjamas, polo shirts and undershirts. P_I is the intermediate product. For space limitations, the discussion is focus on the results and these are presented using matrices. The underlying calculus and the complete cost model can be assessed directly from the authors.

$$\begin{array}{c} \text{Resources} \\ \begin{bmatrix} \mathbf{497.116} \\ \mathbf{940.067} \\ \mathbf{764.597} \end{bmatrix} \end{array} ; \quad \begin{array}{c} \text{Prod} \\ \boldsymbol{P_1} \\ \boldsymbol{P_2} \\ \boldsymbol{P_3} \\ \boldsymbol{P_4} \\ \boldsymbol{P_I} \end{array} \begin{array}{c} \begin{array}{ccc} \text{VC} & \text{FC} & \text{P}_\text{I} \end{array} \\ \begin{bmatrix} \mathbf{14.826} & \mathbf{77.882} & \mathbf{115.592} \\ \mathbf{30.170} & \mathbf{150.490} & \mathbf{304.227} \\ \mathbf{31.101} & \mathbf{164.584} & \mathbf{197.018} \\ \mathbf{23.651} & \mathbf{180.840} & \mathbf{148.760} \\ \mathbf{398.168} & \mathbf{366.271} & \mathbf{0} \end{bmatrix} \end{array} \tag{9}$$

In this case, we can integrate the fifth cost equation, equivalent to X_3, in the previous ones. The new set of cost equations is presented below.

$$\begin{aligned} \boldsymbol{CstEq_{P1}} &= \mathbf{0,150} * \boldsymbol{X_1} + \mathbf{0,1385} * \boldsymbol{X_2} \\ \boldsymbol{CstEq_{P2}} &= \mathbf{0,380} * \boldsymbol{X_1} + \mathbf{0,3160} * \boldsymbol{X_2} \\ \boldsymbol{CstEq_{P3}} &= \mathbf{0,268} * \boldsymbol{X_1} + \mathbf{0,2814} * \boldsymbol{X_2} \\ \boldsymbol{CstEq_{P4}} &= \mathbf{0,202} * \boldsymbol{X_1} + \mathbf{0,2641} * \boldsymbol{X_2} \end{aligned} \tag{10}$$

Before the application of the ABCES model, the company believed that Products 3 and 4 were the most costly. Nevertheless, Product 2 is the most expensive either in terms of materials and conversion costs. Furthermore, the computed cost information was compared with product prices and considering the quantities produced of each product, we were able to establish and compare margins by product. The results in terms of unitary product costs and margins are presented below.

$$\begin{array}{c} \\ P_1 \\ P_2 \\ P_3 \\ P_4 \end{array} \begin{array}{c} \text{Cost} \\ \begin{bmatrix} 208.317 \\ 484.936 \\ 392.730 \\ 352.271 \end{bmatrix} \end{array} ; \begin{array}{c} \text{Prod. Quant.} \\ \begin{bmatrix} 31.507 \\ 59.201 \\ 78.610 \\ 134.308 \end{bmatrix} \end{array} ; \begin{array}{c} \text{Unit Cost} \\ \begin{bmatrix} 6.61 \\ 8.19 \\ 5.00 \\ 2.62 \end{bmatrix} \end{array} ; \begin{array}{c} \text{Price} \\ \begin{bmatrix} 8.15 \\ 10.15 \\ 6.70 \\ 3.55 \end{bmatrix} \end{array} ; \begin{array}{c} \text{Margin} \\ \begin{bmatrix} 1.54 \\ 1.96 \\ 1.70 \\ 0.93 \end{bmatrix} \end{array} \tag{11}$$

These results show Product 4 as the less profitable product. Product 2 is the most costly but the price offers a very good margin. These computed unitary margins can be transformed in results considering the quantities sold. These results obtained by the ABCES model should be compared with the results presented in the Profit and Losses Statement (P&L) in order to validate the cost model.

5 Conclusions

This paper proposes the use of cost equations for cost modeling and cost optimization. A case study conducted in a textile firm was used to illustrate the proposed model. It is assumed that the use of cost equations may support the design of more flexible and dynamic costing models. Thus, ABCES may represent a powerful tool for decision making, particularly, in environments characterized by high complexity and uncertain. Also public and state owned companies as well as large companies where planning and budgeting processes ask for high quality cost information may benefit from these models. The development and application of more sophisticated costing models and systems and the use of optimization techniques are important research questions in the context of cost management. Indeed, there are important opportunities for further research on new approaches for cost modelling and cost optimization. ABCES may represent a good basis for such developments.

References

Benjamin, S. J.; Muthaiyah, S. & Marathamuthu, M. S. (2009). An Improved Methodology For Absorption Costing: Efficiency Based Absorption Costing (EBAC). The Journal of Applied Business Research. November/December. Volume 25, Nº 6.

Cassel, C. & Symon, G. (2004). Essential Guide to Qualitative Methods in Organizational Research. SAGE Publications Inc.

Chansaad; et al. (2012). A Fuzzy Time-Driven Activity-Based Costing Model in an Uncertain Manufacturing Environment. Proceedings of the Asia Pacific Industrial Engineering & Management Systems Conference.

Kaplan, R. S. & Andersen, S. R. (2007). Time-Driven Activity-Based Costing: A Simpler and More Powerful Path to Higher Profits.

Sarokolaei, M. A., Bahreini, M., & Bezenjani, F. P. (2013). Fuzzy Performance Focused Activity Based Costing (PFABC). Procedia - Social and Behavioral Sciences, 75, 346–352. doi:10.1016/j.sbspro.2013.04.039

Searcy, D.L. & Mentzer, J. T. (2003). A framework for conducting and evaluating research. Journal of Accounting Literature, 22, 130–167.

Tse, M.S.C., & Gong, M. Z. (2009). “Recognition of idle resources in time-driven activity based costing and resource consumption accounting models”, Journal of Applied Management Accounting Research, 7(2), 41–54.

Wu, X., Wang, Y., Yue, D., & Sun, Z. (2011). Modeling and error analysis of Time-Driven Activity-Based Costing. IEEE 18th International Conference on Industrial Engineering and Engineering Management, 401–405.

Analysis and implementation of the system FIFO for one production line.

Guimarães GE[1], Pedrali PC[2], Duarte LC[3], Galeazzi D[4], Campos M[5]

Abstract: The area of methods and processes responsible for the routing of the fabrication's process of items and components used in the products of the company, responsible too for the machine's programming through CNC (Computerized Numeric Command), also working in the attendance and participation in the process improvements of industrial management and in the productive process applying techniques and resources that serve this needs, also operates in the adjustment of machines and processes to the regulatory norms, in the preparation of work instructions, among other activities. The activities where it had superior involvement will be described succeeding with a short bibliographical research about the subject which will be emphasizing in this work. Occurred the elaboration of routes with use of software EMS (Enterprise Management System), drawing viewers like DWG and Teamcenter, also participating in the monitoring in industrial process management and production and manufacturing processes.

Keywords: Methods and Processes; Manufacturing; Industrial Engineering; Manufacturing routing; FIFO.

1 Introduction

Companies seek to develop competitive production structures to face challenges, this structure aims to reduce costs and increase the efficiency of production processes. Often have specialized equips in product development and manufacturing processes, but does not have the necessary attention as the way and when will be produced or how it will be controlled. In this context there are numerous philosophies and concepts of production control, and lean manufacturing as the most known and widespread in industries.

The work was carried in one private company in the area of Methods and Processes that attends to industrial engineering.

In the area of methods and processes, stand out activities like the development of manufacturing routing, creating programs using Computerized Numerical Control (CNC) for thermal cutting and shearing machines, bending and machining, the analysis of needs and resources productive with respect to equipment and processes, production performance monitoring, preparation of work instructions, training and qualification of workforce among others. In summary can be said that the methods and processes is the area of constant and full support in the production process of the company.

1 **Gil Eduardo Guimarães** (gil.guimaraes@unijui.edu.br)
DCEEng. Unijuí.
2 **Patricia Carolina Pedrali** (patricia.pedrali@unijui.edu.br)
DCEEng, Unijuí.
3 **Luiz Carlos da Silva Duarte** (lduarte@unijui.edu.br)
DCEEng, Unijui
4 **Daniel Galeazzi** (daniel.galeazzi@unijui.edu.br)
DCEEng, Unijui
5 **Manoela Jorge Campos** (manoela.campos@hotmail.com)
Engenharia de Produção, UNISEB.

2 Activities developed

Before describing the activities it is necessary to be clear what for and in what type of product these activities have been applied.

The Company receives its main raw material in various forms, mostly in metallic hot-rolled sheets, hot rolled and pickled and galvanized sheets. These sheets come in the form of reels and pre-cut sheets when the thickness exceeds 4.75 mm, it also receives metallic material in the form of cylindrical bars and finished components that are used in the assembly of the joint as screws, rollers, motors, belts, transmission chains, non-metallic components among others of lower flow. To transform the raw material into finished components, the company has many resources in manufacturing equipment, which uses modification processes like stamping, machining, heat cutting, shearing, welding, assembly and painting.

In the area of Methods and Processes activities are directed to effectively use all these resources through the work of professionals and specific activities, with the responsibility of meeting the company's interests in making the final product more lucrative as possible. To this is necessary to follow, study and adapt processes to reduce to a minimum the stages using control tools to assist in managing productivity.

Considering the above requirements, were held under the supervision of professionals some responsibility activities of the Methods and Processes department, such as: Development of manufactured items routings; Part of production processes analysis and management of production divided in different sections and monitoring in various production processes, preparation of Work Instructions, among others of minor involvement activities.

3 Description of the problem

Currently the main productive form of Kepler Weber is the form "push" [6] in some cases was implemented "pull" systems with the use of Kanban cards, but in the work centers the production happens arbitrarily by managers and operators, who often do not follow the same principles to define manufacturing priorities, causing an imbalance in the production of sets or liberation of the final product to the customer, this format "allows" that an item wait fabrication for a longer period than other items in and out of the process on the same day or shorter intervals, because of the large volume of stocks in production and the difficult interpretation of priorities for different responsible or the autonomy of the operators to define what they will do first. Another problem of the current productively is the difficulty in identifying and controlling the volume of orders for each equipment, the company works with the push production system, the stocks are inevitable, creating problems to identify priorities in the following operations.

The Company currently uses the SEM business management system (Enterprise Management System) developed by DATASUL, the system will be disabled in January 2015, coming on the SAP (Systeme, Anwendungen und Produkte in der Datenverarbeitung) system that requires a production in an orderly way according to the emission of orders dates and manufacturing orders, so the need to start resources aimed at meeting these requirements.

3.1 Process Description

The analyzed production process uses combined production system between JIT and MRP. According Slack (2009), "even though it have opposite characteristics can complement each other since they preserve their respective advantages." In this case, Kanban that is applied to items with higher demand and repeatability; the Heijunka in its alternative application, objects to the organization of the productivity according to the time available of equipment and to quickly identify or predict the time in which each request will be done; the 5S program go into this process to organize and promotion the discipline of those involved; Finally, the use of the FIFO's frame to order the priorities at high production flow equipment.

[6] In a system of planning and pushed control, activities are programmed by a central system and completed in line with the central directions, as in an MRP system. Each work center pushes the work, regardless if the next job center can use it. (Slack, 2009, p. 303)

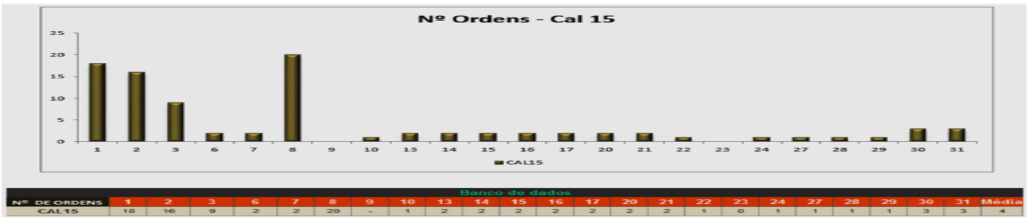
3.2 Studied Problem

Because of the versatility of print works equipment exposed in this work, there is a large concentration in the production volume, making it difficult to control the organization by date, especially when referring to PVI's 32 and 33, because it receive materials from eight different equipment of the cutting sector. Figure 6 shows the current status of material in process.

Fig.1
Material in depot waiting work in PVI's and CAL's.

The main difficulty for maintaining FIFO sequencing rule is the high Work in Process (WIP) as shown in Figure 1, hinders the separation of the material in order of arrival.

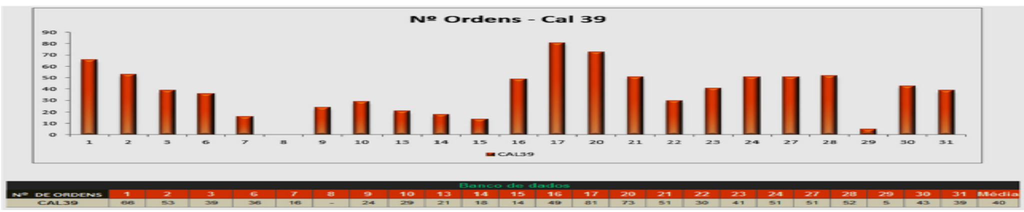
The area marked in orange is for to store material that wait to be manufacturing in the equipment PVI 16, PVI 32, PVI 33, CAL 15 and CAL 39, where it can be observed high volume of boxes and moving cars with different items and quantities, as figure 2.



Nº DE ORDENS	1	2	3	6	7	8	9	10	13	14	15	16	17	20	21	22	23	24	27	28	29	30	31	Média
CAL15	18	16	9	2	2	20	-	1	2	2	2	2	2	2	2	1	0	1	1	1	1	3	3	4

Fig.2
Graph the number of orders per day in CAL 15.

Figure 3 shows the chart of the amount of OF's daily for CAL 39 in October 2014.



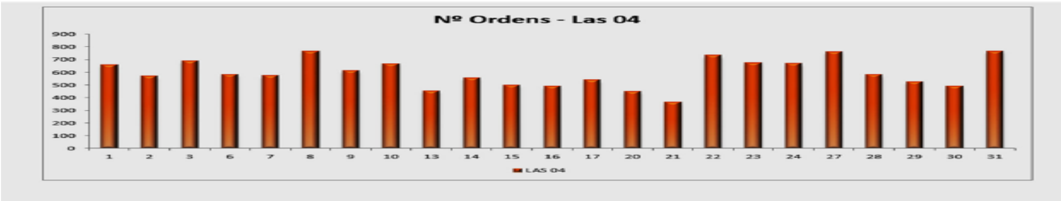
Nº DE ORDENS	1	2	3	6	7	8	9	10	13	14	15	16	17	20	21	22	23	24	27	28	29	30	31	Média
CAL39	66	53	39	36	16	-	24	29	21	18	14	49	81	73	51	30	41	51	51	52	5	43	39	40

Fig.3
Graph the number of orders per day in CAL 39.

In this equipment (CAL 39) it is possible to see in the graph a growth of the daily volume of the Manufacturing Orders processed by the equipment, reaching a daily average of 40 OF's.

In the equipment LAS 04 (laser cutting center) the daily average is 597 orders considered high value, this is the reason for the need for a sequential control system. This equipment typically produces the first operation of each item, produces pieces for later undergo other operations.

The figure 4 illustrates the OF's volume chart (Order Manufacturing) proceeds in the LAS 04 in the period that includes the month of October 2014.

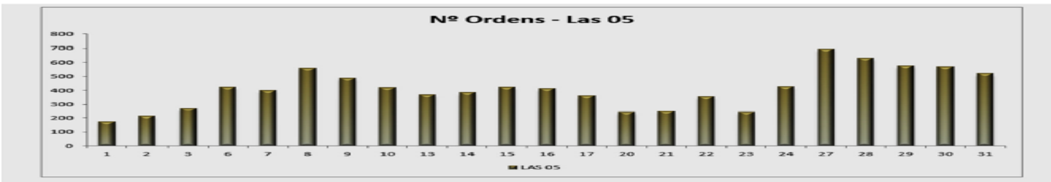


Banco de dados

Nº DE ORDENS	1	2	3	6	7	8	9	10	13	14	15	16	17	20	21	22	23	24	27	28	29	30	31	Média
LAS 04	660	572	691	586	575	768	616	669	455	559	502	491	542	452	367	736	676	671	765	583	529	492	768	597

Fig.4
Graph of the number of orders per day at 04 LAS.

Figure 5 shows the chart of OF's volume processed in the 05 LAS.

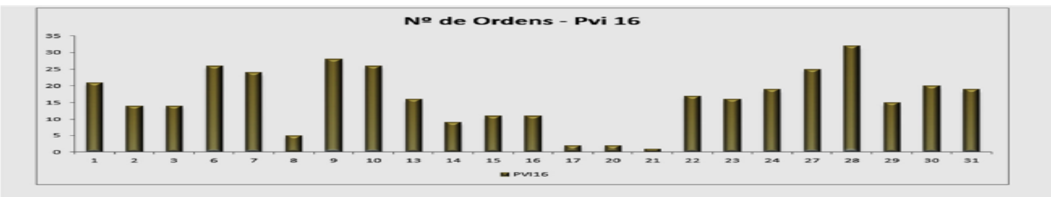


Banco de dados

Nº DE ORDENS	1	2	3	6	7	8	9	10	13	14	15	16	17	20	21	22	23	24	27	28	29	30	31	Média
LAS 05	175	215	272	426	402	560	490	420	372	387	426	415	363	243	250	358	243	429	697	632	578	569	522	411

Fig.5
Graph of the number of orders per day at 05 LAS.

In the equipment (LAS 05), the volume is also considered high, demanding good elaborated control system, requiring some adjustments for using the same system equipment with volumes considered low. As shown in the graph of the Figure 6 of OF's volume processed in the PVI 16.



Banco de dados

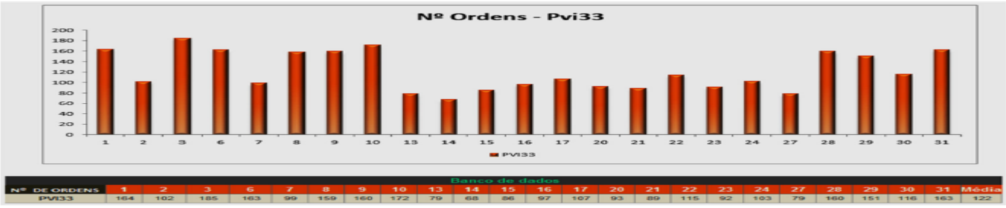
Nº DE ORDENS	1	2	3	6	7	8	9	10	13	14	15	16	17	20	21	22	23	24	27	28	29	30	31	Média
PVI16	21	14	14	26	24	5	28	26	16	9	11	11	2	2	1	17	16	19	25	32	15	20	19	16

Fig.6
Graph of the number of orders per day at 16 PVI.

For PVI 32 the average of 61 daily orders is considered high because these orders arrive in boxes and moving carts from different supplier workstations.

Figure 7 shows the graphic of the volume of OF's processed in the ISP 33, this equipment has an average of 122 daily manufacturing orders. The volume is considered high for this equipment, added to the other pieces that divide storage box, make difficult to control the sequence by dates without a system to assist in this ordering currently made by the movers seeking overdue lists the priorities, but are not always followed, consequently creating new lists.

Generally it can be observed that there is a high flow of manufacturing orders in this sector, considering other equipment that are not contemplated in this study, the volume is even superior so is inevitable delays when not appropriately controlled.



Nº DE ORDENS	1	2	3	6	7	8	9	10	13	14	15	16	17	20	21	22	23	24	27	28	29	30	31	Média
PVI33	164	102	185	163	99	159	160	172	79	68	86	97	107	93	89	115	92	103	79	160	151	116	163	122

Fig.7
Graph of the number of orders per day at PVI 33.

Aiming at adapt the FIFO control system to the needs and characteristics of the sector, will have to be done a separation by box or car as a single volume and represent them in the table by the number of a "guide order" elected by the location criterion by the person who will do this control, another difficulty encountered in the implementation was the understanding of the benefits provided by the sequential control FIFO and the real use of this resource by operators.

Considering that the items in the boxes are from the same work and carrying the same material and manufacturing dates, we can determine that all orders fit into the same priority. It may be noted the large volume of production orders in a single box where was used the number of the order that is marked with green label to represent this volume in the FIFO table.

In the laser cutting equipment, the implementation was not very problematic, because the number of volumes of raw materials is lower. For the material that supplies the LAS 04 and LAS 05, the ordering of the FIFO frame was identified by the job number generated by the program and that came with the material, the previous image is highlighted the programming card which has the job as identification.

4 Results and Conclusions

Was followed the use of the FIFO table during an evaluation period that lasted one week, in this period could be observed some positive results when used correctly, the maximum delay in the OF was three days in this period in all equipment, which confirms the idea of sequential control FIFO. But was very difficult to preserve the sequencing of the table, because the movers forgot to use it, this caused great inconvenience to locate materials misidentified or that had already been made and not removed of the sequencing, having to reorganize or check every day in this week.

As the valuation of the work done by the FIFO table, was randomly chosen two days of August (before FIFO's implantation) and two days of November (after FIFO) to compare results, was observed a reduction in average delays. The figure 8 shows comparative chart with this information, which is on the vertical axis the number of orders and the horizontal axis the number of delays.

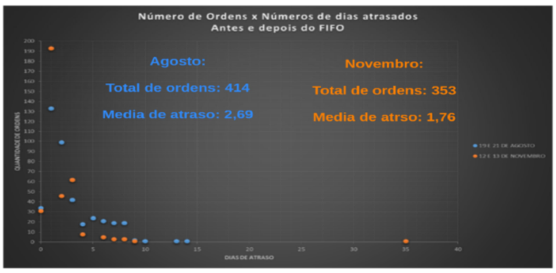


Fig.8
Graph comparing before and after FIFO's implantation.

As a positive result, also can be mentioned the assistance in the fast visual identification of the condition of material stocks in all equipment that has been implemented this tool in one place, so could be compared to decide about priorities, taking care to keep the sequential control FIFO.

The planning of processes will become economic and precise the operations as much as the efficiency of the methods used and the technological and organizational knowledge of the people hired for these activities.

References

SLACK, Nigel; CHAMBERS, Stuart; JOHNSTON, Robert. Administração da produção. 2 e 3 ed. São Paulo: Atlas, 2002 e 2009.

MANHABOSCO, Mariano Kirchner. Manufatura enxuta: Aplicação de suas ferramentas no processo produtivo. 2009. Trabalho de conclusão de curso (Curso de Engenharia Mecânica) – Universidade regional do noroeste do Rio Grande do Sul – UNIJUI.

Processos produtivos + Lean + Visão sistêmica. A casa do STP. Disponível em: <http://davidkond.wordpress.com/2010/06/28/casastp/>. Acessado em: 03 nov. 2014.

Improvement in the fabrication process and adjustment to the norm NR-12 of a platform of bucket's elevators

Campos M[1], Guimarães GE[2], Pedrali PC[3], Duarte LC[4], Galeazzi D[5]

Abstract: The current study will present an adjustment project of the norm NR-12 of a platform of bucket's elevators. The project is outdated in respect to fabrication process and also do not attend the requirement of the technical norm of security. An analysis will be realized, identifying and correcting occasional problems adjustting them to the nr-12 requirements, looking for the lower costs and the maximum utilization of production. Applying those improvements will be checked if the project methodology fulfilled the requirements of the work.

Keywords: NR-12; work security; bucket's elevator; project of platform; agro-business.

1 Introduction

The security's norms in transporter's equipment of grains are not recent, but were never observed in development of the products.

The purpose of this project is to facilitate the production's process and to adjust to the norm NR-12 the platform of bucket's elevators. The project is outdated in respect to fabrication process and also do not attend the requirement of the technical norm of security. An analysis will be realized to improve, and verify if achieve the requirements of the work.

The quick growth in the agricultural market and replacement's pieces makes necessary improve projects to facilitate the production and turn faster the delivery, in addition to adjust parts of equipment to have more secure in the utilization.

2 Methodology

Studies and activities related directly to the segment of pieces and agribusiness's equipment were developed, aiming to mature a project that makes simple the production and is a part of equipment appropriate to NR-12. Were performed the following analyses:

- Analysis of actual project;
- Analysis of fabrication process;
- Analysis of costs;

1 **Manoela Jorge Campos** (manoela.campos@hotmail.com)
Engenharia de Produção, UNISEB.
2 **Gil Eduardo Guimarães** (gil.guimaraes@unijui.edu.br)
DCEEng. Unijuí.
3 **Patricia Carolina Pedrali** (patricia.pedrali@unijui.edu.br)
DCEEng, Unijuí.
4 **Luiz Carlos da Silva Duarte** (lduarte@unijui.edu.br)
DCEEng, Unijui
5 **Daniel Galeazzi** (daniel.galeazzi@unijui.edu.br)
DCEEng, Unijui

2.1 Presentation of existent project

The platform of inspection and maintenance of the bucket's elevators of the company X was first projected to be produced in welded modules, according to the figure 1, with metal floor produced in the company and posteriorly fixed on the modules with screw self-perforates.

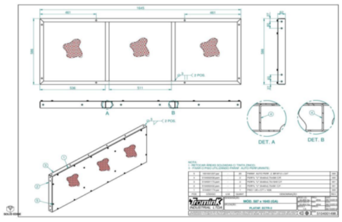


Fig.1
Welded modules platform of inspection and maintenance.

After the modulation of the structure of the platform is fixed the screwed pillars in the lateral of the welded modules, then the tubes of the handrail are fixed and posteriorly the baseboard, according to the figure 2. So is mounted the platform of the bucket's elevator.

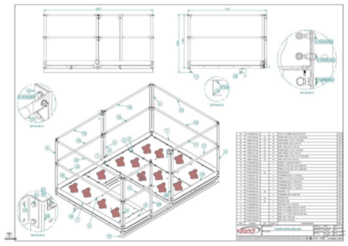


Fig.2
Complex of the platform.

2.2 Project's proposal

Attending to both principals objectives proposed in the work that are the adaptation to NR-12[6] and the improve in the production process was developed the concept of a module that compose the platform without use the solder.

Consisting of a metal sheet perforated fabricated in the company that attend the requirement of the norm about being antiskid, with reinforcement's plait that serves like substitution to the existent module, according the figure 3 below.

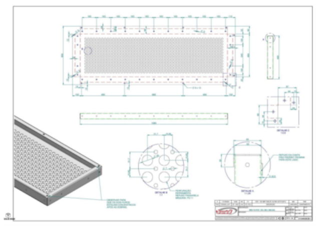


Fig.3
Proposal module.

[6] The norm NR-12 and the appendage, actualized in 12/11/2013, define technical references and protection measures to guarantee the health and physical integrity of the workers and establish minimum requirement to prevent accidents and occupational diseases in the project's phases and the machine's utilization and all kind of equipment.

The 12.122 paragraph in the item a) determine that the yellow should be used in fixed and moveable protections.

Subsequently the elaboration of the antiskid floor module was elaborated a sustentation's structure of the whole platform. This structure is made of two folded profiles screwed, it is not necessary to use solder to do any union. This profile's structure can be observed in the figure 4.

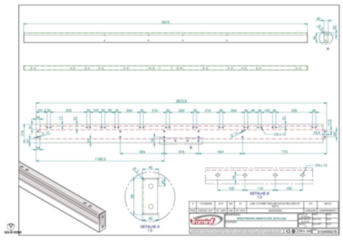


Fig.4
profile's structure and support.

The fixing pillars of the handrail's tubes and the fixing baseboards were reviewed too and actualized during the elaboration of the new project, both have symmetric inserts what permitted that the piece was used in any position.

The baseboards were changed too, the height was increased in function of the norm established, and the material used had to be modified to make possible to paint yellow the finishing.

Finally the handrail's tubes had the material changed too to make possible to paint according the security norm established, this changes can be observed in the figure 5.

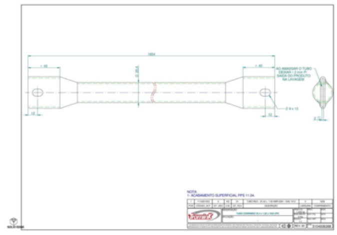


Fig.5
handrail's tube.

At last all the components can be mounted using hexagonal screws, the platform was designed to be symmetric, the work area can be mounted to the right side or to the left side using the same pieces, according the figure 6.

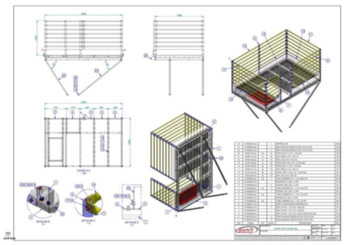


Fig.6
Mounted platform.

2.3 Cost's analyses

Before explore the costs is important to mention facts that were not mentioned until now, the first one is the area's size of the older platform and the new model.

The older platform had a total area of 3,98 m², while the new one has a total area of 4,51 m².This alteration in the utilization area of the platform occurred to turn the verification and maintenance activities more secure for the worker.

The second item to be observed is the quantity of handrails that the actual project presents. The new model has seven sets while the older model had only two.

This increment is not established by the regulative NR-12 norm, the norm only establish the utilization of crossbar higher to 1,2 meters of the floor and the second crossbar 0,7 meters of the floor.

The increase in the quantity is because several of renowned clients in the area of grain's storage requested this, so the company decided to turn this rule in a standard to the elevator's platform. However it can be retired in case of a client's request, without causing any damage at the new project

With that reservation about both specific points is possible to say, examining critically the areas of the new model and the older one, the new model is about 10% more expensive.

The area is bigger and the quantity of handrail's tubes was increased, in addition the special yellow painting requested by the norm. The cost/benefit analysis suggests that this increase in the costs is not representative because the security provided is priceless.

2.4 Prototype

Finished the project's work, one platform was produced and this prototype was mounted in the company to verify if was heeding the requisites that were thought during the project's phase, according the figure 7 below.

Fig.7
Mounted prototype.

In the figure 7 is possible observe the mounting's detail of the baseboards, and also the quality of the antiskid floor. A reservation should be done because in the prototype was not applied a yellow painting in the baseboard and in the handrail's tube like the norm requires, because this is only a mounting verification. In the figure 8 below is possible verify the mounting of the handrail's tube in the pillar.

Fig.8
Detail of the handrail's tube.

Another detail that can be observed is the rigidity and security of the structure that support all the platform, it was executed thinking in connect the sustentation profile, the floor and the pillar that supports the handrail's tube and the baseboard. It is not necessary to use solder to do any union because it will be made by hexagonal screws, what turns the production process easier. The figure 9 below shows this union.

Fig.9
Facilitation of the Mounting by screws.

With the prototype fabrication was possible verify in practice all that was thought and projected for the elaboration of the new concept. Was observed too that a good project and a good case study can bring great results.

The prototype demonstrate how the mounting of the platform is now practical, and testing the platform could be observed the security feeling that it transmits to the user in confrontation with the older model.

2.5 Installation

The next step after the prototype fabrication was the homologation by the engineering. After all this process the next step was the fabrication and application of the first platforms in practice. The figure 10 below shows the use in clients that bought an elevator with new concept of the inspection platform.

Fig.10
Installed platform in client.

The figure 10 demonstrate the need of yellow painting according the norm's requisite, this painting should be realized in the fixed and moveable protection's parts and serves to alert the user about the risks.

Another point that should be accentuated in the figure 10 is the importance that the platform has for the user, in consideration that in most cases the elevator is used with heights ranging between 30 and 40 meters, and a fall is fatal. This is the reason for the project consider all that the norm establish, and was developed and thought to provide the maximum of security to all users.

2.6 Another IPEs

For the knowledge and information about the bucket's elevator X, is not only the platform according to the norm that provides more security to its users.

Other aspects that provide security in this equipment are:

- Access stair step to the platform with antiskid surface;
- Guardrails since the floor until the access to the platform, according to the norm;
- Safety line with steel cable since the floor until the platform;
- Protection system against falls coupled to the safety line;
- Complete sealing of the moveable parts of the elevator;

All these items makes the bucket's elevator more safe for the utilization and demonstrate the company's preoccupation in furnish to the clients equipment capable of realize the tasks for which they were designed also provide resources to preserve the health and promote the safety of all its users.

3 Conclusions

Always is possible improve products by study and analysis, attending the needs of the clients and the needs of the company.

About the objectives proposed by the stage, the actual project analysis, manufacturing process analysis and cost analysis can be affirmed that all items were realized satisfactorily.

The analysis of the existent project was important to comprehend that the concepts used in this model were surpassed and a change was necessary for the establishment of a new concept. This new concept was not made by only one idea, was result of an entirety of improvements that were proposed and analyzed to turn possible to make a choice of the best project done.

Other important phase was the analysis of the production process, with a focus in eliminate, where was possible, the utilization of welded components, this because the welding process is very toxic to the worker by virtue of the emitted gases. This factor was very significant in the elaboration of the new propose.

Finally the cost's analysis exposed that is not always possible to change existents concepts trying to reduce costs, sometimes is necessary to abstain of this idea because of a better result, in this case, the health and security of all involved people, since the production until the utilization.

4 References

WEBER, Érico. Armazenagem Agrícola. Livraria e Editora Agropecuária, 2001.

NR 12 – Segurança no Trabalho em Máquinas e Equipamentos.

Total Cost of Ownership in the Context of Supply Chain Management: an Instructional Case

Afonso P[1], **Leite S**[2]

Abstract: This paper presents and discusses an in-class exercise on Total Cost of Ownership (TCO). TCO can be included within the Supply Chain Cost Management (SCCM) framework being essentially a tool that aims to determine the true cost of buying from a specific supplier. There are some references in the literature on TCO but its dissemination in the industry has been very slow. Thus, it is important to develop and implement case studies and instructional cases to promote and disseminate this technique among both academics and practitioners. Indeed, research supports the assumption that students have varying learning styles which can be supported better by other pedagogical techniques than typical lecturing. The case presented here represents an original instrument for the understanding and dissemination of TCO. The case design and materials used are explained and discussed. This case has been applied in the format of short course but it can also be used in class in a program of several weeks. The results obtained demonstrate that this in-class exercise can be used to involve students or practitioners in a dynamic process of learning and discussion on supplier cost management.

Keywords: Total Cost of Ownership (TCO); Supply Chain Cost Management; Suppliers Management; Case Study, Instructional Case.

1 Introduction

The costs with materials and components is one of the most important for most companies and they represent a significant portion of production costs. In many industries, the costs that reflect the purchasing function represent between 50% and 90% of the production cost. Furthermore, the selection of a supplier should not be made taking, as the unique criterion of reference, the price of the goods purchased. Companies understood that they should select the best supplier, and the best supplier may not necessarily be the one that sells at the lowest price. There are other significant costs beyond the price of the material or component such as: transportation costs, costs of non-quality and non-compliance, delivery delays, costs in the after-sales service, etc. The literature also addressed various monetary and non-monetary criteria, such as risk, quality, and reliability of deliveries, performance track record and the financial position of supplier. Thus, the selection of suppliers should include, in addition to prices, a wide range of quantitative and qualitative parameters. In fact, the exaggerated focus on acquisition costs that prevailed for many years resulted in many hidden costs or future costs which have been affecting corporate profits without a clear understanding of such situation.

Purchasing plays an important role in the competitiveness of companies and, therefore, there are several methods for the selection of suppliers, based on different selection criteria. Among the existing methods, they may be highlighted the Total Cost of Ownership (TCO), the Life-Cycle Costing (LCC), the Zero-Based Pricing and the Cost-Based Supplier Performance Evaluation. The life-cycle costing considers the purchase price and the costs the organization incurs to use, operate and maintain, and finally the disposal costs of a particular asset, that is, has a focus on the costs that occur after the moment of purchasing. The zero-based pricing and the cost-based supplier performance evaluation are two methods that consider the

1 **Paulo Sérgio Lima Pereira Afonso** (psafonso@dps.uminho.pt)
Production and Systems Department. School of Engineering.
University of Minho. Campus de Azurém, 4800-058 Guimarães, Portugal.

2 **Maria Silene Alexandre Leite** (leite@ct.ufpb.br)
Production Engineering Department. Technology Centre.
Federal University of Paraíba, University City, 58051-900 João Pessoa, Brazil.

total costs of suppliers. These methods give special attention to the cost of "doing business" with a particular supplier, i.e. costs prior to purchasing.

The Total Cost of Ownership (TCO) approach considers additional costs such as expenses on the implementation of an order, costs with searching activities and qualification of the supplier, transportation costs, insurance costs, warranties, product inspection and quality costs, replacement possibilities, downtime caused by failures, etc.

Furthermore, the TCO is a methodology used to determine the true cost of buying a particular good or service from a specific supplier, accounting for that all the costs associated using a monetary valuation of all relevant financial and non-financial attributes, for example quality considerations (Ellram, 1995). According to Ferrin and Plank (2002), the Total Cost of Ownership (TCO) is a methodology used in leading companies in worldwide supply chains aiming to determine the true cost of buying a particular good or service from a particular supplier, accounting for it all costs associated with the purchasing activity (Degraeve et al., 2005), using the monetary quantification of all financial and non-financial attributes (Morssinkhof et al., 2011). According to Dickson (1966), the main criteria to be considered in selecting a supplier are: quality, delivery, performance history, warranties and claims policies, supplier facilities and production capacity, price, technical capability, financial position, performance procedures, communication systems, reputation and position in the industry, degree of commitment to the business, management and organizational capacity, level of operational control, capabilities in terms of repairing services, location, level of training and existence of reciprocal agreements.

The exercise presented here represents an original instrument for the teaching, understanding and dissemi-nation of TCO practices. It can be used to involve students or practitioners in a dynamic process where participants should understand and apply this cost management technique. The instrument presented in this article intends to complements previous published research and case studies on TCO. It is an exercise that has embedded a series of important concepts which go beyond the current or common understating of TCO.

One class of students has been used to test this instructional case. A short approach of 240 minutes has been designed and applied in the ENEGEP 2014. Thirty five students have participated in this exercise. This article presents and discusses this instructional case. Furthermore, some managerial implications and opportunities for improvements are discussed. In fact, this research work offers a basis for further replications in a classroom setting and it can be also used to demonstrate the features of TCO to an audience of students or practitioners.

3 Methodology

The traditional lecture method is still extensively used in classrooms primarily because it is cost-effective, useful for passing on large amounts of information quickly, and presents a minimum threat to students in the sense that they do not need to participate in the process (Beegle and Coffee, 1991). Nevertheless, research in higher education (Silberman, 1996) and business education (Salemi, 2002) shows that effective instructors select strategies that involve students as active participants in the learning process and use a variety of teaching methods and presentation skills to stimulate interest in the subject matter. Further research supports the theory that students learn in a variety of ways; that is, students have varying learning styles and a significant number have learning styles best suited with pedagogical techniques other than lecturing (O'Connor, 1999).

This exercise was design to be used as an instrument to explain TCO. It simulates the application of TCO using a real case. All the steps and considerations about TCO are explained in a dynamic process where the participants participate in an iterative process guided by the teacher or by who is responsible for the implementation of the case. The exercise can be a team-based exercise or it can be solved individually. Previous knowledge on TCO and active learning exercises and games is not a requirement or condition but it is important.

In the exercise it is required the computation of TCO using a spreadsheet model and participants are asked to make decisions considering simulated TCO outputs.

The exercise begins just after the definition of the main concepts related with TCO, Supply Chain Cost Management, Suppliers Selection and Management and the Fundamentals of Cost Accounting and Management. The conditions for the computation of TCO are explained through an example which is used to guide participants in the use of the TCO model built in spreadsheets. Each student or team receives a kit including several documents and the spreadsheet model. A set of questions and a guide for the teacher has been also produced. The questions can be grouped and presented into different "output-sheets" which can be given successively.

4 Application of the Instructional Case

The instructional case that has been developed follows a well-defined set of steps and a process which can be managed by the teacher. Figure 1 shows these steps indicating the objectives of each of them, the time set for the different tasks, the inputs or material of each phase and the outputs which are expected to be generated. These phases follow the typical teaching case study approach (e.g. the Harvard case study method). Teaching case studies are designed to give a deep understanding and virtual contact with real life situations. They support teaching methods in the most of business schools since the pioneer example of Harvard University and have been introduced with success in other areas namely, in industrial engineering schools.

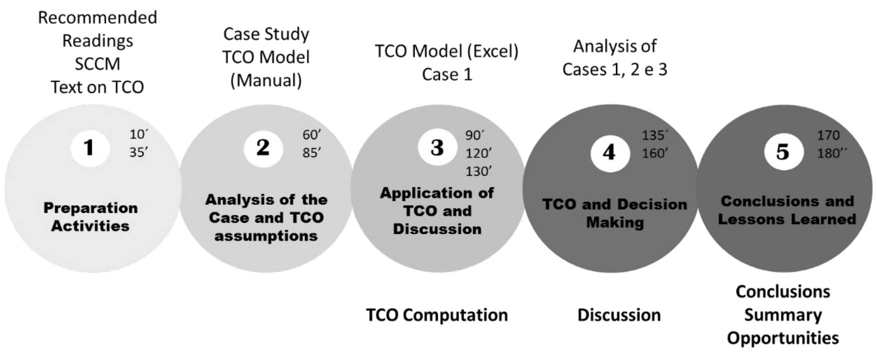


Fig.1
The Five Phases of the Instructional Case.

The case study is supported by several materials namely 1) recommended readings, 2) the case study, 3) the TCO model developed in a spreadsheet, and 4) material for the teacher. The suggested readings have a focus on several concise texts that students have to read before each phase. Six different short documents have been produced to support the instructional case. Participants should go through these documents following the rules defined by the exercise.

Firstly, a concise definition of several fundamental concepts such as Supply Chain Management, Supply Chain Cost Management and Supplier Cost Management is provided. This moment may be used by the teacher to promote some debate or simply to clarify and define concepts and assumptions. After that, students will be more prepared to make the readings on TCO and only after those readings they will be asked to learn about how they can compute the TCO. Fourteen questions have been produced to guide the instructional case in each of the different phases and to turn the case an iterative process where students are able to learn the concepts behind TCO and how they can compute it. At the end of the learning process, participants will be asked to discuss the results of different situations which will be presented to them (e.g. comparing the TCO of national suppliers, comparing national and foreign suppliers, etc.).

The TCO tool presented in the case requires inputs from four different levels: at a global level (i.e. at the company level), at the level of the business unit (does not contain figures), at the factory level and finally, at the project level. The first levels are reviewed periodically but they affect equally all projects. The project level is the one that lead to differences in the computation of the TCO. It includes the following data entry fields: project details, supplier information, order costs, shipping costs, inventory costs, supplier's appointment costs, quality costs, other costs.

The company's logistics department developed a document to help the users of the TCO software where we can find typical values for logistics data such as: transportation costs, conditions of shipping, type of stock and inspection procedures.

After the introduction of all inputs, the software produces a detailed TCO for each of the first three years of the project as well as overall results of the TCO for the entire project in the format of tables and graphs. Figure 2 shows the result obtained with the introduction of the data related to Case 1. This case considers a part with a total production volume of 700.000 unities. Three potential suppliers were selected for quotation. All of them are national suppliers. These suppliers have presented a quotation for the supply of this part and it was possible to proceed to calculate the TCO.

Students have used the TCO tool presented in spreadsheets developed for this teaching case study. This model explains the computation of TCO and simulates a TCO software offering a very real experience. This tool is structured in eleven different worksheets: suppliers database, project details, information about the selected suppliers, order costs (e.g. part 's price, tooling), shipping costs, inventory costs, nomination costs, quality costs, other costs, output (TCO Table) and output (TCO Graph). The last two worksheets (output) present the results and are automatically produced according to the data entered previously.

Figure 2 represents the TCO of Case 1 on which is visually evident the weight of the different cost components and the cost structure of buying from the three potential suppliers.

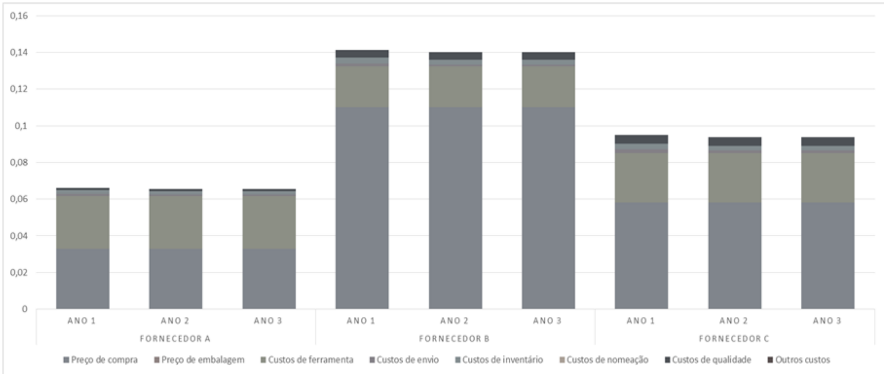


Fig.2
Detailed TCO.

As Figure 2 shows, the results of the TCO are grouped into 8 classes which permits to have a deep understanding of the influence of the different cost items in the computation of TCO: purchase price, price of packaging, tooling costs, shipping costs, inventory costs, appointment costs, quality costs and other costs.

The TCO tool developed for this instructional case and the different cases allow participants to become familiar with the TCO and offer them the opportunity of using a model similar to a real TCO software. Furthermore, participants are asked to analyze and discuss some aspects related to the implementation of the TCO and to interpret the results obtained in different situations.

5 Discussion

The analysis and discussion is one of the most important aspects of an instructional case. In this case, all the questions used to support the case are important but especially the final questions which request analysis and discussion after the computation of the TCO. For example, in Question 10, participants are asked to comment the fundamental principle of TCO that states that “the cheapest supplier may not be the one with the lowest purchase cost." In fact, in the cases presented (which represent the most common situations in the company that provided the basis for the design of this case) the lowest TCO coincides with the lower purchase cost. Then, we can question the interest of TCO which is a detailed approach and a very demanding process in terms of cost calculation if this lead to the same results that would be easily obtained only by comparing the price of the parts.

Indeed, the TCO is not only important to select the supplier that represents the lowest cost to the company. TCO is also important to know more and understand the costs associated with suppliers in order to give to the buyer a better bargaining position and support a more effective managing of supplier’s related costs. In fact, as it can be seen also from Question 12, despite that purchasing cost represents a significant portion of the total computed cost, the calculation of TCO is important to show the real dimension of the cost of buying from a particular supplier. In the cases that have been studied, the TCO (total cost) is between 1.5 to more than 3 times the purchase cost. Therefore, other costs beyond the purchase cost are (very) important and must be managed properly.

In Case 2, three national suppliers are compared with an Asian supplier. The supplier with lower TCO is simultaneously the one with the lower price per unity. However, it is clear that the global cost goes far beyond the acquisition price. Indeed, the total costs of providing this part is equivalent to a value between 2 to 3 times the acquisition costs. The cost of the part is the most significant cost item but in all the cases, such costs are less than 50 % of total cost. With an accurate perspective of the TCO, the company can track and find more cost-reduction opportunities. Table 1 shows these cases.

Table 1
TCO vs Acquisition Costs.

	Supplier A	Supplier B	Supplier C	Supplier D
Acquisition Costs (€)	0,4794	0,2419	0,2310	0,2431
TCO (€)	1,1563	0,7434	0,5148	0,5115
TCO/Part's price	2,4	3,1	2,2	2,1

Another important aspect is that the TCO permits to detail the components of the total cost, and such information can be used to negotiate cost reductions in new rounds of request for quotation. In fact, it was what has happened in Case 2, in which suppliers C and D have presented very similar values in a first round of quotations. The company has selected Supplier C and TCO information highlighted some opportunities for cost reduction and improvements.

TCO has evident advantages and contributes positively for a better management of suppliers' costs. However, it can be complicate to implement because requires very detailed information and some of that information may be subjective (e.g. quality costs), estimated with a high degree of uncertainty or difficult to obtain. In these cases, the TCO can be used to identify the most relevant cost items which can be used to compute a proxy of the TCO based on the most relevant cost items. For example, in the cases presented before, the purchase price and tooling costs represent more than 90% of overall costs, being the inventory the third most significant cost element. The remaining items weigh little in TCO and the decision making could focus on these three main items.

Some final considerations can be made. Firstly, this exercise can be proposed to students with more or less additional or previous teaching material on TCO. This material can be based on several readings or previous lessons. Thus, the exercise can be used to test students' knowledge on these issues or it can be used in an earlier stage. Nevertheless, this exercise was designed and applied considering the first approach. This case requires 360-minute classes. A shorter approach of 240 minutes has been designed and applied in the ENEGEP 2014. Furthermore, it may be also presented in several weeks in a different number of classes or, alternatively, as a take-home exercise with subsequent discussion in class which may include oral presentations or not. This instructional case may be developed individually or by a team of students or other participants. Each participant or team may be asked to answer to all the questions or different questions may be answered by different teams. On the other hand, the results obtained by each team can be measured and a score could be given. The different teams may also be grouped differentially, e.g. one could be for example a buyer, the others, 1st tier suppliers and even 2nd tier suppliers could be considered. Some of the suppliers (i.e. teams) can be involved earlier or later in the buyer's new product development process, being the TCO an important tool to manage the buyer-supplier relationship in such contexts.

During the exercise it was allowed full access to the teaching material. In this exercise it is not necessary that participants are comfortable with the main concepts and techniques of TCO. However, if students have been exposed to TCO, the classroom exercise could be more effective. The time that has been taken to complete each of the outputs should be controlled and recorded in order to determine both the development and the difficult level of each output purposed.

6 Conclusions

This article presents an instructional case and discusses it. It offers a basis for further replications in a classroom setting and also can be used to demonstrate the features of TCO in the context of SCCM activities to an audience of practitioners. Academics and professionals concerned with cost management with suppliers, supply chain cost management and TCO will find this exercise useful. This exercise describes the concepts and techniques of TCO in a user-friendly, in-class activity. In fact, engaging students in such kind of exercises help them to understand and appreciate the concepts involved. Students expressed their appreciation about the exercise and commented that it motivated them throughout the learning process. Two lines of further work can be expected. Firstly, this exercise can be replicated to different audiences of students or practitioners. Secondly, the exercise itself and the methodology may be improved and extended.

7 References

Beegle J, Coffee D (1991) Accounting instructors' perceptions of how they teach versus how they were taught. Journal of Education for Business, 67(2), 90–94

Degraeve Z, Doveren B (2005) The use of total cost of ownership for strategic procurement: a company-wide management information system. Journal of the Operational Research Society, 51-59.

Dickson G.W (1966) An analysis of vendor selection systems and decisions. Journal of Purchasing, 2(1), 5-17

Ellram L (1995) Total cost of ownership: An analysis approach for purchasing. International Journal of Physical Distribution & Logistics Management, 25(8), 4-23

Ferrin B, Plank, R (2002) Total cost of Ownership Models: An Exploratory Study. Journal of Supply Chain Management, 38(2), 18-29

Morssinkhof S, Wouters M, Warlop L (2011) Effects of providing total cost of ownership information on attribute weights in purchasing decisions. Journal of Purchasing & Supply Management, 17 (2), 132-142

O'Connor, T. (1999). Using learning styles to adapt technology for higher education. Indiana State University Center for Teaching and Learning

Salemi M (2002) An Illustrated Case for Active Learning, Southern Economic Journal, 68(3), 721–731.

Silberman, L. (1996). Active learning, 101 strategies to teach any subject. Boston: Allyn and Bacon.

Modelling and simulation of inventory level control in service operations management

Gibelati E[1], **Pereira F**[2]

Abstract: A discrete event simulation is one of the most used techniques in the field of operations research. It is a technique to support the decision, in which the search for a problem solution is performed by analysis of a computational model that describes the behavior of the system under study. Applications of this technique are found in several areas with very significant results. Building a model of discrete event simulation in planning the amount of material is presented in this work. The main objective is the definition of the ideal inventory level for a material at a distribution center. To this end, we propose the development of a modelling and simulation in computer system Arena of a service company supply chain. The construction of the model follows the usual steps of project planning and construction of the conceptual model. With the simulation it is possible to follow the evolution of the model variables, related or not to the queues, observe the conditions under which rupture or excess inventory occur and identify the best option for a given scenario of demand and sales forecast.

Keywords: Discrete event simulation, supply chain management, Inventory management, modelling.

1 Introduction

The discrete event simulation is one of the most used techniques in operational research area. This is a technical decision support, in which the search for the solution of a problem in the analysis of a computational model that describes the behavior of the system under study. Applications of discrete event simulation are found in several areas such as: engineering, finance, supply chain, among others, with very significant results (Aguilar et al, 2009; Hernandez and Librantz, 2013).

However there are still lacks of studies in many areas, especially in service operations. The management operations and services comprises a set of activities that transform inputs (resources) on goods and services (products) demanded by consumers. Such activities occur in all organizations. The following aspects are involved: a) the definition of the strategic objectives; b) technical or quantitative tools used and c) the management of human resources. In the current environment, operations management services and interacts with other functions such as engineering, marketing and finance, assisting the organization in meeting its strategic objectives (Martins, 2000).

The service and operation company stock sizing can be considered similar to an industry. Therefore applications of modelling and simulation used by industries can also be applied in service operations.

In practice, the discrete event simulation can help in the decision-making process by assessing the adequacy of possible solutions to a given problem. Therefore, obtained by simulation information can be used, for example, in an inventory sizing process in managing the supply chain.

In this sense, the goal of this work is to create a simulation model covering the fundamentals of the inventory design process in supply chain, in order to ideal days of stock definition of materials a distribution center. To achieve this goal we develop a modelling and simulation in the computer system Arena®, the supply chain of a service company, as part of a case study in the company Sky Brazil®.

1 **Elizângela de Jesus Gibelati** (elizangela.gibelati@sky.com.br)
Master Student of Master's Program in Production Engineering
Universidade Nove de Julho – UNINOVE. São Paulo – Brazil.

2 **Fabio Henrique Pereira** (fabiohp@uninove.br)
Teacher / Researcher | Master's Program in Production Engineering
Universidade Nove de Julho – UNINOVE. São Paulo – Brazil.

2 Literature Review

Although it represents a very important issue, since the lack or excess materials in stock incur unnecessary costs, this topic is still largely unexplored when considering applications in service operations systems.

In the studies no deal directly with the subject proposed by this article. Studies for inventory management have only one part and discussions of other topics such as, inventory planning models or analysis of some variables that influence in management. In the supply chain there are many variables, but some may be more significant in inventory management, which can interfere directly in the planning. In this aspect, Santoro e Freire (2008) state that the choice between stock models helps decision making based on several variables such as demand forecasting, sales history, amount of purchase orders.

However, the variables of a service operation may be different from those considered in an industry, as there are business features and each service branch also has their characteristics.

On the other hand there are few studies from the perspective of a service operation with respect to the use of modeling and simulation. There were no items with the complete concept to model and simulate several variables that affect the planning of a distribution center from the perspective of a service company.

Sakurada e Miyake (2009) describe the use of discrete-event simulation for service operations, analyze how the modeling process varies according to each type of service analysis and concludes that the simulation technology developments and the even simulation software must evolve to incorporate the ability to represent a more complete range of elements and relationships involved in service processes.

In modeling and simulation in inventory management is important to consider all the variables that interfere with the volume of material planning, because all the results are measured by the volume of material, for example, costs, handling and occupation.

Garcia et al. (2012) address the inventory control for supply chain with an appropriate control based on the lead time, incorporating the production time in the variable of the total time. However, not used modeling and simulation, but could be a tool that would help in the results. Because according Carteni and Luca (2012) a discrete event simulation helps to achieve some goals, overcome the limitations mathematical optimization approaches, supported by computer models and help in decision-making processes. Further states that the approach is very effective in the simulation of operations of a container terminal.

As shown, the supply chain is very complex by their interactions, but it is still poorly explored in service operations companies. Machuca et al. (2006), conducted a research, which showed a lack of research in service management, also said that there are few studies in management of supply chain-related services.

Modeling and simulation can help in decision making through the results, but in service operations is not widely used, there are studies on the subject in industries, but without treating the objective of this work. Tracht et al. (2013) presented simulation for spare aircraft parts, defining storage inventory levels in the aviation industry, taking into account various input parameters and planning output.

Jammernegg and Reiner (2007) discussed the opportunities and challenges to improve the performance of processes. Using simulation, demonstrated how the coordinated implementation of inventory management methods and capacity management as a result, improved performance measures of costs and service levels. Illustrating the approach for a telecommunications branch of the supplier and the automotive industry. Hernandez and Librantz (2013) propose a reduction of all logistics costs involved in the export process, using discrete event simulation as a methodology using the ProModel® software as a simulation platform. The simulated scenarios show a reduction in costs, and a new planning strategy was also evaluated.

Modeling and simulation are widely used in industries, supply chain for inventory management: how to measure levels, capacity, and performance of logistics processes and costs. This way indicates good results, demonstrating that can be applied in service operations, in which processes are similar.

2.1 Modelling and Simulation

According to Aguilar et al. (2009) simulation is a representation of a real-world process, it involves the generation of an artificial system, by observing this system are drawn conclusions about the real system operating characteristics.

Modelling and simulation of a process or system it comes to the simulation of complex problems, so that the model imitate the responses of the real system a sequence of events that occur over time. Of computer vision, the model is a computer program whose variables have the same dynamic behavior and stochastic real system it represents. Bringing these two definitions simulation is the process of designing a computer model of a real system, conduct experiments with this model in order to understand their behavior and / or evaluate strategies for its operation (Freitas, 2008).

Kelton (1998) states that the computer simulation tool, which was previously very expensive and specialized, has been increasingly used in companies and targeted for many applications in the process to support decision-making.

To use the modeling and simulation is necessary to build a model. According to Freitas (2008) for building the model is based on the steps of formulating a study modeling and simulation.

2.2 Supply Chain

Supply Chain Management is the management of the supply chain, that is, the management of the operational part, the management of logistics, which include several areas and processes. The concept is similar to logistic processes, but takes a wider scope and integrated strategically adding value to the entire chain (Ballou, 2006).

One of the areas of supply chain is material planning, which, briefly, is the area responsible for inventory management from the perspective of planning the amount of materials to be used in the production process and finished products (Ballow, 2006). And one of the main issues of planning is to define the optimal amount of stock of each material to be consumed or the stock output. The ideal stock definition is a very important concern, for both the lack and the excess material in stock incur unnecessary costs.

The stock represents in general, materials that are stored awaiting use: consumption or stock output (Garcia et al., 2011). Depending on the type of business (trade, industry or service), the stock may have different characteristics, forms of control and management.

Blackburn (2012) describes one of the most important factors of inventory management is the cost of the total inventory, in other words monetary amount of the total volume stored. To achieve this volume planning is important to define some key parameters to calculate the optimal amount of stock that a distribution center must have.

In the case of a service company, there is not a production process, or the process occurs only moments before delivery of the service; there are no production orders, but there purchase order material, for every service depends on resources to perform the sale. Measure this material volume in days is a way to set a parameter. This parameter need not be changed at any time, this form it is ideal for seasonal demand, in which the volume change can be different every month.

2.2 Modelling and Simulation in service operations management

The modelling and simulation in service operations can be useful to study the material planning on the inventory management process. There are many issues that can be responded, for example, the amount of inventory that a distribution center must have.

Another aspect of the current context that favors the use of simulation is the extraordinary advances in computer technology in the last years, and constantly growing. The Discrete Event Simulation technique was quite favored industries, which now has powerful computational tools, able to study more complex systems involving many variables (Aguilar et al., 2009).

This way, the application of modeling and simulation, can also be satisfactory in service operations, which is more complex due to transformation of demand for goods in services.

3 Materials and Methods

The approach used in this article was a quantitative research of the exploratory type, with the construction of a computational modelling and simulation in Arena® program, with data collected through a field of study in business services operations: Sky Brazil ®.

The construction of the model was based on the steps of the formulation of a study of modeling and simulation (Kelton, 1998). In the formulation and problem analysis, were raised several possible inventory management problems, for example, minimum inventory volume, maximum volume and inventory restocking cycle, which can be answered with computer modeling and simulation.

Before the computational model, a conceptual model was created, defining processes and activities that constitute the system. The next step was carried out to create, verify and validate the computational model, conducted the first tests, confirming that the model will be operating as planned and, where necessary, making adjustments until you reach the desired result.

The final design is also called go live production, in which experiments were conducted, generating some scenarios to be analyzed. At this stage was set the sample size of six months of the scenario simulation and thirty replications.

Following the comparison and identification of the best solutions, the best proposed scenarios will be discussed in detail, by statistical calculations, for example, t-test, statistically to ensure that the response of the model represents the best alternative.

4 Results and Analysis

Following are the results and analysis applying the steps of modeling and simulation. The main purpose is to define the ideal amount of stock for a material in a distribution center.

The conceptual model is part of the supply chain, in which the defined processes directly influence the calculation of income. In this way the processes that have a direct relationship with inventory management were defined (figure 1).

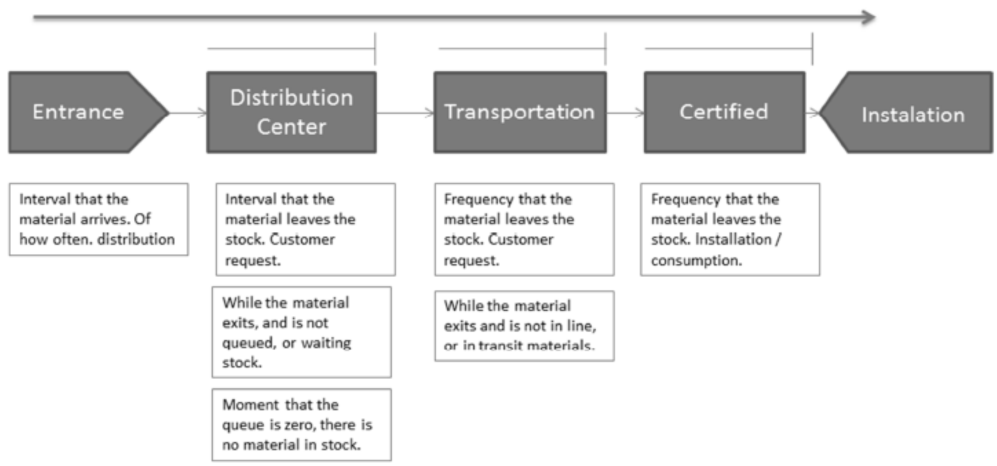


Fig.1
Conceptual model.

The entrance represents the entry in the material in stock. The DC is the distribution center of material, in which the material is stored waiting until his departure. The transportation is the transit of the material until your destination. The certified represents the stock Sky® partner, who will perform the service for the customer. And finally the installation is to provide the customer service for the consumption of the material and the completion of the process.

In this model the queue is the stock, the size is the volume available in stock. For this case does not have a queue is bad because it is the rupture of stock, on the other hand is also bad to have a lot of queue, as it indicates an excess of stock.

The intention of the development of a simple system is precisely to facilitate a business user. In some cases, the business user can stop easier access and processing of data, as it has greater knowledge in day-to-day process.

The computational model is shown in Figure 2. The model was built with the blocks of the basic flow module in ARENA. The entrance of the material was represented by the *Create* module; Distribution Center, transportation and Certified were represented by a *Process* module and, finally, the installation process is represented by a *Dispose* module.

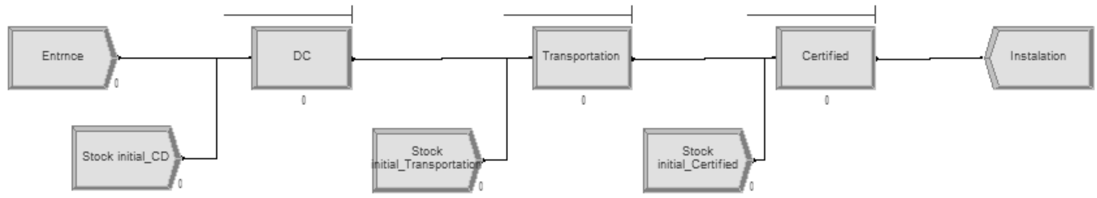


Fig.2
Arena® computational model.

Table 1 shows the results in 30 replications. The response shows the average size of the queues (Number-InQueue) in the different links in the supply chain. The numbers are normalized due to confidentiality agreement. The result, for the scenario tested, there was no disruption of the stock, indicating that the stock size adopted in the simulated scenario is sufficient to meet the defined demand.

Table 1
Normalized results for average size of the queues.
Queues represent the stock

Stock in different links in the supply chain	Volume in days
Distribution Center.Queue.NumberInQueue	1
Transportation.Queue.NumberInQueue	0,25
Certified.Queue.NumberInQueue	0,37

Although it has been enough stock, we cannot state that represents the ideal volume, since it may represent an excess of stock. In order to identify the ideal volume other scenarios should be simulated.

5 Conclusions

This paper presented the development and application of a simulation model for the inventory control process in a service company. With the simulation is possible to follow the evolution of the model variables, related or not to the queues, observe the conditions under which occurs rupture or excess inventory and identify the best option for a specific demand scenario and sales forecast.

As a future prospect, it is intended to simulate the different scenarios as well as using the model in an optimization applications such as, for example, Opquest a tool which is used to optimize an already existing template.

6 References

Aguilar S, Guimarães I, Schuchter D et al (2009) Avaliação dos benefícios da aplicação da simulação, através do software arena 10.0, em uma empresa de transporte ferroviário. Enegep XXIX.

Ballou R (2006) Gerenciamento da cadeia de suprimentos/ logística empresarial. 5. Ed. Porto Alegre: Bookman.

Blackburn J (2012) Valuing time in supply chains: Establishing limits of time-based competition. Journal of Operations Management, 30: 396-405. doi:10.1016/j.jom.2012.03.002.

Carteni, A, Luca S (2012) Tactical and strategic planning for a container terminal: Modeling issues within a discrete event simulation approach. Simulation Modeling Practice and Theory, 21: 123-145.

Chwif L, Medina L (2006) Modelagem e simulação a eventos discretos: tória & prática. 2. Ed. São Paulo.

Freitas, PJF (2008) Introdução à modelagem e simulação de sistemas. 2. Ed. Florianopolis: Visual Books.

Garcia, CA, Ibeas A, Herrera J et al (2011) Inventory control for the supply chain: An adaptive control approach based on the identification of the lead-time. Omega, 40: 314-327.

Hernande M, Librantz A (2013) Improvement of the supply chain for the sugar cane exportation process employing discrete events simulation techniques. Acta Scientiarum. Technology (Online), 35: 637-643.

Jammernegg W, Reiner G (2007) Performance improvement of supply chain processes by coordinated inventory and capacity management. Elsevier - Production Economics, 183-190

Kelton D (1998) Simulation with Arena. Boston: McGraw Hill.

Machuca JAD, Zamora MDMG, Escobrar VGA (2007) Service Operations Management research. Elsevier–Journal of Operations Management, 25: 585-603.

Martins P, Alt P (2000) Administração de materiais e recursos patrimoniais. São Paulo: Saraiva.

Sakurada N, Miyake D I (2009) Aplicação de simuladores de eventos discretos no processo de modelagem de sistemas de operações de serviços. Gest. Prod., 16: 25-43.

Santoro MC, Freire G (2008) Análise comparativa entre modelos de estoque. Prod., 18: 089-098.

Tracht K, Hagen F, Schneider D (2013) Applied repairable-item inventory modeling in the aviation industry. Elsevier, 334-339.

Using Overall Equipment Effectiveness (OEE) to predict shutdown maintenance

Kurscheidt Netto, R J[1], Santos, E A P[2], Loures, E de F R[3], Pierezan, R[4]

Abstract: This research proposes an approach to predict equipment condition using OEE performance metrics. Statistical tools are used to correlate measurements of OEE factors and maintenance history from a real database. The results suggesting that there is a correlation between the Time Between Stoppages and the trend degree of the Mean and/or the Standard Deviation (SD) of cycle time. This approach intended to help the predictions of shutdowns for maintenance.

Keywords: Condition-Based Maintenance. OEE. Trend Analysis, Process Mining.

1 Introduction

Several maintenance strategies are proposed and applied to productive processes, for improving the operational capacity of processes, saving maintenance costs, and improving industrial competition (Kumar *et al*. 2013). An appropriate maintenance action, at the right moment, is necessary for reducing process failures and increasing equipment reliability (Wang, 2012). In order to maximize preventive maintenance effectiveness, the Condition-Based Maintenance technique was proposed. The main motivation of this strategy is that equipment failures are preceded by signals, conditions or indications that the failure may occur (Ahmad and Kamaruddin 2012). According to Ahmad and Kamaruddin (2013), Overall Equipment Effectiveness (OEE) provides an estimation of the lifetime of the equipment where its intended use is influenced by its availability, performance and quality. This paper proposes a study to estimate degradation on an equipment operation using performance factor of OEE index, aiming to monitor the operating condition of equipment to find deviations from its normal condition. The present paper is organized as follows. In section 2 the theoretical background are introduced. Section 3 describes the proposed methodology. A case study of methodology application in a real process is showed in Section 4, covering the found issues and discussions about results. Finally, a conclusion about methodology application and further results are presented in Section 5.

2 Theoretical Background

The approach proposed in this paper is based on the following key concepts: performance measurement based, Condition Based Maintenance and Trend Analysis with attention to the Double Exponential Smoothing trend prediction model. A theoretical foundation on manufacturing event logs is presented.

Van Der Aalst *et al*. (2011) highlights the growth of information systems as Process-Aware Information Systems (PAIS), which record process information in the form of structured and detailed records of events from activities performed by a process (Weber *et al*. 2011). Each event refers to an instance (case ID) and a set of activities (task ID), including information from the beginning, ending, scheduling of this activity, date and time (timestamp) and user who performed the task are possible in some of these (Rozinat *et al*. 2009). Factory Information Systems (FIS) are a subclass of PAIS, which are responsible

1 **Rolando Jacyr Kurscheidt Netto** (rolando.k@pucpr.br)
2 **Eduardo Alves Portela Santos** (eduardo.portela@pucpr.br)
3 **Eduardo de Freitas Rocha Loures** (eduardo.loures@pucpr.br)
4 **Rodrigo Pierezan** (e-mail: rodrigo.pierezan@pcupr.br)
Pontifical Catholic University of Parana,
(PUC-PR). Curitiba, Paraná, Brazil.

for the management of data related to a manufacturing system, where the information is typically received in the form production events (Santos *et al*. 2008). The data acquired by FIS are stored in the form of sequential events into defined structures of data, entries from operators on the factory floor or from sensors installed on monitored machines.

CBM, which is a technique in the context of a predictive maintenance policy, is the most popular and modern technique discussed in the literature (Ahmad and Kamaruddin 2012), where its fundamental basis is condition monitoring, using signals measured by sensors continuously, allowing to identify if the operational condition of the equipment is deviated from a defined normal condition (Jardine *et al*. 2006). Frequent inspections when equipment is in good operation increases the costs of operation. On the other hand, deferring the inspection can increase the occurrence of unexpected failure and economic losses (Abeygunawardane *et al.* 2013). Many types of equipment failures present some kind of change in their condition that is detectable. When the equipment is in a good condition, it has performance or quality factors with known mean μ and variance σ^2 values (Venkatasubramanian *et al.* 2003). However, in a wear condition or in the eminence of a failure, the mean, the variance or both values might change.

The OEE, proposed by (Nakajima 1988), is one of the most used indicators for performance measurement, and is used for measuring the progress made by the Total Productive Maintenance philosophy. It is a quantitative indicator, serving to measure performance, to identify areas for improvement, and to guide efforts to improve the areas that involve the equipment used in the process (Kumar *et al.* 2013). The basic formulation for the OEE is based on the product of three mutually exclusive factors: Availability, Performance, and Quality. Performance factor is the ratio of the actual cycle speed and theoretical cycle time. Its traditional formulation is represented by Equation (1).

$$\textbf{Performance}\ (\%) = \frac{\boldsymbol{Total\ Produced}\ * \textbf{Theoretical Cycle Time}}{\boldsymbol{CalendarTime} - \boldsymbol{ExcludedTime} - (\sum \boldsymbol{DT} + \sum \boldsymbol{ST})} * \mathbf{100} \qquad (\mathbf{1})$$

It indicates the current diversion of in-time production with respect to an ideal cycle (Almeanazel 2010). The denominator in Equation 1 represents the time which the machine is really producing. The term $\sum DT$ (Downtime) is the sum of all no planned stoppages. The term $\sum ST$ (Stoptime) represents the sum of planned stoppages. In this paper we make use of a direct measure from the equipment, provided by FIS data, and obtained from activity “Machine Working”. Using the time difference between its Start and Complete events, it can be computed the measured time cycle.

Trend Analysis (TA) is a statistical tool used to fit a general trend model based on time series data. The application of TA is appropriate because the nature of the component deterioration trend is presented according to a time series form (Maurya *et al.* 2010). The Double Exponential Smoothing (DES) model is one of the practical forecasting models that can be used to predict trending, being specifically used to forecast the future point based on the non-linear trend model (Ahmad and Kamaruddin 2013). The DES model uses an equation for estimating the forecasting value and another equation to estimate the trending, as shown in Equations (2) (3) (4).

$$C_t = \alpha Y_t + (1 - \alpha)(C_{t-1} + T_{t-1}) \qquad (2)$$
$$T_t = \beta(C_t - C_{t-1}) + (1 - \beta)T_{t-1} \qquad (3)$$
$$F_{t+1} = C_t + T_t, \qquad (4)$$

where Y_t is the actual value in time t, α is the value-smoothing constant, β the trend-smoothing constant, C_t is the smoothing value for time t, T_t is the smoothing trend value for time t, and F_{t+1} is the forecast value for time $t+1$.

3 Proposed Methodology

A methodology was proposed in Kurscheidt Netto *et al* (2014) to use the performance measures obtained from an equipment to monitor its condition and therefore, define the optimal moment to preventive maintenance. Figure 1 illustrates the proposed methodology.

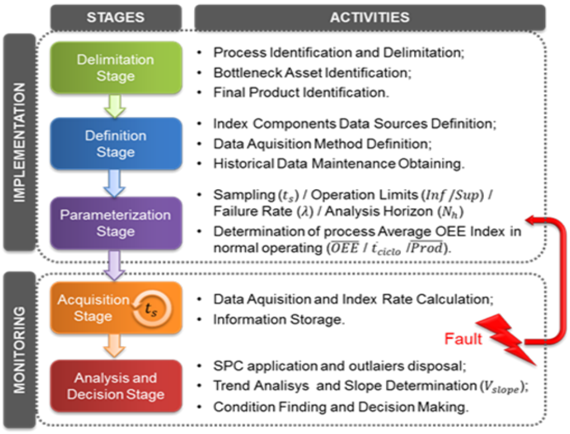


Fig.1
Proposed Methodology (Kurscheidt Netto *et al.* 2014).

Analyzing the variation trend of these measures, it is possible to estimate the equipment condition and the moment for the preventive maintenance action. The phases are defined as Implementation phase, which aims to structure the methodology based on equipment information to be monitored and Monitoring phase, where the equipment condition is monitored and the decision for the maintenance action is taken.

4 Case Study

To validate the proposed methodology, correlation analyses were applied to a database collected from a lathe machine (CNC Turning) through a FIS, installed in an automobile industry. A period of eight months was considered for the event logs of the productive process, totalizing 85,830 events, structured in 85 cases. Each case represents one production day. The equipment under analysis is used for the manufacturing of 13 types of products, with different cycle times and number of operations. Figure 3 graphically summarizes the cycle time variation according to the product type during the period under analysis. The curve represents the cycle time filtered, to eliminate incorrect events, e.g. production times higher than 1,000s. Nevertheless, a noise level was observed in the measures obtained, requiring its treatment for the conduction of the study object of this paper.

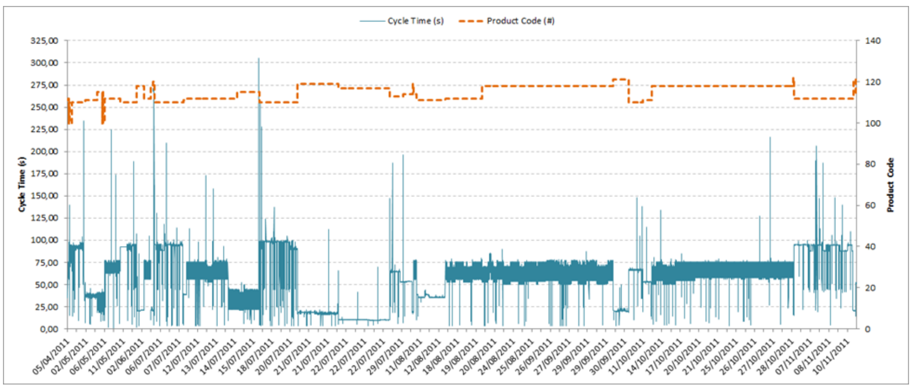


Fig.2
Normal Structure for Production Activities.

5 Results and Discussions

Events registered by the FIS (taskID) were classified into Activities and Events, aiming to extract the process main structure represented by the Activities and identify the occurring deviations, represented by the Events. Events, in their turn, were classified into Production Events, Quality Events, and Maintenance Events. Table 1 summarizes the results obtained with the mining of the event log under analysis, identifying the four activities that compose the process and events classified as non-scheduled stoppages.

Table 1
Structure activities and maintenance events.

Activity description	Freq	Relative freq.	Classification
Machine Working	25142	29,2928%	Activity
Finished Part	20601	24,0161%	Quality Event
Product Removal	20437	23,8110%	Activity
Short Stoppage	18662	21,7430%	Activity
Adjustments	298	0,3472%	Maintenance Event
Tool Wear	54	0,0629%	Maintenance Event
Autonomous Maintenance	6	0,0070%	Maintenance Event
Electrical Maintenance	2	0,0023%	Maintenance Event

4 types of products were selected for the analysis, representing around 80% of the production in the period considered, as pointed out in Table 2. Based on the execution time for activity “Machine Working”, the cycle times were obtained for each day of production and products selected in Table 2. In order to conduct the analyses, the outliers values were removed in order to keep the standard deviation of the cycle time acquisitions at about +/-2s for products #110 and #111, and about +/-10s for products #112 and #118. After that, days with 10 or less pieces produced were removed.

Table 2
Selection of relevant products for analysis.

Prod Code	Quantity	Relative Freq	Cumulative	Days of Prod
118	9141	36,36%	36,36%	21
112	5494	21,85%	58,21%	20
110	3614	14,37%	72,58%	20
111	1697	6,75%	79,33%	9

The DES method was employed, with mean smoothing factors and trend defined in 0.6 for the analysis of the respective cycle time trend (Mean and Standard Deviation). The compiled results are shown in Figure 4, in which both the mean trend and the standard deviation follow normal distributions, at a reliability criterion of 95%. It is possible to observe the occurrence of variations in the cycle time mean values of some products. Operation errors are regarded as factory-floor related, e.g. incorrect definition of the product type and/or acquisition errors of the events timestamp. The analysis is validated through the removal of those values for verification of trends and variations. As attested in the results shown in Figure 3, the cycle times mean and/or standard deviation tend to increase in certain periods. Such trends were related to non-scheduled stoppage events (Downtimes) of the machine under analysis, specifically those related to Maintenance Events, as presented in Table 1.

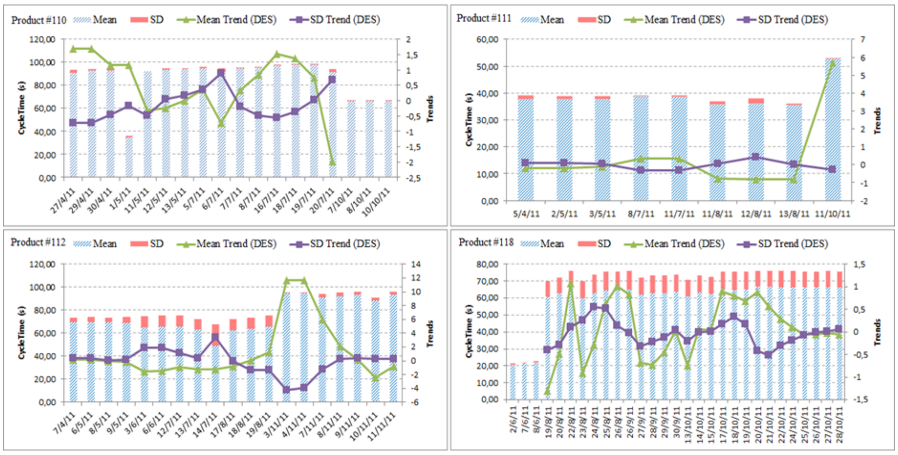


Fig.3
Results of Mean, SD and Trending for each product.

Figure 4 brings the results of the stoppage total time measurement for each day of production analyzed and related to the cycle time mean for each product. The dashed circles highlight the periods in which an increase of the cycle time mean occurred. Considering that the database does not include additional information on the root of such deviations, it is assumed that they are caused by the equipment degradation. So as to found such hypothesis, the mean trend value and cycle time SD were correlated with the Time Between Stoppages (TBS).

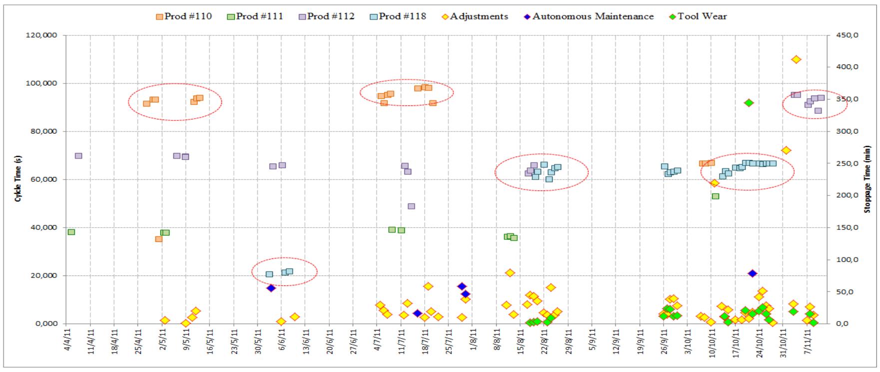


Fig.4
Graphical correlation between Mean cycle time and moment of stoppage.

Figure 5 presents the results obtained and is possible to verify the grouping of the mean and the SD measurements, represented by the points inside the highlighted circles. Regarding the correlation with the mean trend, the analysis of the results shows that product #110 data are more dispersed, while regarding SD trend product #2 is more dispersed. Values for other products are grouped in a certain region, suggesting that there is a correlation between the Time Between Stoppages and the trend degree of the mean and/or the SD. In this analysis, the correlation with all Maintenance Events is considered, although the Electrical Maintenance event has almost no occurrence.

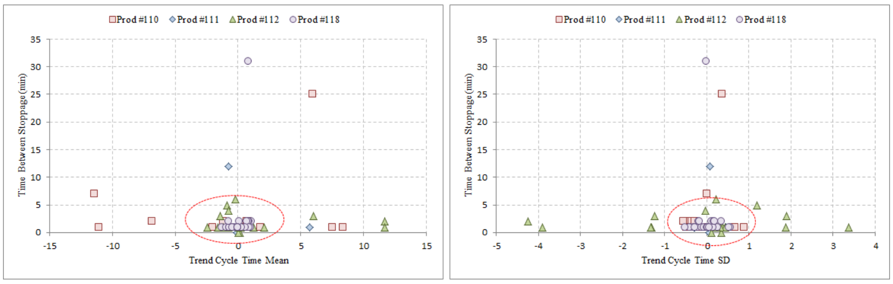


Fig.5
Correlation between TBS and Mean / SD Trends for each product.

6 Conclusions

In this paper, we consider the hypothesis that any reduction in the equipment speed is due to factors such as degradation, aging or fatigue-related failures. With the results obtained, it is possible to attest the correlation between the mean and standard deviation trend of cycle time with the occurrence of maintenance events. Although measures present relative dispersion, most values obtained are grouped.

Indeed, the measurement quality of the cycle time, contributing for the accuracy of the methodology proposed by Kurscheidt Netto *et al.* (2014), can be emphasized. The existence of noise in the values acquired must be observed, increasing the factor variance and influencing the operational limits, thus impacting on the correct identification of the slope value. The main cause determined after the database analysis refers to event registration errors by the operator. In addition to the main objective of this paper, the need for the correct use of events for the explicit and well defined delimitation of the start and end working shifts, machine operation state and start/end of in-progress production. These events help employ mining algorithms, reducing the noise and contributing to the application of the proposed methodology.

7 References

Abeygunawardane, SK; Jirutitijaroen, P.; Xu, H (2013). Adaptive Maintenance Policies for Aging Devices Using a Markov Decision Process. IEEE. Vol. 28 N°3. pp. 3194-3203.

Ahmad, R. Kamaruddin, S (2012). An overview of time-based and condition-based maintenance in industrial application. Computers & Industrial Engineering 63, pp. 35–149.

Ahmad, R. Kamaruddin, S (2013). Maintenance Decision-making Process for a Multi-Component Production Unit using Output-based Maintenance Technique: A Case Study for Non-repairable Two Serial Components. Unit International Journal of Performability Engineering, Vol. 9, No.3, May, pp. 305-319.

Almeanazel, OTR (2010). Total Productive Maintenance Review and Overall Equipment Effectiveness Measurement. Jordan Journal of Mechanical and Industrial Engineering. Vol 4, N° 4, pp 517-522.

Jardine, AKS; Lin, D; Banjevic, D (2006). A review on machinery diagnostics and prognostics implementing condition-based maintenance. Mechanical systems and signal processing. Vol. 20. Nº 7. pp. 1483 - 1510.

Kumar, U; Galar, D; Parida, A; Stenstrom, C; Berges, L (2013). Maintenance performance metrics: a state-of-the-art review. Journal of Quality in Maintenance Engineering. Vol. 19. Nº 3. pp. 233-277.

Kurscheidt Netto, RJ; Santos, EAP; Loures, ER; Pierezan, R (2014). Condition-Based Maintenance Using OEE: An Approach To Failure Probability Estimation. In: 7th International Conference on Production Research - Americas 2014, 2014, Lima. Proceedings of 7th International Conference on Production Research - Americas 2014.

Maurya, MR; Paritosh, PK; Rengaswamy, R; Venkatasubramanian, V (2010). A framework for on-line trend extraction and fault diagnosis. Engineering Applications of Artificial Intelligence, 23, 6, 950-960.

Nakajima, S (1988). An Introduction to TPM: Total Productive Maintenance. Cambridge, Massachusetts: Productivity Press. Portland. OR.

Santos EAP; De Freitas RL; Deschamps F; De Paula MAB (2008). Proposal of an Industrial Information System Model for Automatic Performance Evaluation. IEEE International Conference on Emerging Technologies and Factory Automation. pp. 436-439.

Van Der Aalst, WMP; Schonenberg MH; Song M (2011). Time Prediction Based On Process Mining. Information Systems. Vol. 47. Nº. 2. pp. 237 – 267.

Venkatasubramanian, V; Rengaswamy, R; Kavuri, SN; Yin, K (2003). A review of process fault detection and diagnosis: Part III: Process history based methods. Computers and chemical engineering, Vol. 27, N° 3, pp.327-346. Elsevier.

Supply Chain Risk Management in the Brazilian Auto Parts Industry

Vanalle R M[1], Lucato W C[2], Alves Filho A G[3], Nogueira E[4], Ganga G M D[5]

Abstract: In this article, we seek to present results of a survey carried out in an effort to understand how some companies of the Brazilian auto parts industry are managing risks in their supply chain. We built a questionnaire based on the works developed by Thun and Hoenig (2011) and Lavastre, Gunasekaran, Spalanzani (2012) and analyzed the answers got from forty-four firms. The results show that the main companies' concerns in SCRM are devoted to typical Supply Chain Management problems (e.g. suppliers' quality, demand variation and inventory levels) and that they tend to work together to reduce or eliminate risks. We observe as well that tier1 and tier 2 firms perceive chances and impacts of events in almost the same way, but they have different capabilities of transferring risks to other members of the supply chain.

Keywords: Supply chain management; Risk management; automotive industry.

1 Introduction

Researchers and practitioners have been devoting increasing attention to Supply Chain Risk Management (SCRM) since the middle of the 1990 decade. They have pointed out that supply chains are increasingly exposed to risks, as globalization expands and more companies adopt lean and agile production systems practices to improve their competitiveness (Thun and Hoenig, 2011).

Being a relatively recent stream of research, the body of research is increasing rapidly and the fundamental concepts and bases for empirical research are still under development. Colicchia and Strozzi (2012) presented a systematic literature review highlighting the key themes that have been investigated and proposing a vast research agenda for the future. However, to the best our knowledge, only a few research efforts on this subject were carried out focusing segments of the Brazilian industry, corroborating the incipience of the field in Brazil.

In this article, we seek to explore how some companies of the Brazilian auto part segment perceive risks while managing their supply chain and what attitudes they have been taken towards those risks. We sent a questionnaire composed by close-ended questions to a sample of auto part companies and analyzed the returned responses. The questionnaire was developed based on the ones designed by Thun and Hoenig (2011) and Lavastre, Gunasekaran, Spalanzani (2012).

More specifically, we choose to discuss two general questions: (1) What are the main risks and their potential impact in the supply chains of auto part companies installed in the State of São Paulo - Brazil? (2) What are their main attitudes to deal with supply chain risks?

In the next sections of this article, we present very briefly: the main SCRM concepts, the method adopted in this research, and the analysis of the data collected for the study.

1 **Rosangela Maria Vanalle** (rvanalle@uninove.br)
2 **Wagner Cesar Lucato** (wlucato@uninove.br)
Dpto. de Engenharia de Produção.
UNINOVE. São Paulo – SP, Brazil.
3 **Alceu Gomes Alves Filho** (alceu@dep.ufscar.br)
4 **Edemilson Nogueira** (edn@dep.ufscar.br)
5 **Gilberto Miller Devós** Ganga (ganga@dep.ufscar.br)
Dpto. de Engenharia de Produção.
UFSCar. São Carlos – SP, Brazil.

2 Supply chain risks

Before bringing the central concepts that backing up our specific research, it is worth to point out that SCRM, as an area in its beginning, has its content range still in formation. We can see that authors in the field are trying to identify the main supply chain risks and to propose management schemes that could improve companies' performance.

Colicchia and Strozzi (2012, p. 404) bring the initial and well-adopted definition of SCRM: "Supply chain risk management is defined as, 'the identification of potential sources of risk and implementation of appropriate strategies through a coordinated approach among supply chain members, to reduce supply chain vulnerability' (Christopher et al., 2003). The main aim of supply chain risk management is to protect the business from adverse events."

"A main particularity of Supply C Management (SCRM) contrary to traditional risk management is that it is characterized by a cross-company orientation aiming at the identification and reduction of risks not only on the company level, but rather focusing on entire supply chains."(THUN and HOENIG, 2011, p. 243).

Researchers in correlated fields are nevertheless discussing the fundamental concepts that have been adopted and are proposing significant modifications and expansions of the fields' contents. They highlighted that works on SCRM have been concerned mainly with risks – not including uncertainty – and have focused only the possible negative effects of events that may occur in the supply chains. Ward and Chapman (2003), for example, dealing with Project Risk Management (PRM), argument that the term 'risk' induces a restricted focus: "the association of the term 'risk' with adversity, implying that project risks are potential adverse effects on project performance, and that sources of risk are 'things that might go wrong', or threats to the project." (WARD and CHAPMAN, 2003, p. 98). They argument as well that "…it is important to take uncertainty about anything that matters as the starting point of uncertainty management, defining uncertainty in the simple 'lack of certainty' sense." (WARD and CHAPMAN, 2003, p. 98).

We (the authors of this article) agree with those arguments conveyed by Ward and Chapman (2003) and understand that they are as appropriate to the field of SCRM as they are to PRM. In the near future, we hope that more researches could tackle the need to identify uncertainty and risks, as well as opportunities and threats, in supply chains in order to propose appropriate management schemes to improve their performance. Nevertheless, to identify and to manage risks in a supply chain may be a proper initial step in that direction.

Since there are only a few empirical researches carried out in Brazil on the area of SCRM (Aguiar, Tortato and Gonçalves (2014); Graeml and Peinado (2010); Sellitto et al (2013), we try to identify, in this work, in the perception of the managers, the main risks that could affect supply chains and the main management attitudes taken towards the risks by auto part companies.

It is necessary then to focus our discussion here towards the concepts of risk and of impact or vulnerability. We choose to adopt the definitions presented by Harland, Brenchley, Walker, (2003) and Thun and Hoenig (2011).

Risk is defined as ''…the probability of loss and the significance of that loss to the organization or individual''. (Mitchell, 1995 apud Harland, Brenchley, Walker, 2003, p. 52). The types of risks considered in this research are the ones presented by Harland, Brenchley, Walker (2003) and Thun and Hoenig (2011).

Thun and Hoenig (2011, p. 243) consider that "The impact of an incident on a supply chain depends on the particularity of the incident on the one hand and on the design of the supply chain on the other hand. The latter refers to the aspect of vulnerability of a supply chain."

From those definitions of risk and impact / vulnerability, and from the definition SCRM, we choose to discuss in this research the two questions presented earlier in the first section (Introduction) of this article.

Following the researches carried out by Thun and Hoenig (2011) and Lavastre, Gunasekaran, Spalanzani (2012), we decided to present here the results from a survey carried out in a sample of the Brazilian auto parts industry.

3 Methodolology

Since we had decided to collect data on SCRM in a sample of the Brazilian auto parts industry, we designed a questionnaire based on the ones used by Thun and Hoenig (2011) and Lavastre, Gunasekaran, Spalanzani (2012) in their researches.

The questionnaire was composed mainly by closed questions organized into three blocks: company's general characteristics; company's vulnerability to risks (occurrence of risks, risk impacts); company's attitudes towards risk. The questions used for this analysis are measured by seven-point Likert scales.

The survey was launched during the months of September / October /2014 to a sample of the auto parts industry segment installed in Brazil. The questionnaire was sent by e-mail to people in charge of supply chain management in 150 companies randomly chosen among the auto part companies associated to the SINDIDEPÇAS (Brazilian Union of the Auto Part Manufacturers) and located in the State of São Paulo. Subsequent phone contacts by the researchers requested for the questionnaire fulfilment. From the total sent, 44 (or 29%) of the questionnaires were received back (adequately answered) and were used to support the analyses and findings considered in this paper. From that total, 30 companies belonged to tier 1 of the Brazilian automotive supply chain and 14 to tier 2. Since this is not a random sample covering the entire country, we could not say that it represents the population of companies in the auto part industry installed in Brazil. Nevertheless, the results can give an initial idea of the risks in this segment and how companies are dealing with them.

All mean comparisons developed in this paper were statistically tested using the t test, assuming a significance level of 95%.

3 Results

Analyzing the data received from the field, initially it was possible to conclude that the three major concerns regarding risk perceived by the researched companies were raw material price increases, demand variations and supplier's fault. Conversely, the lowest risk alleged were terrorist attacks, petroleum crisis and natural disasters. The complete list of possible events evaluated in the research is shown in Figure 1. And the complete list of consequences evaluated is shown in Figure 2.

How often the following risks are considered in your supply chain? From 0 (Never) to 7 (Very often)	Mean	Std Dev.	Median
- Raw material price increases	4,02	1,70	4
- Demand variations	3,89	1,87	4
- Supplier's fault	3,85	1,69	4
- Supplier quality problems	3,53	1,54	3
- Restriction in importation and exportation	3,09	2,35	3
- Machine breakdowns	3,06	1,42	3
- Lack of enough inventories throughout the supply chain	3,02	1,44	3
- Red tape in customs clearance	2,94	2,17	3
- Problems in inbound logistics	2,91	1,56	3
- Communications problems in information systems	2,85	1,76	2
- Problems in outbound logistics	2,74	1,58	2
- Strikes	2,53	1,68	2
- Technological changes	2,13	1,51	2
- Accidents (fire, for instance)	1,91	1,47	1
- Natural disasters	1,68	1,35	1
- Petroleum crisis	1,55	1,69	1
- Terrorist attack	0,71	1,47	0

Fig.1
How risks are perceived by the researched companies.

How do you rate the consequences of the following risks to your company? From 0 (Inexistent) to 7 (Very high)	**Mean**	**Std Dev.**	**Median**
- Supplier's fault	4,55	2,05	5
- Supplier quality problems	4,51	1.93	5
- Machine breakdowns	4,28	1,73	4
- Raw material price increases	4,28	1,74	5
- Lack of enough inventories throughout the supply chain	4,00	1,89	4
- Restriction in importation and exportation	3,98	2,35	4
- Demand variations	3,83	1,71	4
- Problems in inbound logistics	3,79	1,76	4
- Problems in outbound logistics	3,77	1,75	4
- Accidents (fire, for instance)	3,68	2,05	4
- Red tape in customs clearance	3,64	2.26	3
- Communications problems in information systems	3,55	1,84	4
- Strikes	3,36	2,21	3
- Technological changes	3,11	1,71	3
- Natural disasters	3,02	2,81	3
- Petroleum crisis	2,32	1,81	2
- Terrorist attack	2,09	2,39	1

Fig.2
How consequences are rated by the researched companies.

Interestingly, the first seven events are the same (in different positions) in figures 1 and 2. They establish the main SCRM concerns of the companies.

However, companies belonging to tier 1 and 2 of the Brazilian automotive supply chain consider those risks differently (Figure 3). Tier 1 and tier 2 firms indicated the same first three events (in different positions) as the ones with the highest chances of occurrence: supplier's fault, raw material price increases and demand variation. Furthermore, supplier quality problems and supplier's fault are amongst the two events Tier 1 companies rated as the ones with the highest risks consequences, and amongst the four events that Tier 2 companies rated as the ones with the highest risks consequences. Tier 2 firms rated machine breakdowns as the event with the highest impact.

			Tier 1			**Tier 2**			
		How often the following risks are considered in your supply chain? From 0 (Never) to 7 (Very often)	**Mean ($\mu 1$)**	**Std Dev.**	**Median**	**Mean ($\mu 2$)**	**Std Dev.**	**Median**	**t test $\mu_1 \neq \mu_2$? α= 95%**
Higher risks for...	**Tier 1**	- Supplier's fault	4,00	1,62	4	3,71	1,68	4	$\mu 1 > \mu 2$
		- Supplier quality problems	3,67	1,49	4	3,43	1,34	3	
		- Red tape in customs clearance	3,43	2,31	3	2,43	2,14	2	
		- Restriction in importation and exportation	3,17	2,12	3	2,79	2,26	3	
		- Problems in inbound logistics	3,07	1,62	3	2,79	1,19	3	
		- Strikes	2,80	1,77	2	2,29	1,44	3	
		- Technological changes	2,17	1,44	2	2,07	1,54	2	
		- Natural disasters	1,87	1,50	1	1,43	0,85	1	
		- Terrorist attack	0,90	1,67	0	0,50	1,09	0	
	Tier 2	- Raw material price increases	3,90	1,63	4	4,43	1,74	5	$\mu 1 < \mu 2$
		- Demand variations	3,97	1,69	4	4,14	1,79	4	
		- Machine breakdowns	2,93	1,08	3	3,50	1,79	4	
		- Lack of enough inventories throughout the supp	2,97	1,47	3	3,14	1,17	3	
		- Communications problems in information systen	2,83	1,76	2,5	3,14	1,51	2	
		- Problems in outbound logistics	2,73	1,53	2	2,93	1,54	3	
		- Accidents (fire, for instance)	1,73	1,44	1	2,36	1,55	2	
		- Petroleum crisis	1,47	1,48	1	1,71	1,98	1	

Fig.3
How risks are perceived in tier 1 and tier 2.

Considering at the same time the mean and median values in Figure 1, we see that Tier 1 companies perceive supplier quality problems and red tape in customer's clearance with higher chances of occurrence than Tier 2 companies do. While Tier 2 companies perceive raw material price increases and machines breakdowns with a higher chances of occurrence than Tier 1 companies do.

Tier 1 companies perceive supplier quality problems, lack of inventories throughout the supply chain and red tape in customers' clearance as events with higher consequences than Tier 2 companies do. While Tier 2 companies perceive machine breakdowns, restriction in importation and exportation and communications problems in information systems with higher consequences than Tier 1 companies do (Figure 4).

			Tier 1			Tier 2			
		How do you rate the consequences of the following risks to your company? From 0 (Inexistent) to 7 (Very high)	**Mean (µ1)**	**Std Dev.**	**Median**	**Mean (µ2)**	**Std Dev.**	**Median**	**t test $\mu_1 \neq \mu_2$? α= 95%**
Higher consequneces for...	Tier 1	- Supplier quality problems	4,77	1,76	5	4,43	2,03	4	µ1 > µ2
		- Supplier's fault	4,70	1,88	5	4,64	2,27	6	
		- Lack of enough inventories throughout the supply chain	4,37	1,83	5	3,50	1,87	4	
		- Red tape in customs clearance	4,33	2,29	5	3,71	2,33	4	
		- Demand variations	4,03	1,54	4	3,71	1,86	4	
		- Problems in inbound logistics	4,00	1,64	4	3,79	1,76	3	
		- Accidents (fire, for instance)	3,93	2,12	4	3,57	1,87	4	
		- Strikes	3,70	2,20	3	3,07	2,20	3	
		- Natural disasters	3,47	1,94	4	2,57	1,91	2	
		- Petroleum crisis	2,40	1,75	2	2,36	1,91	2	
		- Terrorist attack	2,33	2,47	1	1,93	2,40	1	
	Tier 2	- Machine breakdowns	4,30	1,74	4	4,71	1,14	5	µ1 < µ2
		- Raw material price increases	4,37	1,59	5	4,57	1,65	5	
		- Restriction in importation and exportation	3,70	1,97	3	4,00	2,69	6	
		- Communications problems in information systems	3,60	1,85	4	3,86	1,66	5	
	Both	- Problems in outbound logistics	3,93	1,60	4	3,93	1,69	4	µ1 = µ2
		- Technological changes	3,23	1,55	3	3,21	1,97	4	

Fig.4
How the researched companies perceive the consequences of each risk.

Our research also investigated how the auto part manufacturers handle the supply chain risks. Interestingly enough, many companies in tiers 1 and 2 reported almost the same behavior in that respect. In fact, the highest rated conduct indicated that they and their business partners in the supply chain work together to reduce or eliminate risks. We observe that that attitude – collaboration amongst supply chain members – can facilitate the implementation of SCRM initiatives. The complete results obtained for that question are reported in Figure 5.

			Tier 1			Tier 2			
		My company... From 0 (Totally disagree) to 7 (Totally agree)	**Mean (µ1)**	**Std Dev.**	**Median**	**Mean (µ2)**	**Std Dev.**	**Median**	**t test $\mu_1 \neq \mu_2$? α= 95%**
Most frequent actins for...	Tiier 1	...shares the risks with other members of the supply chain.	3,97	2,06	4	3,46	2,11	4	µ1 > µ2
		...usually transfers the risks to other members of the supply chain.	2,10	1,77	2	1,77	1,48	1	
		...does not consider any of the previous alternatives and ignores the risks.	0,43	0,73	0	0,09	0,30	0	
	Tier 2	...takes all the risks and tries to reduce or eliminate them through internal solutions.	3,13	1,93	3	3,77	1,92	4	µ1 < µ2
		...finances risks through its budget and prepare itself for the consequences.	3,53	2,16	4	3,62	1,71	4	
	Both	...and its business partners in the supply chain work together to reduce or eliminate risks.	5,00	1,68	5	5,00	1,78	5	µ1 = µ2

Fig.5
How the researched companies manage risks in the supply chain.

We can see overall, based on the answers of forty-four firms of the Brazilian auto parts industry, that the main companies' concerns in SCRM are devoted to typical Supply Chain Management problems related to suppliers' quality, demand variation and inventory levels, besides some legal and economic problems related to restriction to importations and exportations, and raw material prices.

We observe as well that tier1 and tier 2 firms perceive the chances and the impacts of events in almost the same way and that they tend to work together to reduce or eliminate risks. There are evidences, however, that suggest that tier 1 companies tend to use their capability of transfer risks to other supply chain members while tier 2 companies have to deal more frequently with internal problems (e.g. machine breakdowns) and have to look for internal solutions to reduce and eliminate risks.

This stream of research will continue with a detail investigation of practices and tools that companies in the Brazilian auto parts industry are adopting.

4 References

Aguiar EC, Tortato U and Gonçalves MA (2014) Identificação dos riscos em cadeias de suprimentos: um estudo introdutório com empresas da região Sul do Brasil. Revista de Negócios, 19 (4), p. 64-83.

Colicchia C and Strozzi F (2012) Supply chain risk management: a new methodology for a systematic literature review. Supply Chain Management: An International Journal, 17 (4), p. 403-418.

Graeml, AR and Peinado, J (2010) O efeito das capacidades logísticas na construção de resiliência na cadeia de suprimentos. SIMPOI 2010, Anais.

Harland C, Brenchley R and Walker, H (2003) Risk in supply networks. Journal of Purchasing & Supply Management 9, p. 51-62.

Lavastre O, Gunasekaran A and Spalanzani, A (2012) Supply chain risk management in French companies. Decision Support Systems, 52, p. 828-838.

Sellitto MA, Lazzarotto BO, Longhi A, Borchardt M and Pereira GM (2013) Análise de risco e classificação de fornecedores em uma cadeia de suprimentos. Engevista, 15 (2), p. 202-213.

Thun JH and Hoenig D (2011) An empirical analysis of supply chain risk management in the German automotive industry. Int. J. Production Economics 131, p. 242-249.

Ward S and Chapman C (2003) Transforming project risk management into project uncertainty management. International Journal of Project Management 21, p. 97-105.

Using the Internet of Things in a production planning context

Alarcón F[1], Perez D[2], Boza A[3]

Abstract: One of the most novel concepts that has been applied to companies in recent years is "Sensing Enterprises". This concept implies a drastic change in the way companies operate. Within the framework of this concept, another necessary and complementary concept arises, the so-called "Internet of Things" concept. It seems evident that the Internet of Things can generally help improve the functioning of the processes undertaken in companies, particularly one of the key processes; the production planning process. Despite being able to find abundant information on both themes, and the apparent relevance that using the Internet of Things could have for the production planning process, no works that have jointly studied these matters were found. To bridge this gap, the present work intends to reflect on how the characteristics and advantages of the Internet of Things can be put to good use in the production planning process.

Keywords: Internet of Things; Production planning; Sensing enterprises.

1 Introduction

One of the most novel concepts that has been applied to companies in recent years is "Sensing Enterprises" (SE). This concept entails a drastic change in the way companies operate and, along with other concepts (e.g. liquid, agile, "glocal", sustainable, inventive, humanist, cognitive and community-oriented), seems to mark the future roadmap.

Applying and using the SE concept helps companies to be more sensitive, to become rapidly aware of what is going on around them, and to quickly transfer it to processing centres and decision centres.

Within the framework of this concept, another necessary and complementary concept arises, the so-called "Internet of Things" concept (IoT). The IoT permits an interaction between people and things, and at its highest degree of development, the interaction between things and things. This interaction entails obtaining information from environment, and processing and/or sending this information to other things over the Internet. These other things receive it which, in turn, can set up a new interaction with another thing. In this process, things can basically: acquire and send information over the Internet; process the information they acquire from their environment or which they receive from other things; make decisions; amend their performance or the performance of the system to which they belong.

Nowadays, growing interest is being shown in applying smart products and the IoT to production and supply chain management (Meyer et al., 2009). It seems evident that the IoT can help improve the general operations of the processes undertaken in companies, and one of key process in particular; the production planning process (PPP). Despite there being abundant information on both themes (IoT and PPP), and the apparent relevance that using the IoT for the PPP could have, no works that have jointly analysed these matters were found. To bridge this gap, the intention of the present work is to reflect on how the advantages that the IoT in the PPP offers can be put to good use. To this end, the following section reviews the relevant literature on both themes; IoT and PPP. Section 3 identifies and presents examples of IoT applications in an orderly fashion, and the main benefits of their use for subsequently presenting those aspects that characterise the IoT (IoT characteristics). Finally, Section 4 analyses how the IoT characteristics can be put to the best use in the PPP.

1 **Faustino Alarcón Valero** (faualva@cigip.upv.es)
2 **David Pérez Perales** (dapepe@cigip.upv.es)
3 **Andrés Boza García** (aboza@cigip.upv.es)
Research Centre on Production Management and Engineering (CIGIP),
Universitat Politècnica de València,
Cno. De Vera s/n, 46022, Valencia, Spain

2 Literature review

The interest for the work lies in analysing and understanding how the PPP can improve by using the IoT. Since no previous works that have profoundly dealt with the relation between both these themes were found, we opted to review them all separately. In this way, and depending on the information obtained for each one, the subsequent sections identify and analyze the impact that using the IoT has on the PPP.

Next a literature review on the SE and IoT concepts was done in an attempt to pay attention to the meaning of both concepts, their utility and the advantages/benefits that their use can offer. Then the literature on the PPP was reviewed putting the focus on the activities that comprise it.

2.1 "Sensing Enterprises" and the Internet of Things (IoT)

The "Sensing Enterprises" (SE) concept attempts to *decentralize the company's smartness* for the elements and/or people comprising it, and who work in it, to move on to a scenario in which the company acts as a complex smart organisation capable of detecting, sensing and reacting to business stimuli (FInES, 2012). According to Thoma et al. (2013), two recent technologies now permit the SE concept to become a reality: the real-time analysis of large quantities of data and sensors networks that are beginning to complement the already existing RFID technology.

The elements, technologies or sensors that capture information in an SE context are also known as "things", and have given rise to the term "Internet of things". The IoT is a concept that aims to improve forms of communication between humans and the devices (objects) we employ today by using Internet networks. The IoT attempts not only to help humans communicate with one another (humans-humans), but also the things are able to exchange information among them, over the Internet, which gives way to new forms of communication: humans-things and things-things (Tan and Koo, 2014).

For Gubbi et al. (2013), the IoT is a radical development of today's Internet towards a network of interconnected objects that not only collects information from environment and interacts in the physical world (action/command/control), but one that also uses existing standards on the Internet to provide information transfer services, analyses, applications and communications.

Some examples of objects that can interact in an IoT context include: radio frequency identification devices (RFID), sensors/actuators, communication machines and devices (Miorandi et al., 2012). Wang (2014) also mentions RFID as well as infrared sensors, global positioning systems (GPSs) and laser scanners. Whitmore et al. (2014) cites RFID and sensors/actuators, and adds mobile phones.

As for the benefits or specific advantages that the IoT can provide, Teng Yue (2011) analyses its effect on each link of a food supply chain. This author demonstrates that the IoT can improve the chain's efficiency and the degree of food safety because its use allows real-time communication and it shares accurate information to carry out smart recognition of products, their location, follow-up and monitoring.

The work of Yu Gu and Tiaobin Jing (2011) presents three specific IoT applications and their benefits in a fresh agricultural produts supply chain. The work of these authors includes a table that reflects the improvements obtained from using the IoT in the links of this particular supply chain. Other interesting works mention the benefits of the IoT; e.g., those by Mao Cuiyun and Han Yuanhang (2010) and Zhou et al. (2015).

Given the interest of the business processes perspective for the present work, it is worth highlighting the IoT definition proposed by Carretero and García (2014): the IoT is a network of objects connected to the Internet that are perfectly integrated and can be converted into active participants in business processes.

Although the research conducted by Wang (2014) does not follow a clear business processes approach, it mentions some activities that objects perform in an IoT context: capturing information, accurate transmissions and smart processing. This work also mentions some activities that constitute the information and communications exchange protocol for devices connected to the IoT: smart identification, positioning, follow-up, monitoring and management.

2.2 The production planning process (PPP)

The classic production planning concept, in which many authors coincide about, consists in planning the desired future, the means needed and the activities to be performed to cover demand.

Planning is a process for which all those involved in covering demand are organised with time to optimise their work and to obtain the biggest benefit possible for the company. Its main objective is to respond to customer requirements in quality, quantity and due date terms (Meyer et al., 2011) at the lowest possible cost so that available resources are used in the best possible way.

Production planning is defined as a long-term plan for the operations subsystem which includes the objectives to be met, the actions to take and allocation of resources to various products and tasks. All this must be done to pursue meeting the company's objectives within the corporate strategy framework. This entails establishing a Long-Term Capacity and Production Plan.

There are many ways in which the planning process and controlling production can be arranged with a hierarchical approach, even though the essence is always the same. Normally, the next five phases are distinguished: Long-term or strategic planning, Tactical or mid-term planning, Master planning, Components programming and Execution and control.

For Slack et al. (2004), the activities needed to cover demand can, however, be grouped into the following four tasks: loading, sequencing, programming, and monitoring and control. The first three constitute production planning, while the fourth is known as production control (Meyer et al., 2011). The monitoring and control task covers the activities performed to react to alterations, which enables deviations from the original plan. The majority of academic efforts on the production planning and control theme have been made on more sophisticated planning concepts, while monitoring and control have taken second place (Vieira et al., 2003). The work of Meyer et al. (2011) studies using the IoT from the production control perspective to overcome drawbacks or alterations in the production plant, such as product errors, production errors, machine failure, quality problems or delivery errors.

3 Applications, benefits and characteristics of the IoT

This section summarises the *applications* that the IoT permits companies by means of a literature review, which was done beforehand. With these applications or examples of using the IoT, *benefits* can be obtained, which are also provided, to summarise the literature review done. Studying the applications, along with the benefits of the IoT, and the other contents obtained from the works we consulted will subsequently permit the identification of IoT *characteristics*.

Next, we provide the IoT **applications** cited in the consulted literature, which is not a single or closed list. The IoT can be used to:

- Monitor product quality, which will allow a better control of damaged, lost and stolen products

- Improve and ensure product safety, especially the safety of perishable products, such as food or pharmaceutical products, by means of a powerful real-time traceability system

- Make real-time product information available and for all the supply chain nodes, inclu-ding customers. This will permit better product follow-up all along the transport route, the exact location and recovery of products, if required, and also information about consumer habits. The participants in the chain will be synchronised with changes in demand. It will also allow customers to decide when to buy and it will offer them ample information about products and producers

- Identify products automatically and accurately classify them

- Know the state that equipment is in and its performance in real time, identify and manage emergences more quickly, and confer autonomy to "things" so they can react.

The **benefits** that using the IoT can provide companies, as mentioned in the consulted literature, can be grouped as follows:

- More **efficiency**: The IoT can improve system efficiency in general, and production efficiency in particular, by allowing production to be done according to customer requirements, and will improve the ratio of equipment usage and preparing more realistic plans

- Increased **quality and safety**: the traceability offered by the IoT allows the exact conditions that products must pass through to be known and will, therefore, prevent quality and safety problems

- Facilitate **integration**: the facilities that the IoT offers for supply chain members include information exchange, which favours the chain's integration, coordination and interoperability

- **Costs** reduction: The IoT helps reduce inventory levels, improves the control of spoilt products and increases system efficiency, including production, storage, distribution and transport. It improves system management as it makes it easier. It also helps cut down the number of errors and allows less dependence on operators. Allocating routine activities at the lowest operational levels will allow humans to be capable of concentrating on strategic matters

- Improved customer **response**: the IoT can help achieve more reliable deliveries and a better service level. It is also possible to detect changes in demand more quickly and to make the adjustments required to better cover demand.

According to the consulted information and the interpretation of the authors who wrote the present work, the IoT can be **characterised** by the following four basic aspects:

1. **Reliable and accurate data collection**. The sensors and elements (things), designed according to the environment in which they must work, are capable of collecting very reliable and accurate data

2. **Capacity to collect a huge quantity of data**. The development of information technologies enables huge quantities of data to be stored and processed

3. **Rapid data transmission**. Today's communication technologies enable huge quantities of data to be transported in a very short time (e.g. wireless technologies), and confer "things" with a real-time response capacity

4. **Automated processes**. "Things" can become completely autonomous, and entire activities (data collection, calculations and data processing, sending signals with messages, etc.) and whole processes can be performed, including decision making.

4 Using the IoT in the PPP

After identifying the IoT characteristics, this section analyses which ones can be applied to the PPP to improve it.

Along the same lines as the work of Meyer et al. (2011), in order to analyse which characteristics the IoT can provide to improve the PPP, two main groups were established for the phases, activities or tasks of the PPP, depending on whether its purpose is to: a) develop a plan/programme (Strategic planning, Tactical planning, Master planning and Component programming); or b) run it and control it (Execution and Control). The nature and operation of each group of phases (developing and execution/control), their objectives and, especially the information to be used, will be clearly different. An IoT application to improve the PPP should, therefore, bear in mind these differences by adapting the performance of "things" to the type of process phases which they are to interact with. Next the use of the IoT is analysed for these two groups of PPP phases or activities: developing plans and executing and controlling these plans.

The information that required to **develop plans** is basically demand (forecast and/or firm), forecasting the supply capacity of suppliers and the company's capacities (production, assembly, storage, distribution and installation), and forecasting the status of inventories (at the corresponding information aggregation level in each case).

To develop plans, the IoT can contribute reliable and accurate data collected from points of sale and customers (demand), which will fine-tune forecasts and improve the quality of plans. Reliable and accurate data can be essential as far as the company's capacities and the status of the inventories are concerned.

The IoT's capacity to collect and work with huge quantities of data will be fundamental to create lists and to calculate forecasts according to the number of articles to be managed. It will also be important for processing information on the company's capacities, depending on the number of sections, human resources, machines and the complexity of the production process.

The possibility that the IoT offers for automating these tasks must be suitably assessed and used to improve efficiency and to reduce errors and costs. As far as rapid data transmission is concerned, the IoT characteristic is considered of little relevance to develop plans if we bear in mind the horizons and dates that are usually dealt with, and it is not strictly necessary to acquire input data for real-time plans.

However, for **executing and controlling the plan**, the IoT characteristic will be extremely valuable for rapid data transmission. To execute and control the plan, it will be necessary to know the plan itself in adequate detail and the performance of all our resources, preferably in real time, so that we can react as soon as possible to incidences or deviations from the plan. Likewise, the reliable and accurate data collection that the IoT offers can be used to send plans and to execute them, and to also follow-up and exactly control their execution. Automation is also considered most important for this case, and the IoT performs tedious, hazardous, complex or repetitive tasks. Perhaps the least relevant IoT characteristic to execute and control the plan is the capacity to collect a large quantity of data, but what is really necessary in this case is to follow-up what occurs in the plant in real time.

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6 References

Carretero J, and García JD (2014) The internet of things: Connecting the world.18(2): 445-447. doi: 10.1007/s00779-013-0665-z.

FInES (2012). "FInES research roadmap 2025." future internet enterprise systems cluster (FInES). Retrieved 01/14, 2015, from http://cordis.europa.eu/fp7/ict/enet/documents/fines-research-roadmap-v30_en.pdf

Gubbi J, Buyya R, Marusic S, and Palaniswami M (2013) Internet of things (IoT): A vision, architectural elements, and future directions.29(7): 1645-1660. doi: 10.1016/j.future.2013.01.010.

Mao Cuiyun, and Han Yuanhang (2010) *Discussion on the application of internet of things in logistics production management* doi: 10.1109/ICEE.2010.979

Meyer GG, (Hans) Wortmann JC, and Szirbik NB (2011) Production monitoring and control with intelligent products. Int J Prod Res, 49(5): 1303-1317. doi: 10.1080/00207543.2010.518742.

Meyer GG, Fr\amling K, and Holmstr\om J (2009) Intelligent products: A survey. Comput.Ind., 60(3): 137-148.

Miorandi D, Sicari S, De Pellegrini F, and Chlamtac I (2012) Survey internet of things: Vision, applications and research challenges.10(7): 1497-1516. doi: 10.1016/j.adhoc.2012.02.016.

Slack N, Chambers S, & Johnston R (2004) *Operations management*. Harlow: Pearson Education.

Tan J, and Koo SGM (2014) *A survey of technologies in internet of things* (Marina del Rey, CA ed.) doi: 10.1109/DCOSS.2014.45

Teng Yue (2011) *Internet of things technology application in the food supply chain management* doi: 10.1109/ICEBEG.2011.5882613

Thoma M, Antonescu A, Mintsi T, and Braun T (2013) Linked services for enabling interoperability in the sensing enterprise. In M. van Sinderen, P. Oude Luttighuis, E. Folmer & S. Bosems (Eds.), (pp. 131-144) Springer Berlin Heidelberg. doi: 10.1007/978-3-642-36796-0_12

Vieira GE, Herrmann JW, and Lin E (2003) Rescheduling manufacturing systems: A framework of strategies, policies, and methods.6(1): 39-62.

Wang XF (2014) *Research on security issues of the internet of things* doi: 10.4028/www.scientific.net/AMR.989-994.4261

Whitmore A, Agarwal A, and Da Xu L (2014) The internet of things-A survey of topics and trends. Inf.Syst.Front.,: 1-14. doi: 10.1007/s10796-014-9489-2.

Yu Gu, and Tiaobin Jing (2011) *The IOT research in supply chain management of fresh agricultural products* doi: 10.1109/AIMSEC.2011.6011477

Zhou L, Chong AYL, and Ngai EWT (2015) Supply chain management in the era of the internet of things. Int J Prod Econ, 159(0): 1-3. doi: http://dx.doi.org/10.1016/j.ijpe.2014.11.014.

Re-location of EMS Facilities Using GIS

Fares E[1] **and Musharavati F**[2]

Abstract: This paper studies the usefulness of contemporary geographic information system tools in re-locating emergency medical service (EMS) units on periodical bases. Research has already shown that the service level of an EMS system is highly related to many factors. Such factors include; (a) factors associated with the environment that is surrounding the EMS facility, and (b) factors associated with the design and operations of the EMS system itself. Since most of these factors are dynamic and since they change periodically, it is often necessary to re-locate and assess the effectiveness of an EMS system occasionally. In this paper, the EMS system in Qatar was used as a case study. Geographical information system (GIS) tools were implemented to assess the effectiveness of the locations of EMS units with respect to current demand. A comparison of the re-located EMS with the current EMS showed differences in the service area covered.

Keywords: EMS, GIS, re-location, facility planning and layout, simulation, healthcare.

1 Introduction

Facility location allocation models provide an optimal location and allocation of facilities in order to supply a set of demand points. The literature in this field is vast since facility location allocation is considered as a critical element in strategic planning for both private and public sectors. The facility planning and layout problem becomes more crucial when the systems under consideration are related to human beings since any inefficient location and allocation could result in the loss of human life.

A typical example of systems that can use facility location allocation models are emergence medical service (EMS) systems. A specific example of EMS systems is the location and allocation of ambulance vehicles. As stated by the Institute of Medicine in USA; "…safe, effective, patient centered, timely, efficient, and equitable care service…" are all considered as dimensions of quality care (Committee on the Future of Emergency Care in the United States Health System Board on Health Care Services, 2006). The discussions in this paper focus more on response time as one of the most important indicators for a quality service in EMS systems. For ambulance service systems, response time covers simply the period from receiving an urgent call until an ambulance reaches the scene (Breen, Woods, Bury, Murphy, & Brazier, 1999).

As stated by American Heart Association within four to six minutes after cardiac arrest, the brain death and permanent death occur and the chance to survive is reduced by 7% to 10% with every minute that passes without advanced life support assistance (Ludwig, 2004). Furthermore, based on the National Fire Protection Association 1710 standard, 90% of EMS calls have to be covered within four minutes or less (Office of Strategic Health Autohrities, 2009). Consequently, the response time of an EMS system should not exceed 10 minutes if saving lives is the principal mission of the EMS system. Accordingly, there is an inherent need to make sure, from the beginning, that the EMS facilities are located in the right location. However, due to the increasing complexity of the real-life EMS systems there is a growing need to use advanced tools and methods that are capable of solving EMS location allocation problems in reasonable time.

One of the tools that has gained popularity in solving EMS problems is the geographic information system. GIS is "an organized collection of computer hardware, software, geographic data, and personnel designed to efficiently capture, store, update, manipulate, analyze, and display all forms of geographically referenced information to support geographical decision making" (Murray, 2010). It is also a powerful

1 **Enas H. M. Fares** (enas.fares@qu.edu.qa)
2 **Farayi Musharavati** (Farayi@qu.edu.qa)
Department of Mechanical and Industrial Engineering,
College of Engineering, P.O.Box 2713, Doha, Qatar

and efficient instrument to: i) make location decisions specially for dynamic and complicated conditions, ii) find the best location , iii) find the best way to get to that location, and iv) optimize the use of the available resources (Vafaeinezhad, Alesheikh, Hamrah, Nourjou, & Shad, Using GIS to Develop an Efficient Spatio-temporal Task Allocation Algorithm to Human Groups in an Entirely Dynamic Environment Case Study: Earthquake Rescue Teams, 2009).

GIS has been used in many researches related to facility location allocation. For example, Vafaeinezhad, et al. (Using GIS to Develop an Efficient Spatio-temporal Task Allocation Algorithm to Human Groups in an Entirely Dynamic Environment Case Study: Earthquake Rescue Teams, 2009) modeled task allocation to persons in a totally dynamic and complicated environment where they used GIS to simulate data, and to generate and evaluate the results of the tasks for two groups of life-detectors and rubble-removers of earthquake rescue teams. Thus, GIS used here as both to generate inputs and to find problem solution. GIS has also been used by Rodrigues, et al. (Solving a location-routing problem with a multiobjective approach: the design of urban evacuation plan, 2012) as source of input data and to present model results. Similarly, Bender, et al. (location software and interface with GIS and supply chain management, 2002) used GIS to export attribute and coordinate information to be used in location modeling problems. In Bozakaya, et al (A GIS-Based Optimzation Framework for Competitive Multi-Facility Location-Routing Problem, 2010), a Tabu search heuristic algorithm was coupled with GIS software to solve a vehicle routing problem. It was also used to store, analyze and visualize the location routing solutions.

The remaining of this paper is organized as follows: section 2 describes the background of the case study used in this research. Section 3 states the method and tools used to solve the problem. Section 4, discusses the results and finally the conclusion is presented in section 5.

2 Background

EMS design and operational issues differ from country to country. In the State of Qatar, for example, the population is continuously increasing. Therefore, it is sometimes necessary to evaluate and re-evaluate the performance of an existing EMS in order to avoid operating a sub-optimal EMS system. In the state of Qatar, the EMS system incorporates more than one type of facility, namely; (i) static facilities, which are ambulance hubs and, (ii) transportation facilities, which are mainly represented as ambulance vehicles. The focus of this paper will be on the transportation facilities. Since GIS is a very promising tool which offers multiple functions that could in principle be used for solving facility location allocation problems, this research focused on using GIS in location-allocation problem setting in order to solve location-allocation problem for the EMS system in the state of Qatar.

3 Methodology

In this paper ArcGIS 10.1 was used for location allocation analysis of the EMS system. ArcGIS 10.1 is a software capable of analyzing both spatial and non-spatial data (Zhang, Johnson, & Sutherland, 2011). ArcGIS location-allocation analysis tool includes six problem types, namely; minimize impedance (p-median), maximize coverage, minimize facilities, maximize attendance, maximize market share and target market share. In this paper, the maximize coverage model in ArcGIS was used. In implementing the maximal covering problem, a geodatabase was created. The geodatabase included the following GIS layers: (i) road network, (ii) spatial distribution, (iii) population district polygons, and (iv) candidate locations of EMS units.

In a maximal covering model, facilities are located such that as many demand points as possible are allocated to solution facilities within an impedance cutoff. Impedance cutoff is a predefined critical distance or time between a facility and a demand point. For example, in EMS systems the impedance cutoff is the response time which in our target is 10 minutes. Therefore, any emergency case that is positioned within 10 minutes or less from a facility will be served by that facility. For EMS location this model is important because emergency services are required to arrive at all demand points within a specified response time. The mathematical representation of maximal covering model is shown below.

$Max\ \sum_{i=1}^{m} h_i Z_i$ (3.1)

Subject to:

$Z_i \leq \sum_{j=1}^{n} a_{ij} X_j \quad \forall\, i$ (3.2)

$\sum_{j=1}^{n} X_j \leq P$ (3.3)

$X_j \in \{0,1\} \quad j = 1,2,\ldots,n \quad \forall\, j$ (3.4)

$z_i \in \{0,1\} \quad i = 1,2,\ldots,m \quad \forall\, i$ (3.5)

where,

$$X_j: \begin{cases} 1, if\ the\ facility\ is\ located\ at\ point\ j, \\ 0, otherwise \end{cases}$$

$$Z_i: \begin{cases} 1, if\ the\ demand\ point\ i\ is\ covered\ , \\ 0, otherwise \end{cases}$$

$$a_{ij}: \begin{cases} 1, if\ the\ distance\ from\ candidate\ point\ j\ to\ the\ demand\ point\ i \\ \ \ is\ not\ greater\ than\ S, \\ 0, otherwise \end{cases}$$

i: Index of demand points, i=1,2,3,…m; j: Index of candidate location points of facility, j=1,2,3,…,n; S: The maximum acceptable service distance; P: The total required servers to be located.

To compare between the effectiveness of the existing and proposed models, GIS simulation was used. More specifically, service area analysis was used. In service area analysis, the GIS was asked to generate the service area for 8, 10, and 15 minutes. The generated areas where used to find the number of covered districts regardless of whether they are populated or not. They are also used to find the number of populated districts and the number of covered population. Obtained results are discussed in section 4.

4 Results

Using the maximal covering model, a GIS based EMS system was developed by seeding existing locations of EMS units. This was regarded as an exercise to update/upgrade the existing EMS system using the recent population data. The reason for this procedure was to find out if the GIS environment can be used iteratively i.e. in two steps to provide a better EMS system. Thus, all existing EMS units' locations were seeded as candidates locations and the GIS asked to select 49 units (the exact number of existing EMS units) in such a way to meet the objective (i.e. maximal the covering). It was expected that all 49 units would be selected. However, even at a cut-off value of 5 to 60 minutes, it was observed that only 43 units of the existing were selected and the rest of the unselected EMS units were considered as redundancy i.e. units that do not add any value to the EMS system. This could be an indication that the existing system is over designed.

In order to compare between the two systems, service area analysis for ambulance response times of 8, 10, and 15 minutes was applied. The summary of the service areas analysis is shown in Fig. 1, Fig. 2, and Fig. 3 while the locations of EMS units for the existing and the updated systems are represented in Fig. 4.

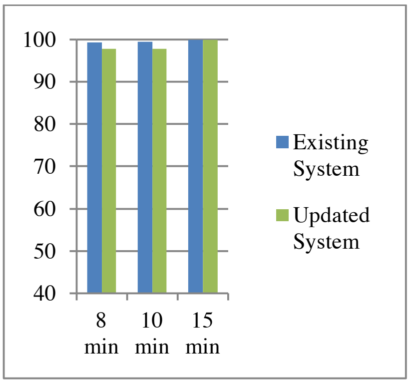

Fig.1
Percentage of covered population for the two alternative EMS systems.

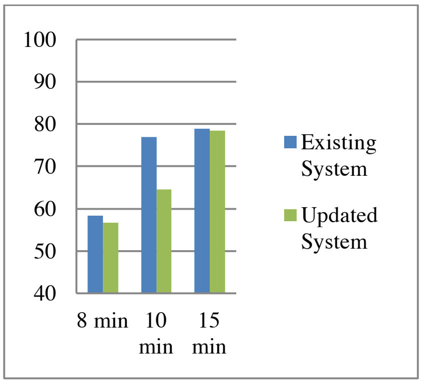

Fig.2
Percentage of covered districts for the two alternative EMS systems.

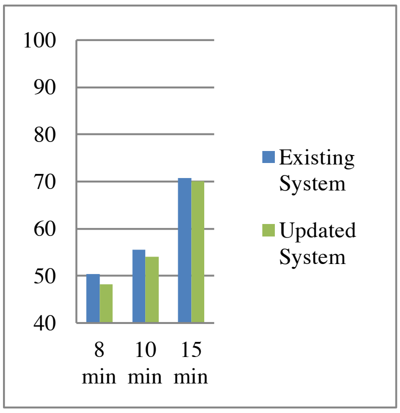

Fig.3
Percentage of covered populated districts the two alternative systems.

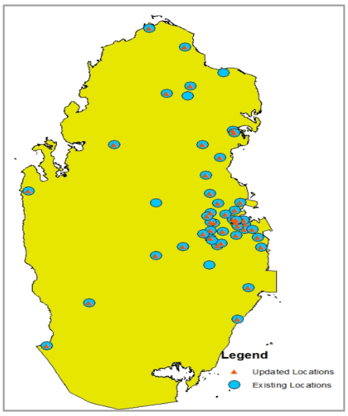

Fig.4
Existing vs. updated EMS locations.

Based on the population data, (Fig. 1), it is found that the existing system generate better results if we are considering the population data points. However, in Fig. 2 and Fig. 3, the new system proposed by the GIS method gives almost the same results as the existing system although the EMS units is only 43 i.e. less by 6 units. This may suggest that the redundancy in the existing system makes the system more costly but without any gain in the performance of the system if the service providers focusing on the number of district covered. Consequently, determining the best system to apply is depending on the service provider objectives. For example, if the service provider considers the number of population covered as the main objective, the existing system will be preferred. However, if the number of districts covered and the cost of the system are the main focus, then, the proposed system is preferred.

5 Conclusions

In conclusion, it is found that the GIS environment can be used to model, simulate, assess, evaluate and compare the performance of a number of EMS systems. The results also showed that the suitable location and allocation of EMS facilities is determined by first deciding the main objective and focus of the EMS system.

It can be noted that surprisingly, the GIS based proposed system was designed with only 43 EMS units while the existing system currently operates with 49 EMS units. This could be an indication that the existing system is either over designed or was designed to operate with some redundancy. Obtained results have shown that the performance of the system with 43 EMS units (re-located system) is comparable with the performance of the system with 49 EMS units if the objective is to maximize the number of districts covered and reduce the cost.

6 References

Bender, T., Hennes, H., Kalcsics, J., Melo, M. T., & Nickel, S. (2002). location software and interface with GIS and supply chain management. In Z. Drezner , & H. W. Hamacher (Eds.), *Facility location: applications and theory.* New yourk: Springer.

Bozakaya, B., Yanik, S., & Balcisoy, S. (2010). A GIS-Based Optimzation Framework for Competitive Multi-Facility Location-Routing Problem. *Networks and Spatial Economics, 10*(3), 297-320.

Breen, N., Woods, J., Bury, G., Murphy, A. W., & Brazier, H. (1999). A national census of ambulance response times to emergency calls in Ireland. *Emergency Medicine Journal*, 392–395.

Committee on the Future of Emergency Care in the United States Health System Board on Health Care Services. (2006). *Emergency medical services at the crossroads.* USA: The National Academies Press.

Ludwig, G. G. (2004). *EMS World website: EMS Response Time Standards*. Retrieved 3 10, 2013, from http://www.emsworld.com/article/10324786/ems-response-time-standards

Murray, A. T. (2010). Advances in location modeling : GIS linkages and contributions. *Journal of Geographical systems, 12*(3), 335-354.

Office of Strategic Health Autohrities. (2009). *Emergency Service Review: A comparative review of international Ambulance Service best practice.*

Rodrigues, J. C., Tralhão , L., & Almeida, L. A. (2012). Solving a location-routing problem with a multiobjective approach: the design of urban evacuation plan. *Journal of Transport Geography, 22*, 206-218.

Vafaeinezhad, A. R., Alesheikh, A. A., Hamrah, M., Nourjou, R., & Shad, R. (2009). Using GIS to Develop an Efficient Spatio-temporal Task Allocation Algorithm to Human Groups in an Entirely Dynamic Environment Case Study: Earthquake Rescue Teams. *Computational Science and Its Applications, 5592*, 66-78.

Zhang, F., Johnson, D. M., & Sutherland, J. W. (2011). A GIS-based method for identifying the optimal location for a facility to convert forest biomass to biofuel. *Biomass and Bioenergy, 35*, 3951-3961.

Supply Chain Risk Management: a framework for risk assessment and the application of Decision Support tools

Cruz C[1], Ferreira L[2]

Abstract: Supply Chain Risk Management (SCRM) is in the agenda of both academics and entrepreneurs. In a context of increasing competitiveness and globalisation of relationships between organisations, the understanding of Supply Chains (SC) underlying mechanisms, as well as related phenomena which might result in competitive advantage may dictate the difference between success and failure. SCRM is, therefore, a global concern. There is a growing need to know organisations' reality in real time, to create models and tools that allow them dealing with these challenges. The volatile business context, as well as the increasing pace of change in terms of products, technologies and other variables changes SC exposure to risk, and also the very nature of risk itself. Thus, typically stable and predictable SC, due to evolution, economic conjuncture or globalisation, might be exposed to increased disruption risk. Due to the magnitude of their impact on organisations, both in operational and financial terms, as well as their recovery ability, disruptions must be the object of particular caution and analysis. Within this scope, tools that enable organisations to deal or reduce the risk of disruptions, from mitigation strategies to flexibility or alternative scenario planning are primordial in the recovery and reestablishment of SC.

Keywords: Supply Chain Risk Management, Decision Support tools, disruption, mitigation.

1 Research goals

SCRM has suffered a significant increase in the number of related publications. This trend may suggest a growing interest in the topic, both in academic and managerial contexts. However, the increasing number of publications reveals heterogeneity of approaches and scopes whose analysis and synthesis through a systematic literature review may help to clarify what is known and unveil future research opportunities (Seuring, 2012). SCRM literature points out the urgency of creating, developing and adapting Decision Support (DS) tools to manage SC risks. Researchers must be motivated to develop new models for managing risk, particularly quantitative models, as their current scope is primarily on operational risks, instead of disruption events (Tang, 2006; Tang and Musa, 2011).

This research starts with a review of SCRM literature, looking for state of the art techniques for mapping complex, multi-echelon SC, identifying potential risk in each level, analysing risk and evaluating its impact in terms of disruptions in SC (IEC/ISO 31010, 2009), based on metrics that may be related to response time, recovery costs and other considered relevant. By having a deeper knowledge on the nature and impact of risk, criteria may be defined to prioritise risk, thus allowing it to be treated according to objective metrics.

1 **Carla Cruz** (cscruz@ipb.pt)
Dpto. de Gestão Industrial. Escola Superior de Tecnologia e Gestão.
Instituto Politécnico de Bragança. Campus de Santa Apolónia. 5300-253 Bragança.

2 **Luis Ferreira** (lmferreira@ua.pt)
Departamento de Economia, Gestão e Engenharia Industrial.
Universidade de Aveiro. Campus Universitário de Santiago. 3810-193 Aveiro.

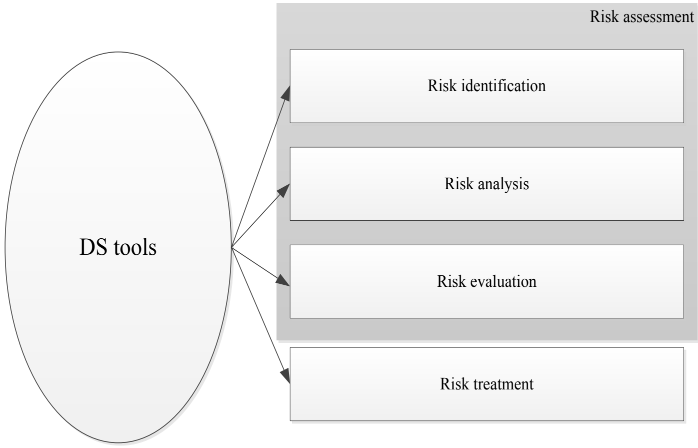

Fig.1
Adapted from the "Contribution of risk assessment to the risk management process".
(source: IEC/ISO 31010, 2009)

Afterwards, applicable DS tools will also be identified, found in the literature reviewed, as well as the scope for their use. A special attention will be paid to quantitative tools as, according to relevant academics in the area of SCRM, they are lacking (Tang and Musa, 2011).

By mapping SC and categorising risk events, as well as researching relevant DS tools, it will be possible to build a framework that enables its users to perform the identification of potential risks and their impact on the SC. This framework will be designed in accordance with IEC/ISO 31010 (Risk management – Risk assessment techniques) and subsequently adjusted to real situations. This construct will enable the application of adequate risk reduction or mitigation strategies (Simangunsong et al., 2011).

With the help of this model, SCRM will be addressed as a process that begins with in depth knowledge of the SC, by mapping all the levels and their interveners, goes on with risk identification, analysis and evaluation and proceeds to the stage of risk treatment through the application of the appropriate DS tools, in accordance with priorities defined.

2 Research questions

SCRM is a very broad research area, whereby it is fundamental to define the scope for the present study. The focus is SC mapping, risk assessment (identification, analysis and evaluation) and the use of DS tools in risk management. Within this context, the research questions for this study are listed below:

RQ1: How can risk be classified in terms of SCRM?

RQ2: What metrics can be used to assess the impact of risk in SC?

RQ3: Which DS tools or techniques can be used to address risk in SC?

RQ4: How can multi-echelon SC be mapped?

RQ5: What metrics can be used to evaluate the performance of DS tools and techniques in reducing or mitigating risk events?

3 Methodology

This study will start with a literature review on the topic of SCRM. The main focus will be on risk assessment, DS tools and SC mapping techniques. This literature review will be based on a list of sources, such as journals, books and online databases. Literature will be reviewed according to topic, theory and methodology.

This theoretical background will then be applied to real situations, using primary or secondary data, as the research questions presented seek an understanding of reality and phenomena that lead to an empirical study.

In depth case study will also be conducted, in order to apply the reviewed theory, mapping a real multi-echelon SC, assessing risk and the appropriate toolkit in terms of DS tools.

Currently, the final steps of the literature review phase are undergoing, aiming for a systematic approach that might validate the identification of gaps and research opportunities.

4 Research outcomes

By the end of the present study, the author intends to obtain the answers to the RQ presented and, by doing so, to create an approach to the risk management process within the scope of SCRM that might be applicable in real context.

The aim of this study is to describe the current state of research in the area of SCRM, particularly in what concerns to the assessment of risk events. By using IEC/ISO 31010 framework, it will be possible to identify and categorise DS tools, and their application in the risk management process.

Overall, the author expects to take the SCRM research area a bit further in terms of the knowledge related to the application of DS tools, while developing a framework according to the IEC/ISO 31010 that might be applied in diverse managerial contexts to assess and manage risk.

5 References

IEC/ISO 31010, (2009). Risk management – Risk assessment techniques, Ed. 1.0, ISBN 2-8318-1068-2

Seuring, S., & Gold, S. (2012). Conducting content-analysis based literature reviews in supply chain management. Supply Chain Management: An International Journal, 17(5), 544-555.

Simangunsong, E., Hendry, L. C., & Stevenson, M. (2012). Supply-chain uncertainty: a review and theoretical foundation for future research. International Journal of Production Research, 50(16), 4493-4523.

Tang, C. S. (2006). Perspectives in supply chain risk management. International Journal of Production Economics, 103(2), 451-488.

Tang, O., & Musa, S. N. (2011). Identifying risk issues and research advancements in supply chain risk management. International Journal of Production Economics, 133(1), 25-34.

6 Annex

Luís Miguel D.F. Ferreira is an assistant professor of Supply Chain Management with the Industrial Engineering and Management Department of the University of Aveiro and a researcher with the Centre for Governance, Competitiveness and Public Policy. He received his PhD from the Universidade Técnica de Lisboa. His research interests include: Supply Chain Management and Supply Management.

Understanding Employee Resistance to 5S Implementation in a Portuguese SME

Amorim M[1], Pires C[2]

Abstract: It has been extensively acknowledged that the adoption of quality and Lean techniques make a positive contribution for the competitiveness of organizations. However, evidence suggests that their kick-off implementation can involve substantial difficulties, arising from staff resistance and lack of familiarity with the specific methods and tools. This has been particularly noticed in the case of small and medium sized companies (SMEs), which often lack the resources and the internal capabilities to invest in adequate training. In this paper we present the results of an internal questionnaire employed by a Portuguese SME, for stimulating employee awareness about the benefits from the implementation of 5S.

Keywords: 5S, Lean, Quality, SMEs.

1 Introduction

Whereas the implementation of quality management philosophies is acknowledged as a key driver of manufacturing performance, and the knowledge about existing tools for quality improvement has become widely disseminated, the systematic adoption of such methodologies still creates important challenges for small and medium sized companies (SMEs). Small manufacturers often operate with very limited resources, a context which poses important constraints to introducing operational changes, for the elimination of waste and the improvement in productivity. For these companies the adoption of hands on methodologies, such as the 5S technique described in this paper, may offer an important initial step to address quality problems, and to fight existing inertia in the production and staff routines (Kumar and Madu, 2005).

In this paper we describe the kick-off of the application of the 5S methodology in a Portuguese SME (a manufacturer of furniture for the healthcare sector). The company experienced difficulties in the control of raw materials, which had been leading to inefficiencies in the management of resources. The lack of systematic quality management practices, inserted a progressive inertia in the production system, notably in staff routines and attitudes towards change. Moreover, these problems were aggravated by the recent growth on the operational volume and variety, as the company steadily had been investing and progressing towards new export markets. The paper addresses the key difficulties and sources of resistance found in the kick-off process, and presents the results of a communication strategy adopted to surpass them: the conduction of an internal questionnaire to assess the employees' perceptions about the existing quality and Lean practices in the company, and the expected benefits from implement the 5S technique. The results of the questionnaire were communicated internally and contributed positively to build up the workers acceptance towards the quality program, with many of them contributing with suggestions which were useful to the preparation of the 5S implementation strategy. The preliminary preparation phase was determinant for the effective follow up of the 5S routines, an involved the setup of teams which were responsible for the development of strategies to disseminate the objectives of the 5S technique, and to motivate the employees. This approach contributed to achieve an early visibility of the 5S results across the company, leading to a reinforced employee's commitment in the implementation.

1 **Marlene Amorim** (mamorim@ua.pt)
2 **Carla Pires** (e-mail: carlajoao@ua.pt)
Dept. of Economics Management and Industrial Engineering.
University of Aveiro. Campus Universitário de Santiago, 3810-193, Aveiro, Portugal.

2 Quality and Lean Management

2.1 Quality and Lean Approaches and Techniques

Organizations commit a considerable volume of resources to implement quality management systems to effectively compete in increasingly sophisticated contexts (e.g. evolving customer requirements, sustainability issues, legislation, etc.) (Kaynak, 2003). Such investments build on the existing evidence that suggests that companies that deploy quality management models improve their ability to meet customer requirements, achieving gains in productivity and efficiency (Khan, 2003).

Quality management models, methods and tools that are prevalent in today's practice reflect a hands-on approach to quality, i.e. a perspective that promotes an active involvement of all staff across an organization in a shared effort of continuous improvement (Bou and Beltrán, 2005). The guiding principle of this management philosophy is to achieve world class quality in products and services, building on a culture of participation, teamwork and learning, promoting a continuous zeal for improvement (Reed et al., 2000). The deployment of quality management across organizations is supported by a number of techniques and tools that have been developed to reflect the values of modern quality management philosophies, in particular the ability to involve and engage all actors in an organization in the quality improvement processes (Tari and Sabater, 2004).

The development of quality management efforts often goes hand-in-hand with the adoption of Lean philosophies, i.e. the pursuit of the objective of eliminating waste, to increase productivity and efficiency. Much alike in quality management thinking, Lean approaches touch both at the strategic and the operational level. The operational level deals with the various tools and practices support the organizational changes for the elimination of waste and pursuit of continuous improvement (Demeter and Matyusz, 2011).

2.2 The 5S technique

5S is a commonly used technique to achieve and maintain a well-organized, and clean workplace for the pursuit of work effectiveness and quality, originally developed by Osada (1991) as a baseline tool for quality improvement.

The maintenance of an orderly work environment is considered an important step for embedding in the organization the values of cleanliness, order, standardization and discipline. To this end, the implementation of 5S is often one of the first lean practices implemented by companies pursuing quality and lean management goals (Chapman, 2005). 5S - short-stands from the Japanese words for: *sort*, *set in order*, *shine*, s*tandardize*, and *sustain*, that are defined as follows (Hirano, 1996): *Sort*: Refers to the practice of sorting through all the tools, materials, etc., in the workplace with the goal of keeping only essential items, whereas everything else should be stored or discarded. Sorting thus removes the excess, broken or obsolete materials, clearing up floor space. The results include the reduction of hazards and less clutter to interfere with productive work; *Set in Order*: Refers to the need for having and orderly workplace. This involves the systematic arrangement of tools, equipment, and materials, in order to enable and easy and efficient access to them when necessary, using techniques such as the painting of the floors, outlining working areas and locations, using shadow boards, etc; *Shine*: Represents the need to implement the regular practice of keeping the workplace neat. To this end, regular practice include cleaning up working areas at the end of each sift; *Standardize*: Refers to the need for standardizing the best practices in order to achieve consistency on the application of the neat principles across the organization; *Sustain*: Refers to the maintenance of the archived standards in order to keep the workplace orderly and safe in the long run. Sustaining the aforementioned changes is considered the most difficult ''S'' to implement and maintain. Resistance typically accompanies the changes, and staff often turns back to the status quo.

The 5S technique therefore relies on the application of simple wisdom in a systematic manner. For this reason it can be introduced in management practice with ease, making it an attractive tool to kick-of changes in the organizational mindset required for initiating quality and Lean change processes in organizations. It's results include gains in the organization of the workplace, reduction of working area, and the improvement of the quality and safety of work (Bayo-Moriones et al., 2010).

While the benefits of 5s are extensively acknowledged in the literature, is is also recognized that its effective implementation (as well as with other quality and Lean techniques) is a long-term process, with frequent resistance of staff and return to initial status quo (Bou and Beltrán, 2005). This is particularly referred in the context of SMEs, not only due to the already mentioned limitations in resources and capabilities, but also to a disseminated perception that the quality and Lean frameworks have been developed and derived primarily from the context and experience of larger sized organizations rather than small businesses, therefore leading to questioning and resistance to their use (Kumar and Madu, 2005).

3 A Case of 5S Implementation in a Portuguese SME

3. 1Company Context and Motivation for the Adoption of 5S

This study reported on this paper was developed in the context of the implementation of 5S in a Portuguese manufacturer of geriatric and hospital furniture (e.g. electric beds, emergency trolleys, etc.).Having started business as a small locksmith, the company experienced an important growth in recent years – with increases in sales reaching about 15% annually – and a growing presence in international markets. By transforming a once small family business into an international manufacturer, these circumstances determined profound changes in the organizational context and culture. Together with the need for a physical expansion of the workplace, as well as of the staff (employing about 90 people at the time of the study), the company was forced to embrace quality and lean management principles, in order to compete with world class manu-factures in the international scene. Together with the implementation of the production standards required in its competitive context (e.g. ISO 14001), the management team felt the need to start creating the adequate environment for the development of a quality management system.

5S offered an adequate approach for the management team to initiate the aimed processes of change and improvement for several reasons, including: the possibility of involving all the different staff (e.g. from top management to production line workers, young employees as well as more senior staff the was in the firm since its establishment, etc.); its simplicity and intuitiveness, including for example the extensive utilization of visual clues in processes of setting the work space in order; and the potential for evidencing improvements in a relatively short period of time (e.g. by means of the preliminary results of sorting and setting in order activities). The prospect of evidencing results in a short period of time was considered an important aspect for the company, notably for motivating and engaging the relatively more reluctant senior staff in the desired processes of change and improvement.

The implementation of 5S was initiated in two vital departments of the company: the so-called production area that included the key transformation operations necessary for the production of the furniture (e.g. involving operations such as laser cutting, metal bending and pressing, drilling. etc.), and the assembly and expedition sector. The choice for the kick-off of 5S implementation relied on the departments which exhibited stronger volumes of waste and cluttering. The goal was to achieve visible results in a short period of time in these departments, in order to benefit from the visibility of such results to motivate the further adoption of 5S methods to other areas in the workspace.

3.2 Understanding Challenges in the Kick-off of 5S

In the kick-off for the implementation of 5S the company experienced the usual resistances and difficulties of small and medium sized enterprises (SMEs). It is recognized that SMEs face limitations in the resources available, such as in the volume of staff, the access to adequate skills and the financial resources for investments in the aimed processes of change (Antony et al., 2005). Lack of familiarity with quality management and lean concepts and practices is also very common in these contexts, often leading to a misunderstanding of the purpose and concepts in stake. Moreover, SMEs often face the important issue of lack of motivation, or staff resistance, to the implementation of the quality and lean techniques. Such resistance is often driven by beliefs that the implementation of techniques such as 5S can affect the way that staff organizes their daily working routines, and that it can lead to subsequent reduction in staff in the pursuit of productivity gains (Achanga et al., 2006). All these elements were present in the context of this study. The familiarity of the staff with specific quality and lean techniques was rather low – both in senior staff that was in the company since its inception and small size, a context were standardized quality management methods were not in place, and in younger staff, employed by the company as a response to the recent growth, which overall had very few years of work experience (for many the work in the company was their first job experience).

In order to address the resistance to the kick-off for the implementation of 5S, the management team employed several standard approaches for these situations, including the dissemination of information by means of awareness and training sessions involving both the operational and managerial staff. In addition the company decided to develop an internal questionnaire to assess the awareness of employees about the existing wastes and the need for changes in work practices and in the organization of the work place. The questionnaire included 18 items related to the various phases of 5S implementation, and used a closed response approach, asking respondents to rate the given statements about their perceptions and behaviors of cleanliness and discipline in a scale from 1 (Never) to 6 (Always). The questionnaire included two main parts: one asking staff to state their perceptions about the existence of quality and Lean practices in their department or section (e.g. “All the materials in my section are being used”; “The stock of material sin my section is organized”; “It’s easy to access to the materials in my section when we need them”, etc.) ; and a second part where respondents were asked to state their perceptions about their own behavior in terms of quality and Lean practices (e.g. “I use all the resources at my disposal before I request for new ones”; “I keep my workplace neat and clean”; etc.). The questionnaire was applied across all the sections in the organization, as follows: Raw Materials and Cut Section (3 questionnaires); Transformation (9); Welding (12); Metal (7); Polish (2); Paint (6); Assembly (18) and Administration (14). Respondents were included a majority of male staff (about 90%).Women were essentially present in administrative functions. Regarding age, most respondents were in the intervals [23, 34] and [35, 54], (about 90%). As for work experience in the company, only 1,8% were there for more than 20 years. The remaining were distributed as follows: less than 5 years (25,4%),]5, 10], (40,8%) and]10, 20] (32,4%).

The preliminary analysis of the results[3] revealed that respondents had positive perceptions about the organization’s, as well as about their own practices regarding the maintenance of a clean and orderly work environment.

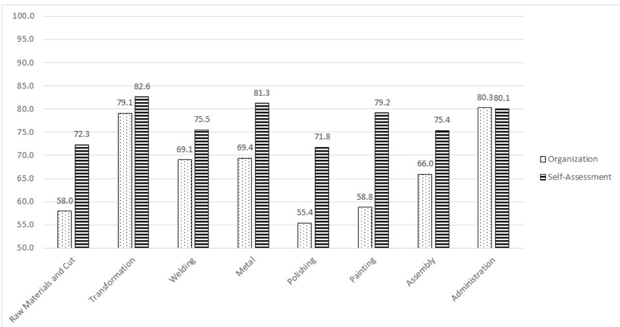

Fig.1
Average total ratings attributed by respondents to the 18 questionnaire items for the different company production sections.

When assessing the organizations’ about the cleanliness and organization of the workspace, only 18% summed up response ratings below 0.60 (indicating a perception of important gains to be obtained from a 5S implementation). This perception was even stronger in the results about the self-perceptions of cleanliness, organization and discipline: 100% of the responses attributed ratings above 0.6 to the total of 18 questionnaire items. Respondent’s self-perceptions about their quality and Lean practices were substantially higher that the perceptions they held about the organization (see Fig. 1). Moreover, respondents from the sections of painting and polishing expressed lower perceptions, both about the organization and their own behavior. A further analysis of the average and standard deviation for the responses per section, revealed also that overall respondents had higher perceptions about the

[3] Results were obtained using the following index:

$$\frac{\sum \boldsymbol{Ratings\ \ given\ by\ respondent\ to\ the\ 18\ questionnaire\ items}}{\boldsymbol{Maximum\ rating\ for\ the\ 18\ questionnaire\ items\ (18\ X\ 6\ (always)=108)}}$$

organizations' quality and Lean practices related to the first Ss (i.e. Sort, Set in Order …). As documented in Table 1, average responses about the frequency of observation of quality and Lean practices related to Sort include, for example values about 4.75 for the Transformation section, whereas the values fall for 1.39 for the questionnaire items related to the Sustain practices.

Table 1
Ratings attributed by respondents to the perceptions about the organization quality and Lean practices, arranged by group of questions and by production section - Averages (Av.) and Standard Deviations (S.D.).

Sections	SORT		SET IN ORDER		SHINE		STAND.		SUSTAIN	
	Av.	*S.D.*	Av.	*S.D.*	Av.	*S.D.*	Av.	*S.D.*	Av.	*S.D.*
R. Mat./Cut	3.67	*1.04*	3.76	*0.91*	3.25	*1.32*	3.17	*1.04*	1.15	*1.15*
Transf.	4.14	*0.52*	4.85	*0.66*	5.36	*1.03*	5.56	*0.58*	1.39	*1.39*
Welding	4.16	*0.88*	4.37	*0.90*	3.77	*0.96*	4.63	*1.32*	1.70	*1.70*
Metal	3.95	*0.48*	4.12	*0.66*	4.61	*0.78*	4.79	*0.57*	0.57	*0.57*
Polish	4.75	*0.71*	3.57	*1.62*	1.71	*0.06*	2.25	*1.06*	0.00	*0.00*
Paint	3.58	*0.66*	3.73	*1.43*	3.33	*1.26*	3.50	*1.14*	1.63	*1.63*
Assembly	3.95	*0.48*	4.06	*0.66*	4.24	*0.82*	4.08	*1.13*	1.34	*1.34*
Admin.	4.57	*0.77*	4.80	*0.67*	5.20	*0.68*	4.50	*1.47*	1.97	*1.97*

The same pattern seems to hold for the respondent's self-assessments (see Table 2), although again for this cases it is noticeable averages are significantly higher. Results suggest that one of the sources for employee resistance in adhering to a systematic implementation of 5S can be related to this asymmetric perception about their performance vs. the rest of the organization. The substantially high perceptions about self-behavior can induce in staff a disbelief in the benefits to expect from the implementation of quality and Lean techniques. The results were communicated to the company staff, leading to an increase in the awareness of the potential benefits for the 5S implementation. These results open a new perspective for the importance of analyzing employee motivation when initiating the implementation of quality and Lean techniques.

Table 2
Ratings attributed by respondents to their self-perceptions about quality and Lean behaviors, arranged by group of questions and by production section - Averages (Av.) and Standard Deviations (S.D.).

Sections	SORT		SET IN ORDER		SHINE		STAND.		SUSTAIN	
	Av.	*S.D.*	Av.	*S.D.*	Av.	*S.D.*	Av.	*S.D.*	Av.	*S.D.*
R. Mat./ Cut	4.33	*0.58*	4.50	*0.87*	4.19	*0.71*	4.67	*0.58*	4.50	*1.00*
Transf.	5.67	*0.50*	4.95	*0.57*	4.99	*0.49*	5.61	*0.42*	3.83	*0.66*
Welding	5.36	*0.81*	4.73	*0.59*	4.37	*0.74*	5.14	*0.50*	4.00	*0.89*
Metal	4.83	*1.47*	4.54	*0.47*	5.11	*0.51*	5.14	*0.94*	3.86	*0.80*
Polish	5.50	*0.71*	4.38	*0.53*	4.06	*0.71*	5.25	*1.06*	3.75	*0.35*
Paint	6.00	*0.00*	4.58	*0.44*	4.73	*0.83*	5.25	*0.76*	5.25	*0.76*
Assembly	5.00	*0.88*	4.55	*0.58*	4.56	*0.57*	4.84	*0.65*	3.89	*0.59*
Admin.	5.67	*0.49*	4.81	*0.78*	4.72	*0.72*	5.38	*0.55*	4.54	*1.14*

5 References

Achanga. P., Shehab. E., Roy. R., Nelder. G. (2006). Critical success factors for Lean implementation within SMEs. Journal of Manufacturing Technology Management. 17 (4): 460-471.

Bayo-Moriones. A., Bello-Pintado. A., Merino-Díaz de Cerio. J. (2010). 5S use in manufacturing plants: contextual factors and impact on operating performance. International Journal of Quality & Reliability Management. 27(2):217-230.

Bou. J. C.., Beltrán. I. (2005). Total quality management, high-commitment human resource strategy and firm performance: An empirical study. Total Quality Management & Business Excellence. 16 (1): 71-86.

Chapman. C. D. (2005). Clean house with lean 5S. Quality progress. 38 (6): 27-32.

Demeter. K., Matyusz. Z. (2011). The impact of lean practices on inventory turnover. International Journal of Production Economics. 133(1): 154-163.

Hirano. H. (1996). 5 pillars of the visual workplace. Productivity press.

Osada. T. (1991). The 5S's: five keys to a total quality environment. Tokyo: Asian Productivity Organization.

Khan. J. H. (2003). Impact of total quality management on productivity. The TQM magazine. 15 (6): 374-380.

Kaynak. H. (2003). The relationship between total quality management practices and their effects on firm performance. Journal of operations management. 21 (4): 405-435.

Kumar.A., J., Madu. C.N. (2005). Six sigma in small- and medium-sized UK manufacturing enterprises: Some empirical observations. The International Journal of Quality & Reliability Management. 22 (8/9): 860-874.

Reed. R., Lemak. J.D. and Mero. N.P. (2000). Total quality management and sustainable competitive advantage. Journal of Quality Management. 5: 5-26.

Tarí. J. J., Sabater. V. (2004). Quality tools and techniques: are they necessary for quality management?. International journal of production economics. 92(3): 267-280.

Using Mixed-Integer Linear Programming to solve a real distribution problem

Moura A[1]

Abstract: This work presents a mathematical model of Mixed-Integer Linear Programming to solve a distribution problem of a Portuguese company that has a minority of its suppliers whose material flow is performed in both directions. The objective is to determine a minimum cost daily route for a vehicle, which must collect and deliver cargo to multiple suppliers considering its time windows and the vehicle's capacity in terms of weight and volume. The contribution of this work involves the presentation of three mathematical models. The first two reflect the integration of Vehicle Routing Problem with Simultaneous Delivery and Pick-up with the Capacitated Vehicle Routing Problem with Time Windows. The third one is a model that packs all the items on pallets in order to be delivered to the suppliers, that reflects a Single Stock Size Cutting Stock Problem.

Keywords: Vehicle Routing Problem with Simultaneous Delivery and Pick-up; Capacitated Vehicle Routing Problem with Time Windows; 3D- Packing Problem.

1 Introduction

In a production company, the distribution process can directly or indirectly affect all stages of production and the distribution system, representing a significant percentage of 10% to 20% of the product's final cost (Toth and Vigo, 2002). From the supplier's perspective, a good transport service is vital, since the delays in the delivery will affect the production schedule, which might lead to an unsatisfactory service and affects the supplier-customer relationship. Thus, in this particular problem, an efficient and effective distribution is necessary in order to not jeopardize the production process and also to achieve higher performance at lower cost.

2 Objectives and Methodology

The company addressed in this work has a small minority of suppliers, where the flow of components is done in both directions. To create greater pressure on suppliers in order to force them to meet the delivery deadlines and to control in an effective way the material flow, the company intended to be responsible for the products transportation. Thus arising the need to optimize the transportation process and evaluate their costs that will be imputed to the company. Given the limited number of the suppliers the idea was to develop a mathematical model that optimizes the products flow and where the main objective is to minimize the total transportation cost between the company and suppliers. Taking into consideration this scenario, the first problem that must be dealt is an integration of two variants of the vehicle routing problem, called Vehicle Routing Problem with Simultaneous Delivery and Pick-up and the Capacitated Vehicle Routing Problem with Time Windows. According to the main objective, some improvements in the pallets loadings must also be considered in order to minimize the number of pallets that has to be delivered to the suppliers. So, the second problem that must be dealt is the 3-Dimensional Packing Problem.

1 **Ana Moura** (ana.moura@ua.pt)
CIDMA - Center for Research and Development in Mathematics and Applications.
University of Aveiro, Portugal.

4 Results

With the real data, the number of suppliers of the company is relatively small (a maximum of nine per route) and the weight and volume of the boxes in each route is always smaller than the vehicle's capacity. The models always achieve the optimal solution in a very low computational time when the real problems are solved. So, in order to test the efficiency of the presented models in bigger and more challenging problems instances, the benchmark tests (PDPTW) from (Li and Lim, 2001) were also used. The 3D-PP model was also tested with the benchmark problem sets thpack9, from (Ivancic et al, 1989).

5 Conclusion

In work a PDPTW and a 3D-PP mathematical model, applied to a real world case study is presented. The models of (Castillo and Westerlund, 2005) were modified and adapted in order to consider all the problem constraints and requirements. Considering the complexity of those problems it was proven that when applied to small scale problems, like the one presented in this work, it is possible to achieve optimal solutions efficiently generated in a reduced computational time by a standard solver.

References

Castillo I and Westerlund T (2005). An ε-accurate model for optimal unequal-area block layout design. Computers & Operations Research 32 429-447.

Ivancic N, Mathur K and Mohanty BB (1989). An Integer-programming based heuristic ap-proach to the three-dimensional packing problem. Journal of Manufacturing Operations Management 2 268-298.

Li H and Lim A (2001). A metaheuristic for the pickup and delivery problem with time win-dows. 13th IEEE international conference on tools with artificial intelligence (ICTAI) 160-170.

Toth P and Vigo D (2002). The vehicle routing problem, Philadelphia: Society for Industrial and Applied Mathematics 2002b, Eds:1-26.

Adapting transport modes to supply chains classified by the uncertainty supply chain model: A case study at Manaus Industrial Pole

Oliveira FL[1], Oliveira AR[2], Rebelo LMB[3]

Abstract: This paper discusses transport modes supporting Uncertainty Supply Chain Model (USCM) in the case of Manaus Industrial Pole (PIM), an industrial cluster in the Brazilian Amazon that hosts six hundred factories with diverse logistics and supply chain managerial strategies. USCM (Lee, 2002; Fisher, 1997) develops a dot matrix classification of the supply chains considering several attributes (e.g., agility, cost, security, responsiveness) and argues that emergent economies industrial clusters, in the effort to keep attractiveness for technological frontier firms, need to adapt supply chain strategies according to USCM attributes. The paper takes a further step, discussing which transport modes are suitable to each supply chain classified at the USCM in PIM´s case. The research´s methods covered the use of PIM´s statistical official database (secondary data), interviews with the main logistical services providers of PIM and phone survey with a sample of firms (primary data). Findings confirm the theoretical argument that different supply chains will demand different transport modes running at the same time in the same industrial cluster (Oliveira, 2009). In the case of PIM, this implies investments on port and airport infrastructure and a strategic focus on air transport mode, due to (1) short life cycle of products, (2) distance from suppliers, (3) quick response to demand and (4) the fact that even PIM´s standard products use, in average, forty per cent of air transport at inbound logistics.

Keywords: Uncertainty Supply Chain Model, Manaus Industrial Pole, transport.

1 Introduction

One of the most important aspects linked to the competitiveness of emergent economies and industrial clusters refer to supply chain management and its correlated logistics strategies (Oliveira, 2009). To determine the conditions under which supply chains located in these less developed geographic contexts can operate in higher competitive level standards demands broad and detailed theoretical and empirical exam of the needs, limits and possibilities of each supply chain, as well of the public policies involved in their supporting.

Among the many supply chains theoretical perspectives (Halldorsson et al, 2007) and classifying models available in the literature (e.g., Marques et al, 2008), the Uncertainty Supply Chain Model (USCM)[4] focuses as its core theoretical contribution the developing of a dot matrix classification of several supply chains, considering uncertainty as an essential parameter (Oliveira, 2009; Lee, 2002; Fisher, 1997). This uncertainty matrix is useful to categorize the supplying (raw materials/components) and demand (consumer market processes), considering the singularities of each manufactured product, as also to indicate the suitable logistics strategies for the diverse domestic and global supply chains.

1 **Fabiana Lucena Oliveira** (flucenaoliveira@gmail.com)
Social Science Division (ESO)
State University of Amazonas, Manaus-Amazonas, Brazil.
2 **Aristides da Rocha Oliveira Junior** (aristides.jr@hotmail.com)
Management Sciences Dept.,
Federal University of Amazonas, Manaus-Amazonas, Brazil.
3 **LuizaMariaBessa Rebelo** (lmbrebelo@gmail.com)
Public Safety Post Graduate Program,
State University of Amazonas, Manaus-Amazonas, Brazil.

4 Acronym used by Oliveira (2009) to designate the theoretical model developed in the works of Fisher (1997) and Lee (2002).

Transport modes is one of the strategic aspects to be considered in enhancing supply chain performances, but it is, at the same time, a variable strongly dependent to the characteristics of the final goods produced by the diverse existent supply chains and their respective markets.

This paper explores this theoretical linkage between the USCM and transport strategies in the context of a concrete case: the Manaus Industrial Pole (PIM). Operating as an industrial cluster in the very heart of the Brazilian Amazon (in the city of Manaus) since1967, PIM hosts about six hundred companies manufacturing durable goods classified mainly in the sectors of consumer electronics, motorcycles, information technology hardware, chemicals, watches, among others.

2 The Uncertainty Supply Chain Model and Transport Strategy

This USCM has as core framework an Uncertainty Matrix used to categorize the supplying (raw materials and components) and demand (consumer market) processes, considering intrinsic characteristics of each manufactured product. In general terms, the USCM classification shows that there are some goods characterized by demand and supply stability, longer cycle of life and low added technological value, that will demand a more simplified logistics strategy, and that there are other goods, characterized by demand and supply instability, very short life cycle and high added technological value, will require special logistics strategies management.

Figure 1 reproduces the Uncertainty Matrix (Lee, 2002). USCM classifies products in two main categories: *functional* - characterized by low technological added value and stable demand (consumer market) and supply (raw material/components)processes - and *innovative*- characterized by cutting edge technology, unstable demand (consumer market) and supply (raw material/components)processes. For each one of these product categories, a different SCM strategy was theorized.

		Uncertainty of Demand	
		Low (Functional Products)	High (Innovative Products)
Uncertainty of Supply	LOW (STABLE PROCESS)	Candies, basics, common apparel, foodstuffs, oil and gas	Fashion apparel, computers, audio, video
	HIGH (DEVELOPMENT PROCESS)	Hydroelectric apparatus, some food segments	Telecom, high-end computers, semi-conductors

Fig.1
The Uncertainty Matrix.
*Source: Aligning Supply Chain Strategies with Product Uncertainties: Lee, 2002

This being so, the products considered to present low uncertainty of supply and low uncertainty of demand are those that aggregate low technological value in their production, in other words, the life cycles of these products are usually longer and their manufacturing depends in a low degree on technological evolution. Whereas those with low uncertainty of supply and high uncertainty of demand are the audio and video, telecommunications and computer products that follow the tendencies of a market characterized by the consumption of novelties that aggregate new technologies, in the expectation of keeping up with technological evolution. These products already usually present a short life cycle and require agility in the management of their supply chains, since the tendencies in technological evolution can be very fast.

Those products with high degrees of uncertainty in supply and low degrees of uncertainty in demand (e.g., hydroelectric power generating equipment, cables and connections and mining equipment) and some food segments that transform specific raw materials. The sources for the supply of raw materials to manufacture these products are limited and this leads to uncertainty of supply, since demand is stable and the need for production remains constant from a source with scarce supply.

Goods with a high degree of uncertainty in demand and a high degree of uncertainty in supply are represented by telecommunications products, high-end computers and semi-conductors. These products have sources of even scarcer supply and that are sometimes monopolized by a handful of companies. From the point of view of demand, telecom products (e.g., mobile telephony) have short life cycle, high competitiveness and a high degree of uncertainty regarding the consumer desire to buy. Agility in the management of this supply chain is vital to the survival of the product´s manufacturing. Industrial clusters that wishes to include companies classified in the lower quadrants of the Uncertainty Model, needs to consider agility as one of its pillars of development (Oliveira, 2009).

The strategies for the uncertainty models are classified according to four types: (1) Efficient Supply Chains, (2) Supply Chains with risk coverage, (3) Sensitive Supply Chains and (4) Agile Supply Chains. Figure 2 presents a summary of these supply chain classifications:

Uncertainty of Supply	Low (Functional Products)	High (Innovative Products)
Low (Stable Process)	Efficient Supply Chains	Sensitive Supply Chains
High (Development Process)	Supply Chains with Risk Coverage	Agile Supply Chains

Fig.2
Supply Chain Strategies.
Source: Aligning Supply Chain Strategies with Product Uncertainties: Lee, 2002*

According to Grieger (2002), the most critical variables to analyze in the USCM are: a) Fast Product Life Cycle; b) Just in Time Production; c) Cost leadership; and d) Global Competition. Based on the behavior of these variables, it is possible to research and predict which logistics strategies will be more suitable to supply chains located on one of the four quadrants of the uncertainty matrix, as, for example, the choice of the transport modes involved either to import raw materials/components or to export final goods (Oliveira, 2009). This theoretical aspect adjusts the rationality of transport decisions in the way they are currently exposed in the SCM and business logistics literature (e.g., Bowersox et al, 2002), which does not explicitly and formally integrates these uncertainty variable as a SC classification parameter to be considered in firms´ logistic decision-making and strategy.

3 Methodology

The methodology used in the empirical investigation conducted in the case of the Manaus Industrial Pole (PIM) covered three main strategies: (1) The use of PIM´s official statistical database (SUFRAMA, 2015a) and PIM´s Companies´ Official Profile (SUFRAMA, 2015)[5], as also the current customs legislation of Brazil, as documental sources of secondary data (number and name of the enterprises by sector, main manufactured goods, sector revenues, imports and exports, customs processes etc.); (2) interviews conducted with the main logistical services providers (LSP´s) of PIM as a source of primary data directed to the classification of PIM´s supply chains in the USCM quadrants and the actual usage of transport modes by each SC; and (3) phone survey with a sample of firms (also primary data) to confirm the data collected in the previous steps.

The first effort was to outline the universe of PIM´s companies in such a way as to identify how this model may fit the reality of an industrial pole (geographical delimitation), and of the current customs legislation in this country, or in their respective particularities.

5 Both documents regularly published by Superintendência da Zona Franca de Manaus (SUFRAMA), public federal agency encharged to manage tax benefits and public policies oriented to the regional developing of Brazilian Western Amazon and PIM.

From the PIM´s sector revenues, we identified the most twenty important products of PIM. Based on this products list and crossing with supply chain strategies respectively, all supply chains of these products have been identified, so was their respective companies.

Then, the LSP´s interviews and subsequently phone survey with the companies involved to confirm their most used transport modes. This survey was done by telephone and using some personal contacts with clearance people. All the information about transport modes were filled up without previous checking just to guarantee we were capturing the real transport mode in use, even knowing some products were standard.

The transport modes appointed by the theoretical model were confirmed, with increased use of air transport even in the standard product supply chains.

With regard to the purposes, this survey was explanatory and applied, because it aimed not only to clear up the factors involved, but also to contribute to the making of decisions and propose concrete solutions to concrete and immediate problems.

The universe for study refers to the group directly involved in the formulation of the problem, the companies in the Manaus Industrial Pole (PIM).

This analysis, adapted and chose the Uncertainty Model in its most extreme aspect uncertainty of supply and uncertainty of demand, using an industrial unit that has its supply chain perfectly adapted to this reality as its research universe.

The results obtained here, therefore, are restricted to the industrial units with extreme uncertainty regarding their supply chains, following the guidance of Brazilian customs legislation, and improving the processes already identified as being promising by the case study for the Brazilian customs authorities: The Manaus Industrial Pole (PIM).

4 Results (Case Study: Manaus Industrial Pole- PIM)

The most important products of PIM represents eighty percent of the total billed by this agglomerations model within one year. A sample of these products took us twenty-seven companies whose products make up the list of the most lucrative of the PIM.

This research set out to identify the classification of these companies between global and multinational, and from the uncertainty model and its respective supply chains derived from them. Then, to identify the modes of transportation actually used for incoming inputs, independent of type of supply chains. The first result was on the PIM´s composition: seventy percent of the companies operating on it are subsidiaries of global companies. This means that logistics strategies are defined in their respective foreign dies, leaving minimal autonomy for decision and adaptation of local logistics strategies.

It helps to explains why, passed almost fifty years of PIM´s existence, until now there isn´t a single SC strategy formally formulated and implemented by policy-makers (e.g., SUFRAMA, Amazonas State Government etc.). When it checks the types of supply chains, the result was 11 Agile Supply Chains, 05 Sensitive Supply Chains, and 11 Efficient Supply Chains. This means that a total of twenty seven companies surveyed, sixteen need the air mode to remain competitive because their supply chains have a level of uncertainty still present. This represents fifty nine per cent of dependent companies of air transportation and therefore potential users of the infrastructure improvements at airports for PIM.

This high usage rate of air mode confirms the hypothesis that to remain competitive logistics of PIM, it is necessary to accept that being away from the supply base and also to final customers makes the airline the able way enable the uncertainty of supply and demand. Thus, if the expectation is to attract companies whose products are technological innovation, Brazil needs to be special attention to the logistical support of the air mode. Table 1 presents the types of companies, their supply chains and transport modes considered for inbound.

5 Conclusion

Brazil is an emergent country which works with regional, multinational and global companies. Manaus Industrial Pole is very important to keep around a hundred thousand employments in a city with less than two million people and which is responsible for economic activity for the north region in Brazil.

Table 1
Supply Chains Identified at PIM.
Source: Elaborated by authors (2015).

Company Type	Products	Supply Chain	Transport Mode for Inbound	Transport Mode for Final Product
Global	Mobile Phones	Agile	Air	Air
Global	Razor & Toothbrush	Efficient	Sea	Road
Global	Pens, lighters	Efficient	Sea	Road & Air
Global	Computers & TVs	Agile	Sea Air	Air
Global	Computers & TVs	Agile	Sea Air	Air
Global	Computers & TVs	Agile	Sea Air	Air
Global	Medical Equipment	Efficient	Sea Air	Air
Multinational	Microwave Oven	Efficient	Sea	Road
Multinational	Cameras	Agile	Sea Air	NA
Multinational	Board Assembly	Agile	Sea Air	NA
Global	TV	Agile	Sea	Road & Sea
Global	ATMs	Efficient	Sea	Road & Air
Global	Mobile Phones	Agile	Air	Air
Global	Acessories for Cameras	Sensitive	Air	NA
Global	Batteries	Agile	Sea Air	NA
Global	TVs & Microwave	Efficient/Sensitive	Sea Air	Road & Sea
Global	Electric Shaver	Efficient	Sea	Road & Sea
Global	Battery Charger for Mobile Phone	Agile	Sea Air	NA
Global	TVs & Mobile Phone	Sensitive/Agile	Sea Air	Road & Air
Multinational	Electronic Components	Efficient	Sea	NA
Global	TV & Audio	Sensitive	Sea Air	Road & Air
Multinational	CD e DVD	Sensitive	Sea	Road
Multinational	Toner	Sensitive	Air	Air
Global	Air Conditioner	Efficient	Sea	Road & Sea
Multinational	Air Conditioner	Efficient	Sea	Road & Sea
Global	Air Conditioner & Microwave	Efficient	Sea	Road & Sea
Multinational	Motorcycle	Efficient	Sea	Road & Sea

Not to find regional or local companies listed on the most important products from PIMseems to be aworrying matter to PIM´s policy-makers. It means that domestic capital is not present in the manufacturing of high-tech products.

In the other hands, Brazil has to be able to attract and keep these international companies on different agglomeration models.

If Brazilian government as a representative of emergent economy, wants to keep industries´ competitiveness based in Brazil, a high investment on airports and air transport infrastructure has to be done. The risk, if it is not done in a short time, is to keep in Brazil only companies without innovative products and delay the consumption of innovative products by Brazilian society, since it will be imported, not manufactured in the country.

References

Bowersox, D. J., Closs, D. J., & Cooper, M. B. (2002). Supply chain logistics management (Vols. 1 and 2). New York, NY: McGraw-Hill.

Christopher M (2000) In: The Agile Supply Chain: competing in volatile markets. Industrial Marketing Management 29, 37-44.

Fisher, M. L. (1997) In: What is the right supply chain for your product? Harvard Business Review. March-April, 1997, 105-116.

Grieger, M. (2003) In: Electronic Marketplaces: A literature review and a call for supply chain management research. European Journal of Operational Research, v. 144, nr.02, 280-294.

Halldorsson, A., Kotzab, H., Mikkola, J. H., &Skjøtt-Larsen, T. (2007) In: Complementary theories to supply chainmanagement. Supply Chain Management: An International Journal, v. 12, nr. 04, 284-296.

Lee, H. (2002) In: Aligning supply chain strategies with product uncertainties. California Management Review, vol.44. nr.03.167-179.

Marques, G. C., Pereira, S. C. F., & Carona, N. (2008) In: Proposta de um modelo dinâmico para classificação de cadeias de suprimentos. Anais do XI SIMPOI, Rio de Janeiro.

Oliveira, F. L. (2009)Gestão Estratégica das Cadeias de Suprimento com base no Modelo Logístico de Incerteza: O caso do Polo Industrial de Manaus (PIM). Universidade Federal do Rio de Janeiro (DoctoralThesis).

Rohit, B, Amrik, S. S.l (2005) In: Supplychaincompetitiveness: measuringtheimpactoflocationfactors, uncertaintyandmanufacturing practices. Available via http://sciencedirect.com, technovation 443-456.

SUFRAMA – Superintendência da Zona Franca de Manaus. (2015) Indicadores de Desempenho do Polo Industrial de Manaus. SUFRAMA, Manaus. Availableat: http://www.suframa.gov.br.

SUFRAMA – Superintendência da Zona Franca de Manaus. (2015) Perfil das Empresas Incentivadas do Polo Industrial de Manaus. SUFRAMA, Manaus.Availableat: http://www.suframa.gov.br.

Stochastic Machine Maintenance under Imperfect Maintenance

Ruiz-Hernandez, D[1], Delgado-Gómez, D[2], Pinar-Pérez, J[3]

Abstract: The high operation and maintenance cost of industrial equipment (wind turbines, coal mills, and so on) combined with the limited accessibility by human resources to the engines and components, requires the use of complex maintenance scheduling systems in order to fulfil the requirements of high availability, reliability, maintainability, and safety. Glazebrook et al (2006) established the indexability of a class of restless bandits (Whittle, 1988) designed to model machine maintenance problems in which maintenance interventions have to be scheduled to mitigate escalating costs as machines deteriorate, and to reduce the chances of a machine breakdown. Whittle (1996) and Glazebrook et al (2005) have previously given index-based analysis of particular models, whereas Glazebrook et al (2006) shown that indexability is guaranteed in general. However, in that work the state transitions under maintenance interventions were assumed to be state independent. In this work we further develop those findings by presenting an alternative formulation for which explicit formulae for the Whittle index can be derived. In this case, we relax the previous assumption that maintenance interventions are perfect, and allow for some randomness in the active transitions. Moreover, the effectiveness of maintenance interventions is assumed to be state dependent. Numerical investigation testifies the strong performance of Whittle's index heuristic.

Keywords: Imperfect Machine Maintenance; Restless Bandits; Indexability.

1 The Machine Maintenance Problem

Under certain independence assumptions, the multiple machine maintenance scheduling problem under imperfect interventions can be modelled as a multiarmed restless bandit problem. Each machine is characterised by $(S, P^0, P^1, C, k, \beta)$, where S represent the arm's state space; P^0 the transition dynamics when the machine is under operation; P^1 the dynamics under maintenance intervention; C and k the intervention and operation costs, respectively; and β is a discount factor. We further parameterise our problem with an activity charge, W.

Consider an intervention policy that, at any intervention time t and state x, takes the system to state $y < x$, with probability $P^1(x,y)$. After that, the system is operated optimally until the first entry, after y, into state x. Once the machine returns to state x a new intervention is performed and the policy is repeated indefinitely. The expected discounted cost of such policy is given by $B(x,W) = E_{y<x|x}B(x,W) + W$. Consider an alternative set up where, after entering state x, the machine is allowed to evolve (deteriorate) for additional τ periods, after which, a maintenance intervention is conducted. From that point, the system is operated optimally. The Gittins index for such policy is given by the expression

$$G(x) = \inf_{\tau}\left\{\frac{K(x,\tau) + E\left[\beta^{\tau}C\left(X(\tau)\right)|x\right] - C(x)}{1 - E[\beta^{\tau}|x]}\right\}$$

1 **Diego Ruiz Hernández** (d.ruiz@cunef.edu)
CUNEF. Madrid.Spain.
2 **David Delgado Gómez** (ddelgado@est-econ.uc3m.es)
Universidad Carlos III. Madrid.
3 **Jesús María Pinar Pérez** (jesusmaria.pinar@cunef.edu)
CUNEF. Madrid.Spain.

Assume that $X(0) = x \in S$. Operation is optimal at time $t = 0$ if and only if there exists some stationary stopping time $\tau \geq 0$ on the machine process $\{X(t), t \geq 0\}$ evolving under passivity, such that any policy which chooses operation at times $t = 0, \dots, \tau - 1$; intervention at time $t = \tau$; and then optimally at any other time $t \geq \tau + 1$; has total expected costs no greater than the best policy among those which choose intervention at $t = 0$. This can be expressed by the inequality

$$G(x) \leq B(x,W).$$

The *Passive Set* of our *problem* is $\Pi(W) = \{x \in S{:}G(x) \leq B(x,W)\}$
Following Whittle's discussion (see Whittle, 1988) the restless bandit characterized above -and the associated machine maintenance problem-, will be indexable if $\Pi(W)$ is increasing in W.

Once indexability is established, the following index rule is applied:
Whittle Index Policy: Consider an indexable restless bandit problem with M machines and Whittle index $W_i: S_i \rightarrow R$ for machine $i, 1 \leq i \leq M$. The Whittle index heuristic prescribes, at each time $t \in N$, to intervene the q machines with largest index $W_i\big(X(t)\big)$, and to operate the remaining $M - q$ machines.
In this work we apply the indexability analysis developed above on two alternative families of machine maintenance problems: simple deterioration models (with no breakdowns) and breakdown/deterioration models. The performance of the index policy is tested exactly against the optimal solution, for small cases, and by simulation, comparing it against alternative myopic or naïve policies, for real sized instances.

References

Glazebrook K. D., Ruiz-Hernandez D., and Kirkbride C. (2006). Some indexable families of restless bandit problems. Advances in Applied Probability, 38:643-672.

Whittle P. (1988) Restless bandits: Activity allocation in a changing world. Journal of Applied Probability, 25A: 287-298.

Whittle P. (1996), Optimal Control, Basics and Beyond. John Wiley, Chichester.

Glazebrook K. D, Mitchell H. M., and Ansell P. S. (2005). Index policies for the maintenance of a collection of machines by a set of repairmen. EJ of Operational Research, 165:267-284.

Factors of Influence in Tugger Train Systems

Martini A[1], Stache U[2]

Extended Abstract: Tugger trains are increasingly spread in manufacturing logistics due to their efficiency and for safety reasons. The complexity of planning and optimizing tugger train systems is caused by the high number of design options and interdependencies of the input factors effecting the objectives. Consequently, there are controversial views in literature concerning the relative importance of these factors. The objective of the research project is to identify the relevant system-specific influence factors by measuring the intensity of different dimensioning parameters. The importance of the input factors is determined by a series of sensitivity analysis based on a static-deterministic EXCEL-simulation. The basic program calculates nine cost and performance figures for a given tugger train system. The test design comprises of two sets of tests referring to systems with small load carriers (SLC) and large load carriers (LLC). For each system, eight input factors are examined in individual tests by stepwise modifications over reasonable ranges. In addition, parameter changes of two input factors are combined in a test series resulting in three-dimensional output surfaces. The resulting curves (objective value over input factor value) can roughly be classified as either negative exponential functions or more or less linear increasing functions (partly with steps). The level and sequences of the factor importance vary strongly between the SLC-tests versus the LLC-tests. There are asymmetrical interdependencies between input factors mutually either weakening or strengthening the effect on the objectives. Moreover, the sensitivity of input factors with negative exponential curves varies from high to low with an increasing value of the input factor. So even for a single input factor it is not possible to decide in general if it is important or not. That means that the planning and operation of an efficient tugger train system always requires a detailed simulation and analysis.

1 **Andreas Martini** (andreas.martini@uni-siegen.de)
2 **Ulrich Stache** (ulrich.stache@uni-siegen.de)
Industrial Logistics. Department Mechanical Engineering.
University of Siegen. 57068 Siegen, Germany.

Lean wastes in Andalusian aeronautical industry: identification and analysis of the main causes

González L[1], Muñuzuri J[2], Hidalgo M[3], González MJ[4]

Abstract: Through an action research methodology based in case study in 17 aeronautical companies, this investigation has identified Lean wastes that appear most frequently in aeronautics industry and has analyzed the main causes for its occurrence. Finally, these causes have been classified according to their origin: external or internal to the companies. So, most important external factors are: variable production schedule by leading company and a supply chain unconsolidated; otherwise, most relevant internal factors identified are: an inadequate production planning and an inappropriate purchasing management.

Keywords: Lean; Aeronautical; Improvement.

1 Introduction

Lean aims to identify and eliminate wastes that decrease companies' performance (Womack and Jones, 1996)

Thus, in recent years there is a strong engagement in aeronautical companies with Lean, implanting it not only in single undertakings (Prida and Grijalvo, 2011), but also in their supply chain (Martínez and Moyano, 2011).

In Andalusia, where this sector accounts for 19% of industrial GDP of the region (Fundación Hélice, 2014), aeronautical companies also have been implementing Lean (Díaz et al., 2012).

In this sense, this investigation aims to identify most frequently Lean wastes in Andalusian aeronautical companies and to detect its most relevant root causes.

2 Objectives

- Identifying most important Lean wastes in Andalusian aeronautical companies.
- Analysing these wastes and detecting the root causes of them.

1 **Lorenzo González Bolea** (lgonzalez@iat.es)
Instituto Andaluz de Tecnología.
C/ Leonardo da Vinci, 2, 41092 Sevilla.

2 **Jesús Muñuzuri Sanz** (munuzuri@esi.us.es)
Escuela Superior de Ingenieros. Universidad de Sevilla.
Camino de los Descubrimientos, s/n. 41092 Sevilla.

3 **Manuel Hidalgo Arjona** (mhidalgo@iat.es)

4 **María José González Sánchez** (mjgonzalez@iat.es)
Instituto Andaluz de Tecnología.
C/ Leonardo da Vinci, 2, 41092 Sevilla.

3 Methods

In this research have been involved 17 of the 57 manufacturers aeronautical companies stablished in Andalusia (Fundación Hélice, 2014).

Firstly, in all of them Lean has been implemented analysing a pilot product, according to the methodology proposed by Rother and Shook (1998).

Based on the analysis of the Value Stream Maps (VSMs), was developed a list that included all of the Lean wastes presented in these companies. Then, using specific methodologies (5-Why, for instance), the root causes of these Lean wastes were detected and classified.

4 Results

Most frequently Lean wastes detected in Andalusian aeronautical companies analysed were: inventory, waiting and transportation; they appeared multiple times in each company.

On the other hand, the main causes of these wastes could be classified in two categories according to their origin: external or internal to the companies.

So, most important external factors are: variable production schedule by leading company, a supply chain unconsolidated and a lack of authorized suppliers; otherwise, most relevant internal factors identified are: an inadequate production planning and an inappropriate purchasing management.

5 Conclusion

Researchers have identified the main factors that could decrease productivity in Andalusian aeronautical companies. So, based on this research, futures studies can be developed in order to improve performance in this sector (researching about specific methodologies, for example).

References

Díaz M, Vega P, Ortega A (2012) La implantación de" lean production" en los proveedores del sector aeronáutico:¿ dependencia o compromiso?. *Universia Business Review*, (36), p. 32-47.

Fundación Hélice (2014) *Estudio 2013 Sector Aeroespacial en Andalucía*. Sevilla.

Martínez PJ, Moyano J (2011) Lean Producción y gestión de la cadena de suministro en la industria aeronáutica. *Investigaciones Europeas de Dirección y Economía de la Empresa*, 17(1), p.137-157.

Prida B, Grijalvo M (2011) Implementing Lean Manufacturing by means of action research methodology case study in the aeronautics industry. *International Journal of Industrial Engineering*, 18(12).

Rother M, Shook J (1998) *Learning to see – value stream mapping to add value and eliminate Muda*. Brookline, MA: Lean Enterprise Institute

Complexity and operations performance: a case research from Brazilian automobile industry

Salomon A[1], Simon M[2], Peixoto M[3]

Abstract: Increase or decrease operations complexity depends on corporate strategy, as Mass Customization, for instance. However, operations issues are also very important for corporate results. The case research aims to identify a model to measure complexity and evaluate it with operations performance. The research object is an automobile assembly line in Brazilian State of Rio de Janeiro.

Keywords: Automobile Industry; Complexity; Operations Management.

1 Introduction

Automobile assemblers find themselves often under the pressure to increase the variety of their products. Mass Customization (Pine et al., 1993) is a strategy to search for increasing products variety under mass production costs. In 2006, there were 165 different models of automobile in the United States, corresponding to 375% more than in 1969. In West Germany, from 1975 to 1990, the variety of autoparts grew 400%. BMW says that one of its product family has 10^{17} different combinations (Hu et al. 2008).

To attend this strategy, the first consequence are more complex operations. Complex manufacturing systems may have unpredictable results, uncertainty by lacking in knowledge, and many disconnected or unrelated components (Efthymiou et al., 2012). This scenario creates a dilemma: Mass Customization is good for commercial management, but it can be bad for operations management. That is, as greater the variety of products, as harder automobile assemblers deliver their products with desirable costs, quality, and time (Fisher & Ittner, 1999).

2 Objectives

The main objective of the research is to propose actions for management of complexity on the operations of automobile assembly. This work presents the development of the research, by the end of 2014 and beginning of 2015.

3 Methods

Case research is one of the most powerful methods in operations management (Voss et al. 2002). Nevertheless, the research will also apply Mathematical Modeling (Bertrand & Fransoo, 2002). Therefore, this is a mixed-method research (Bryman, 2005). The researched object is an assembly line of commercial automobiles located in the State of Rio de Janeiro.

1 **ValérioAntonioPamplonaSalomon** (salomon@feg.unesp.br)
Dpto. de Produção. São Paulo State University.
Av. Dr. Ariberto P. Cunha 333, 12516-410, Guaratinguetá, SP, Brazil.
2 **Mateus Lemos Simon** (mateus.simon@volkswagen.com.br)
São Paulo State University.
Av. Dr. Ariberto P. Cunha 333, 12516-410, Guaratinguetá, SP, Brazil.
3 **Marcelo Peixoto** (marcelo.peixoto@volkswagen.com.br)
Volkswagen do Brasil, MAN Latin America.
Rua Volkswagen, 100, 27537-803, Resende, RJ, Brazil.

4 Results

There are four main methods for measurement of Complexity in manufacturing:

1. Non Linear Dynamics Theory
2. Information Theory
3. Axiomatic Design Theory
4. Reynolds Number

The research aims to present a model to measure the complexity and evaluate its suitability to a real manufacturing system. The increasing and decreasing complexity will be compared with operations performance indicators as costs, delivery reliability, and quality (Hallgren, 2007).

5 Conclusion

There is a lack in the literature on models to deal with complexity and operations performance. However, findings for some kind of industries may not been proper to another kind. The way this situation can be solved is from empirical researches.

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Main References

Efthymiou K, Pagoropoulos A, Papakostas N, Mourtzis D, Chryssolouris G (2012) Manufacturing systems complexity review: Challenges and outlook. Procedia CIPR, doi:10.1016/j.procir.2012.07.110

Fisher ML, Ittner CD (1999) The impact of product variety on automobile assembly operations : Empirical evidence and simulation analysis. Manag. Sci., doi:10.1287/mnsc.45.6.771

Hallgren, M. (2007) Manufacturing strategy, capabilities and performance. Linkoping University, Linkoping, Sweden.

Hu SJ, Ko J, Weyand L, El Maraghyd HA, Lien TK, Koren Y, Bley H, Chryssolouris G, Nasr N, Shpitalni M (2008) Assembly system design and operations for product variety. CIRP Ann. Manuf. Technol., doi:10.1016/j.cirp.2011.05.004

Pine, II BJ (1993) Mass customization: The new frontier in business competition. HBS, Cambridge, MA, USA.

Complete list of references from authors, upon request.

VSM-based framework for managing the supply chain

Puche JC[1], Pino R[2], Priore P, Gómez A, De la Fuente D, Rosillo R

Abstract: Supply chain collaboration is a fruitful research area, and its potential to outperform reductionist solutions is widely understood. This work proposes an integrative framework based on the Viable System Model (VSM). It shows how the VSM can be used to define the supply chain's system structure. Supply chain processes integration is better controlled through a collaborative performance system. It is aimed to create management awareness about how the entire supply chain can benefit from this collaborative approach.

Keywords: Supply Chain Management, Viable System Model; System Thinking.

1 Introduction

The globalization age have forced companies to place a premium upon Supply Chain Management (SCM) as a key source of competitive advantage. Several authors have demonstrated that considering the global strategy as a sum of individual strategies leads to large inefficiencies. In other words, supply chain collaboration enables the members to create and capture mutual benefits for all of them (Fisher, 1997). For this reason, different approaches to collaborative supply chains have been proposed in literature –*e.g.* Collaborative Planning, Forecasting, and Replenishment. Nevertheless, practitioners find it difficult to address the issue of proposing an appropriate collaborative framework (Mentzer *et al.*, 2000). In other words, the interaction phenomena among different features of supply chain collaboration must be understood, in order to prepare the members to create collaborative efforts successfully (Lambert *et al.*, 2004).

2 Objectives and Methods: Viable System Model (VSM)

This work aims to propose an integrative framework to supply chain collaboration based on the Viable System Model (VSM). This approach is used to define the supply chain systemic structure, which must be combined with the integration of supply chain processes and the definition of a collaborative performance system.

The Viable System Model (VSM) (Beer, 1985) allows to scientifically designing an organization in order to constitute a system endowed with capacities –for learning, adaptation and evolution– required for "survive" over time. To achieve this, VSM proposes an invariant structure based on the definition of 5 functions: (1) System One represents the production processes that enable the organization to generate its products or services; (2) System Two dampens the uncontrolled oscillations that occur in System One; (3) System Three identifies the synergies among processes and provides an integrative approach; (4) System Four looks outwards to the environment to monitor how the organization needs to adapt to remain viable; and (5) System Five defines the ideological aspects and organizational principles.

1 **Julio César Puche Regaliza** (jcpuche@ubu.es)
Dpto. de Economía Aplicada.
Facultad de CCEE, Universidad de Burgos, España.

2 **Raúl Pino Diez** (pino@uniovi.es)
Dpto. de Admon. de Empresas.
EPI de Gijón, Universidad de Oviedo, España.

3 Results

This research shows how the VSM can be used to establish the framework for supply chain collaboration in the Beer Game scenario. Based on the five-feature collaborative approach proposed by Simatupang and Sridharan (2005), and understanding information sharing as an enabler, the systemic structure defined by the VSM allows decision synchronization and promotes aligning incentives. Hence it must be coordinated with a collaborative performance system, as well as the definition of integrated supply chain processes.

4 Conclusion

The hypothetical case presented in this research can help managers to change from a reductionist approach where each node looks for their individual interest to a holistic approach where each node looks for the overall interest of the supply chain. Thus, the performance of the entire supply chain and the performance of each of the nodes that compose it are better. The best solution to the system is the best solution for each member of the system.

References

Beer S (1985) Diagnosing the System for Organization. John Wiley & Sons.

Fisher ML (1997) What is the right supply chain for your product? Harvard Business Review 23(4):660-679.

Lambert DM, Knemeyer AM, Gardner JT (2004) Supply chain partnership: model validation and implementation. Journal of Business Logistics 25(2):21-42

Mentzer JM, Min S, Zacharia ZG (2000) Information sharing in supply chains. International Journal of Technology Management 20(3/4):373-387.

Simatupang T, Sridharan R (2005) An integrative framework for supply chain collaboration. The International Journal of Logistics Management 16(2):257-274.

Lean Production Systems Deployment and Monitoring using Discrete-event Simulation

Guimarães C[1], Marques A[2], Moniz S[3]

Abstract: This paper explores and reports, through a case study in a metalworking SME, the use of discrete-event simulation modeling as an enabling tool for both ex-ante Lean implementation evaluation, serving Value Stream Mapping purposes, and ex-post, changing the production drivers during deployment, monitoring on-going results. A successful change of production system from “push” to “pull”, one of the pillars of Lean Production system, was achieved disclosing the benefits of using discrete-event simulation in pre, during and post Lean deployment. It aims to contribute to the scarce literature on Lean monitoring tools for Lean sustainability.

Keywords: Lean Production; Pull System; Simulation; Decoupling Point.

1 Introduction

When exploring the barriers and enablers of a sustainable Lean culture, some posit that the discontinuity of deployment, taking Lean as experiment events, short-term orientation, exclusive focus on Lean tools, and lack of on-going audits prevent the creation of a Lean mind-set (Guimarães and Carvalho, 2012). Achieving “Lean Thinking” (Womack and Jones, 1996, 2003) is though achieving a mind-set, a way of life, or a “way of doing things around here”. Mann (2009) attributes to Lean management the linkage role to overlap the gap between Lean tools and Lean Thinking but does not explore the tools that can present ex-ante Lean results. Many large companies seem to have embraced Lean practices, while SMEs, that represent 99% of all European businesses and 67%of EU employment (European Commission 2014) are still in an embryonic stage of Lean deployment (Shah and Ward, 2003). The use of simulation as a planning and decision support tool allow for the impact analysis of candidate plans before substantial investments in the production layout. This paper also explores and reports the use of discrete-event simulation modelling as an enabling tool for both ex-ante Lean implementation evaluation, serving Value Stream Mapping purposes, and ex-post, changing the production drivers during deployment, monitoring on-going results. It aims to contribute to the scarce literature on Lean monitoring tools for Lean sustainability and present a research stream to fill a literature gap and provide practitioners new Lean tools.

2 Theoretical background and research questions

2.1 Lean Production System

Womack et al. (1990) reformulated and streamlined the core Lean concepts based in Taiichi Ohno’s Toyota Production System (TPS), describing lean production in five elements: (i) lean manufacturing, (ii) lean product development, (iii) supply chain coordination, (iv) customer distribution, and (v) lean

1 **Cristina Machado Guimarães** (cristina.m.guimaraes@inesctec.pt)
2 **Alexandra Marques** (alexandra.s.marques@inesctec.pt)
3 **Samuel Moniz** (presenter) (samuel.moniz@inesctec.pt)
INESC TEC (formerly INESC Porto)
and Faculty of Engineering, University of Porto

enterprise management. Research has been strongly concentrated in lean manufacturing and only recently the discussion on lean production included the concept's relation to Six Sigma and Total Quality Management (TQM) (Liker 2004). Lean is about doing more with less (Christopher 2011). Presented as an antidote to *muda* (waste), converting *muda* into value*,* "Lean thinking" was coined by Womack et al (1990) as a five principle improvement philosophy: (i) specify value, (ii) identify the value stream, (iii) make the value-creating steps for specific products flow continuously, (iv) let the customers pull value from the enterprise, and (v) pursue perfection. In this paper, we explore the contribution of simulation tools in pull system deployment.

Lean deployment requires not only to be lead but also to be measure as, following Drucker's axiom, "what doesn't get measured doesn't get managed". As so, another issue explored is the need of implementation monitoring in Lean deployment. In fact, there's a lack of studies on methods for implementing and assessing Lean Production (Marodin and Saurin, 2013).

2.1.1 Pull System

Pull production is one of the main principles within Lean (Karlsson and Ålström, 1996; Womack and Jones, 1996) and one of the ten dimensions of a Lean system according to Shah and Ward (2007). Where a push production system entails jobs being pushed from one workstation to the next upon completion, a pull system consists of jobs that are pulled by successive workstations, as and when required. Pull in simplest terms means that no one upstream should produce a good or service until the customer downstream asks for it (Womack and Jones, 1996).

Thus, a push system schedules the release of work, while a pull system authorises the release of work. A push schedule is prepared in advance on the basis of demand forecasting, while pull authorisation depends on the plant status. A push strategy, sometimes described as an open system, releases new material into it at a constant rate (uniform release strategy) based on either a demand forecast or the desired throughput rate of the system, without considering the work in process (WIP) level or machine status of the line. In contrast, a pull control mechanism, or a closed system, has a feedback loop within the structure so that material release is dependent on the status of the line. The authorisation of work into a line is made either to synchronise the workflow in the line (e.g. Kanban – the Japanese word for tag or signal) or to control the overall level of WIP (Spearman and Hopp, 1990).

Therefore, pull production is considered as a method of workload control. Workload control can be divided into three main levels: job entry, job release, and priority dispatching/WIP control. The job entry level considers demand and capacity management, for example the decision as to whether to accept or reject orders, the setting of due dates, and the management of capacity. Job release determines the time of release for accepted orders, and short-term adjustments in capacity. Finally, priority dispatching/WIP control manages the flow of orders on the shop floor (Fredendall et al 2010).

2.2 Leagility

The original concept of agility was introduced by academics (Lehigh University) and practitioners, in 1991, referring to a new manufacturing paradigm (high quality and highly customized products, high information and value added products/services, mobilization of core competences, responsiveness, response to change and uncertainty and intra/inter-enterprise integration). Gunasekaran (1998) present the key enablers of agile manufacturing to respond to 21st century challenges: (i) rapidly changing markets; (ii) globalization; (iii) decreasing new product time-to-market; (iv) increasing inter-enterprise co-operation; (v) interactive value-chain relationships; and (vi) increasing value of information/service.

Agility is mutual compatible with leanness (Jones et al 1999; Katayama and Bennett 1999; Naylor et al. 1999; Yusuf et al. 1999; Mason-Jones et al. 2000; Hormozi 2001), as lean is needed to build agility (Marcus 2010). Containing "little fat", leanness may be an element of agility, but by itself does not warrantee satisfying the customer more rapidly as is expected from a "nimble" organization (Christopher 2011). For Narasimhan et al (2006) lean does not imply agile, but agile does imply that many of the principles and techniques of lean are in place. The Total Cycle Time Compression Paradigm (Towill 1996) is, though, sufficient to achieve lean, but represents only one necessary condition, not sufficient, to achieve agile (Christopher 2002). Therefore, agile is a post-lean paradigm leaving to lean a "foundational" role.

"Leagility" (Naylor et al. 1999; Mason-Jones et al. 2000; van Hoek 2000) is the combination of both paradigms (lean and agile) within a total supply chain strategy marked by a decoupling point downstream of which an agile strategy responds to a volatile, unpredictable demand, and upstream providing level scheduling and eliminating waist, non added-value activities and bottlenecks pursuing a lean strategy. This strategic point separates the supply chain part that is pulled directly by the end customer and where variability asks for agility and effectiveness, from the upstream supply chain part lead by efficiency purposes and forecast driven. Leagility is, thus, also called hybrid strategy (Christopher 2011). Both paradigms can coexist separated: (i) by space (matching agile supply chain with innovative products and functional products); (ii) within a whole and its parts (by settling a decoupling point); (iii) in time (having short lead times for "fashion" or "emergency" and longer ones for "basics" or "elective"); and (iv) upon condition (using order winner criteria in market segmentation or in product design modularization) (Stratton and Warburton 2003). It is also possible for a corporation to simultaneously pursue both lean and agile strategies by adopting a leagile infrastructure (Krishnamurthy and Yauch 2007).

2.3 Simulation for Manufacturing Operations Management

The increasing complexity of the production systems calls for new planning and decision support tools that can easily analyse the impact of candidate plans before entering into production or before substantial investments in production layouts, what can be critical in a SME context. Such tools virtually represent the dynamics of the production system over time, anticipating the value of relevant process performance indicators such as: lead-time, order delivery dates and level of utilization of the resources.

Simulation models can be used for manufacturing system design and operation namely: (i) in manufacturing operations planning and scheduling (long and short-term production planning, automated material handling systems operations, general, flow shop and job shop scheduling, flexible manufacturing system and semiconductor manufacturing scheduling); (ii) in maintenance operations planning and scheduling; and (iii) in real-time control (Negahban and Smith, 2014).

Simulation studies have been carried out in operations management in manufacturing settings for several purposes: for disturbance reduction (quality losses, speed losses, unplanned stops and in planned stops as set-ups and maintenance) in manufacturing systems (Ingemansson and Bolmsjõ, 2004); to reduce different bottlenecks in different products combining simulation results with manufacturing improvements in real settings (Ingemansson et al, 2005); to explore impacts of different policies for allocating resources to production and engineering work (Crist and Uzsoy, 2011), showing efficiency gains before and after they are produced.

Simulation approach has been used, for instance, to improve process flow analising workload distribution in park homes production process testing scenarios to determine the optimum line balance for every section of the production process (Garza-Reyes et al. 2012).

Other authors present simulation tools to study the batch size effect on production lead-time in a multi-stage assembly pull system considering the combined effect of push and pull production conditions (Hung and Liker, 2007).

Simulation studies were classified by Jahangirian et al (2010) in three types according to their empirical nature: (i) real problem-solving; (ii) hypothetical problem-solving and (iii) methodological.

Having the presented arguments as challenges, it is, therefore interesting for both academics and practitioners to explore the use of discrete-event simulation in Lean deployment, particularly in SMEs context, so two research questions were identified:

RQ1: How can discrete-event simulation introduce Lean principles, namely pull system?

RQ2: What can be the extension of pull system and how can discrete-event simulation contribute for the definition of the decoupling-point?

Therefore, and driven by real problem-solving, this paper presents a case-study approach to address these research questions.

3 Methods

A case study methodology (Yin, 2009) appropriated to "How" and "What" questions and to investigate a contemporary phenomenon in its real-life context when the boundaries between phenomenon and context are not evident recurring to several data collection techniques and different evidence sources, was carried out. This qualitative method, allowing a deeper understanding of phenomena (Flyvbjerg, 2006), has been frequently used in management studies, namely in operational management (Voss *et al*, 2002) and logistics (Ellram, 1996; Renner and Palmer, 1999). Being more a idiosyncratic than a generalizing method, was chosen by its descriptive and exploratory character, not to produce causality statements but to achieve a logical sequence of connection between empirical data, problem/research questions and findings/conclusions. Though, the unit of analysis chosen was a SME metalworking company hosting a research project for Make-to-Order production improvement.

For data collection, semi-structured interviews with a primary on-site contact, which was the CEO and the production manager, were conducted. Also were interviewed Consultants and/or project managers involved in the simulation project implementation. One of the researchers was identified as the primary interviewer and was present at all interviews. Data triangulation was carried out by direct observation and through use of documentation in order to strengthen construct validity. Production and production planning processes were analyzed and improved by a production-scheduling tool using novel discrete-event simulation algorithms in order to first evaluate, and then implement, a make-to-order system serving a "pull" strategy.

Data analysis followed Miles and Huberman (1994) recommendations on data codification, reduction and categorization techniques. Data gathered from different informants and sources was reduced to precise categories in common tables (Miles and Huberman, 1994), and then systematically interrogated (Yin 2009) comparing and noting patterns (Miles and Huberman 1994).

4 Case Study

A metalworking Small- Medium Sized (SME) company producing a large number of products in small pro-duction series and short delivery times presented a challenge to introduce discrete-event simulation to change production system into a weekly make-to-order (MTO) production were each product could have alternative production routing and also, the use of specialized workers was often a bottleneck for the planning process.

The discrete-event simulation tool was introduced for scheduling the weekly production.

Two sorts of resources were considered in the model: (i) Plant resources: layout (machine location), transportation (material and people paths), machine efficiency and availability, machine groups (parallel unrelated machines) and specialized manpower; (ii) Process resources: operations sequence; limited storage of the machine queues and machine setups and sequence-dependent changeovers.

The operations sequence is presented in Figure 1:

- cutting → **bending → tooling** → welding →pre-assembling → assembling
  or
- cutting → **tooling → bending** → welding →pre-assembling → assembling

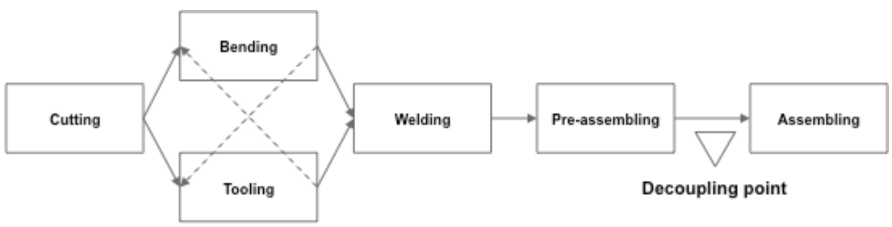


Fig.1
Operations Sequence.

The scheduling problem (the assignment and sequencing of jobs to machines in a given time horizon) implies two different types of decisions:

– Assignment decisions – allocation of a job to a machine and

– Sequencing decisions – the order a job is processed in a machine

The relevant events considered in the simulation model were: urgent job arrival; job cancellation; delay in the arrival or shortage of materials; change in due date or job priority; machine failure; over or underesti-mation of processing times; rework or quality problems; operator absenteeism; and transportation tasks.

The due date, or the date in which a job must be ready to deliver to the customer (Vinod and Sridharan, 2011) taking into account that:

– Job due date must be defined before its release;

– Due dates can be defined:

  – externally be the customers: - exogenous method**;**

  – or, internally by the scheduling system: - endogenous method; and

– Internally set of job due dates reflects the congestion of the shop floor

The simulation model was built to find the best approach to determine/update the WIP norm and also to understand what should be done in the scheduling and simulation components with the targeted WIP level determined by the Workload control (WLC).

The simulation approach is presented in Figure 2 and Jobs modeling is presented in Figure 3 where production orders are converted to jobs (simulation entities) with unitary lot size and jobs are represented always by sequential operations.

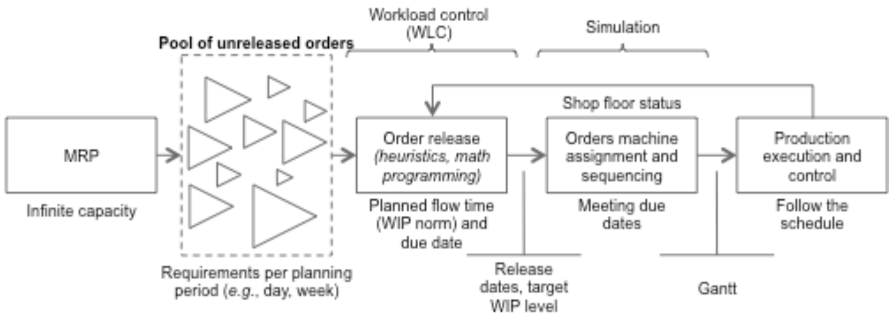


Fig.2
Simulation Approach.

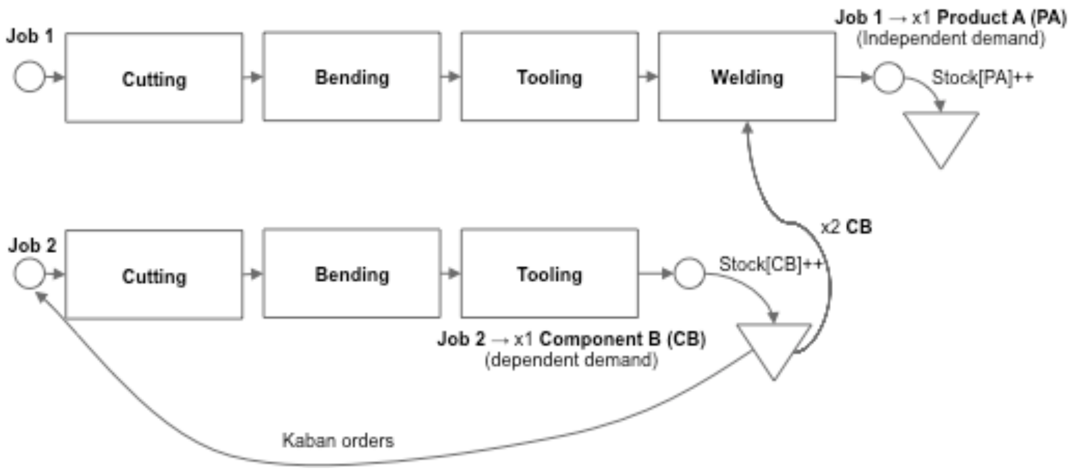


Fig.3
Simulation model- Jobs modelling.

Preliminary results suggest that the proposed tool enables a better allocation of the workers to the jobs, dynamically generated by the simulation model, while assuring the fulfillment of the delivery dates. The simulation results allowed the swift from a pure push system into a hybrid one. As so, an assembly-to-order (ATO) system was so far introduced introducing pull production system into the value chain.

5 Conclusions

The production driver paradigm moved from make-to-stock to a make-to-order paradigm through this simulation tool, improving the planning process in several dimensions: selection of alternative product routing, reducing specialized workers related bottlenecks and better order fulfillment. This tool enabled the Lean Production implementation, setting "pull" system by changing: production planning of orders over time, scheduling orders in machines, sizing-up buffers, and re-organizing the industrial layout.

The tool will allow on-going assessment and adjustments to the coexistence of both push and pull systems while reducing the weight of forecasting-based decisions.

This case study's results suggest that the proposed tool enables a better allocation of the workers to the jobs, while assuring the fulfillment of the delivery dates. It also allows better assess the current production system and provides a valuable trial environment considering candidate production plans and its influence on production performance. The proposed discrete-event simulation tool provides an important contribution towards the efficiency, adaptability, and sustainability of the new production system allowing for being incorporated into more flexible business models.

The presented case illustrates a successful change of production system from "push" to "pull", one of the pillars of Lean Production system, and discloses the benefits of using discrete-event simulation in pre, during and post Lean deployment. Through simulation it is possible not only to foresee the gains of moving from a make-to-stock system to an assembly-to-order and make-to-order system, but also to use as a tool in sche-duling the weekly production. Simulation proved to be valuable to Lean Production deployment, avoiding relying only in trial and error changing pathways.

6 References

Christopher M (2011) Logistics and supply chain management: creating value-adding networks, 4th Edition, Prentice Hall, Pearson Education Limited, UK.

Christopher M (2002) Viewpoint: You are Lean but are you agile?, *PPI*, May Vol. 44 (5), pp. 3.

Crist K, Uzsoy R (2011) Prioritising production and engineering lots in wafer fabrication facilities: a simulation study. International Journal of Production Research Vol.49 (11), pp3105-3125.

Dod J (1999) Effective Substances. In: The dictionary of substances and their effects. Royal Society of Chemistry.Available via DIALOG. http://www.rsc.org/dose/title of subordinate document. Cited 15 Jan 1999

Ellram L M (1996) The use of case study method in logistics research. Journal of Business Logistics Vol 17(2), pp. 93-138.

European Commission, (2014) Small and medium-sized enterprises (SMEs): Fact and figures about the EU's Small and Medium Enterprise (SME). Available from: http://ec.europa.eu/enterprise/policies/sme/facts-figures-analysis/index_en.htm [Accessed 1 May 2015].

Flyvbjerg B (2006) Five Misunderstandings About Case Study Research, Qualitative Inquiry, Vol 12 (2), pp.219-245.

Fredendall L D, Ojha D, Patterson J W (2010) Concerning the theory of workload control. European Journal of Operational Research, Vol 201 (1), pp. 99–111.

Garza-Reyes J A, Oraifige I, Soriano-Meier H, Forrester P L, Harmanto D (2012) The development of a lean park homes production process using process flow and simulation methods, Journal of Manufacturing Technology Management Vol.23 (2) pp. 178-197.

Guimarães C M, Carvalho J C (2012) Lean, a Tool Set or a Mind Set? – A Healthcare Case Study in Joldbauer, H. Olhager, J. and Schonberger, R.J. (Eds), Modelling Value, Physica-Verlag, A Springer Company, pp.313-328.

Gunasekaran,A. (1998) Agile manufacturing: enablers and implementation framework. International Journal of Production Research, Vol. 36 (5), pp. 1223-1247.

van Hoek,R I (2000) The thesis of leagility revisited. International Journal of Agile Management Systems, Vol.2 (3), pp: 196.

Hormozi A M (2001) Agile manufacturing: The next logical step. Benchmarking: An International Journal Vol.8 (2), pp. 132-143.

Hung K T, Liker J K (2007) A simulation study of pull system responsiveness considering production condition influences. International Journal of Industrial and Systems Engineering Vol 2(2) pp.123-136.

Ingemansson A, Bolmsjõ G S (2004) Improved efficiency with production disturbance reduction in manufacturing systems based on discrete-event simulation. Journal of Manufacturing Technology Management, Vol 15 (3) pp. 267-279.

Ingemansson A, Ylipãã T, Bolmsjõ G S (2005) Reducing bottle-necks in a manufacturing system with automatic data collection and discrete-event simulation. Journal of Manufacturing Technology Management Vol 16 (6) pp.615-628.

Jahangirian M, Eldabi T, Naseer A, Sergioulas L K, Young T (2010) Simulation in manufacturing and business: a review. European Journal of Operational Research Vol 203 pp.1-13.

Jones,C., Medlen N, Merlo C, Robertson M, Shepherdson J (1999) The Lean enterprise. BT Technology Journal Vol 17(4), pp:15-22

Karlsson C, Ålström P (1996) Assessing changes towards lean production. International Journal of Operations & Production Management, Vol 16 (2), 24–41.

Katayama H , Bennett D (1999) Agility, adaptability, Leanness: a comparison of concepts and a study of practice, International Journal of Production Economics, Vol. 60/61, pp. 43-51

Krishnamurthy R, Yauch C A (2007) Leagile manufacturing: a proposed corporate infrastructure, International Journal of Operations & Production Management, Vol.27 (6), pp. 588-604.

Liker J K (2004) The Toyota Way-14 management principles from the world's greatest manufacturer. McGraw Hill, New York.

Mann D (2009) The Missing Link: Lean Leadership, Frontiers of Health Services Management, Vol 26 (1) pp.15-25.

Marcus I (2010) Agile supply chain: strategy for competitive advantage, Journal of Global Strategic Management, Vol.7, June, pp 5-17.

Marodin G A, Saurin, T A (2013) Implementing lean production systems: research areas and opportunities for future studies. International Journal of Production Research, Vol 51 (22) PP. 6663-6680.

Mason-Jones R, Naylor B, Towill, D R (2000) Engineering the leagile supply chain, International Journal of Agile Management Systems, Vol. 2 (1), pp. 54-61

Miles M B, Huberman A M (1994) Qualitative Data Analysis, Thousand Oaks, Sage Publications, Inc.

Narasimhan R, Swink M, Kim S W (2006) Disentangling Leanness and agility: An empirical investigation. Journal of Operations Management, Vol.24 pp 440-457.

Naylor J B, Naim M M, Berry D (1999) Leagility: integrating the Lean and agile manufacturing paradigms in the total supply chain. International Journal of Production Economics, Vol. 62, pp. 107-18.

Negahban A, Smith J S (2014) Simulation for manufacturing system design and operation: Literature review and analysis. Journal of Manufacturing Systems Vol. 33 pp. 241-261.

Renner C, Palmer E (1999) Outsourcing to increase service capacity in a New Zealand Hospital, Journal of Management in Medicine, Vol 13(5), pp. 325-338.

Shah R, Ward P T (2003) Lean manufacturing: context, practice bundles, and performance. Journal of Operations Management, 21 (2), 129–149.

Shah R, Ward P T (2007) Defining and developing measures of lean production. Journal of Operations Management, Vol 25 (4), pp.785–805.

Slifka MK, Whitton JL (2000) Clinical implications of dysregulated cytokine production. J Mol Med, doi: 10.1007/s001090000086

Spearman M L, Woodruff D L, Hopp WJ (1990) CONWIP: A pull alternative to Kanban. International Journal of Production Research, Vol 28 (5), 879–894.

Stratton R R, Warburton D H (2003) The strategic integration of agile and Lean supply. International Journal o Production Economics, Vol. 85, pp. 183-198.

Towill, D R (1996) Time compression and supply chain management a guided tour. Supply Chain Management, Vol.1 (1), pp. 15-27.

Vinod V.,Sridharan R (2011) Simulation modeling and analysis of due-date assigment methodes and scheduling decision rules in a dynamic job shop production system. International Journal of Production Economics, Vol 129(1) pp. 127-146.

Voss C, Tsikriktsis N, Frohlich M (2002) Case research in operations management, International Journal of Operations and Production Management, Vol 22(2), pp. 195-219.

Womack J P, Jones D T (1996) Lean thinking: Banish waste and create wealth in your corporation. New York: Simon and Schuster.

Womack J P, Jones D T, Ross D (1990) The Machine That Changed the World, Rawson Associates, New York

Yin RK (2009) Case Study Research: Design and Methods, 4th Edition, Sage Publications, London.

Yusuf Y Y, Sarhadi M, Gunasekaran A (1999) Agile manufacturing: The drivers, concepts and attributes. International Journal Production Economics, 62,

Experimentation tool to study and improve rail container terminals

García-Hernández A[1], García-Miranda I[2]

Abstract: In this work, an experimentation tool is presented to make easier the search and the evaluation of improvement proposals for rail container terminals. The tool is composed of two elements: a simulation model that imitates the performance of a terminal, and an experimentation module that generates alternative scenarios from the information set by a decision maker. The tool can be used to find new terminal configurations that meet a service level established in advance.

Keywords: experimentation tool; terminal simulation; combined transport.

1 Introduction

Simulation is frequently used to evaluate improvement proposals for rail container terminals (purchase of a new crane, etc.). In the literature, these proposals are presented in two ways. In the first one, the authors simulate the initial state of a terminal and use the simulation results to identify them. In the second one, the new configurations are proposed at the beginning of the study, without any previous simulation. In both cases, the simulation scenarios are limited and are generated by changing one or a few characteristics of the terminal (number of cranes, shifts, etc.). In this context, a simulation tool able to generate and evaluate a wide number of terminal configurations can be very useful, being that it would make easier the study of multiple improvement proposals before starting a redesign project.

2 Objectives

The aim of this work is to develop an experimentation tool composed of two elements: a simulation model with different preprogrammed characteristics among which a decision maker can choose through an user interface to configure the initial state of a terminal, and to get information about its performance; and an experimentation module that automatically generates and evaluates several alternative scenarios for the terminal. This module used three sets of input data: terminal characteristics that can change from one scenario to other, values among which these characteristics can change and restrictions that invalidate certain combinations of characteristics/values. The simulation results show which combinations of input data can satisfy the demand without generating delays on the outgoing trains and attending most of the trucks in less time than the maximum allowable dwell time. This tool has been developed using the commercial software Witness.

1 **Alicia García Hernández** (agarci1@ing.uc3m.es)
2 **Iván García Miranda** (ivan.garcia@uc3m.es)
Área de Ingeniería de Organización.
Dpto. de Ingeniería Mecánica. Universidad Carlos III de Madrid.
Avda. de la Universidad, 30. 28911 Leganés (Madrid).

3 Methods

The methodology is divided into four phases. In the first one, the literature was reviewed to verify the originality of the experimentation tool. None of the works studied has an experimentation module to facilite the simulation of new scenarios. In the second phase, we worked on a model developed in previous investigations to increase its realism. Among the improvements included highlights the definition of several terminal operation rules (storage policies, allocation of cranes to working areas, etc.) as input data. These rules remain fixed in other models reviewed in the literature. In the third phase, the experimentation module was developed and joined with the simulation model. Finally, the experimentation tool was used to analyze a case study.

4 Results

The experimentation tool has been used to seek improvement proposals in a terminal. After exploring over 20 scenarios, several improvement configurations have been found. There wouldn't have been obvious to find some of them without the help of the experimentation module.

5 Conclusion

The approach used to build the experimental tool allows users with little programming knowledge to model and study different terminals, and to analyze different improvement proposals where a wide number of terminal characteristics may vary. In future work, it would be interesting to add a cost module to the experimentation tool, in order to determine which of the proposed improvement configurations is the most appropriate.

References

Angeloudis P, Bell MGH (2011). A review of container terminal simulation models. Maritime Policy & Management, doi:10.1080/03088839.2011.597448

Caris A, Macharis C, Janssens JK (2008). Planning problems in intermodal freight transport: accomplishments and prospects. Transport Plan and Tech, doi: 10.1080/03081060802086397

Supply Chain design and analysis: a case study on a low-cadence car production

García-Miranda I[1], García-Hernández A r[2]

Abstract: The study presents a case study on the design and analysis of a supply chain in a low cadence car manufacturing plant in order to maximize the added value in the line. Lean manufacturing tools are used to design the internal logistics and upstream processes. Among all tools, kitting stands out as a solution for maximizing value, reducing WIP, lead times and machine utilization. Comparative cost-analysis is conducted obtaining a saving of variable costs of 10% in the logistic and assembly costs.

Keywords: material handling; assembly lines; manufacturing management.

1 Introduction

The automotive industry's customers demand a wide variety of models and variants. Manufacturers thus compete by offering customised cars.

This demand and the manufacturing strategy result in the handling of a large number of components in production systems. The problem of keeping many and varied components is met in many companies by materials kitting. A materials kit consists of all the components needed to assemble an individual product or a complete part of a product. Kanban, small parcel and manufacturing supermarket and other different lean manufacturing techniques are implemented in order to obtain a more efficient solution. In a lean world, kitting is considered a waste. However, Toyota has started using kitting in some of their plants for high volume assembly operations. The advantage of this approach is more value added time by the operators, cleaner work areas with visual control, fewer part selection errors, and easier training of assembly operators. The disadvantage is increased manpower by adding kitting personnel.

2 Objectives

Lean manufacturing principles are usually applied in mass series production by the biggest carmakers worldwide. This work seeks to respond to the need for a car manufacturer for the re-design of its Supply Chain, intended for the production of a vehicle of low-cadence, in particular 16 vehicles per day, 10 operations in assembly line and high diversity. These aspects represent a logistical challenge, since on the one hand the volume is not enough to obtain economies of scale and on the other hand, the number of references to handling is also very high.

1 **Iván García Miranda** (ivan.garcia@uc3m.es)
2 **Alicia García Hernández** (agarci1@ing.uc3m.es)
Área de Ingeniería de Organización.
Dpto. de Ingeniería Mecánica. Universidad Carlos III de Madrid.
Avda. de la Universidad, 30. 28911 Leganés (Madrid).

3 Methods

Using lean manufacturing techniques a value stream mapping on the supply chain is conducted. The restrictions are that both the product, production process and component suppliers are defined. The geographical location of the factory and suppliers are restrictions of first level that must be follow the design of the supply chain.

After that internal logistics are designed, detailing the supply of the different line processes from the entrance of the material on the premises of the manufacturer. Then external or upstream logistics, which can carry components from different suppliers to assembly factory, are defined.

4 Results

The costs of direct labour and rental of means of support are reduced 10% in case of use of the presented system.

To be necessary a lower surface by use of optimized warehouse, the associated overheads will be 5% lower in the case of using materials kitting.

5 Conclusion

Collaboration between companies of the same supply line allows getting large economies, notably in the early stages of a project. In logistics, the choice of a supplier of components or the design of a container will be the more optimal; the more takes into account the different actors in the Supply Chain.

References

Bozer YA, McGinnis LF (1992) Kitting versus line stocking: a conceptual framework and a descriptive model. International Journal of Production Economics, 28, pp. 1–19

Limère V, Landeghem HV, Goetschalckx M, Aghezzaf EH, & McGinnis LF (2012) Optimising part feeding in the automotive assembly industry: deciding between kitting and line stocking. International Journal of Production Research, 50(15), 4046-4060.

Simchi-Levi D (2005) Designing and managing the supply chain. Mcgraw-Hill College.

The role of International Purchasing on the competitiveness of industrial companies in Portugal: an empirical study

Lopes O[1], Ferreira L M, Moreira A

Abstract: International purchasing and global sourcing (IP/GS) are research subjects that have been developed mainly during the last two decades (Quintens et al., 2006). Nevertheless, this is a field of research with a lot of potential, especially in small countries like Portugal, where the knowledge and research about this subject is almost inexistent. The ultimate goal of this study was to understand the actual contribution of international purchasing (IP) practices for the competitiveness of industrial companies. Two main conclusions are: (1) IP, for Portuguese companies, is not an option but instead a necessity due to the frequent lack of feasible domestic options and; (2) in most cases, it's easier to achieve competitive solutions through IP, although geographic distance could be an obstacle to the increasingly required flexibility strategy on purchasing.

Keywords: International Purchasing; industrial companies; competitiveness.

1 Introduction

IP/GS are research subjects that have been developed mainly during the last two decades (Quintens et al., 2006). Nowadays, and counteracting the trend of the last years, researchers are paying more attention and studying more deeply international purchasing issues. Some factors such as the development of information and communication technologies and the development of distribution systems, besides market globalisation, are responsible for the increasing of IP/GS activities in companies, making those themes of great interest as research fields (Hultmam et al, 2012; Knudsen and Servais, 2007; Nassimbeni, 2006).

2 Objectives

The present study aims to understand how the growth of purchasing to international markets can contribute (or if it actually contributes) to the development of competitiveness of industrial companies. In order to achieve this main objective, three research questions are proposed: (1) How, and why, is triggered IP in industrial companies?; (2) How can organizational and structural issues be related with the purchasing processes in the international markets?; and (3) How can IP contribute to industrial companies competitiveness?

3 Methods

This study was developed using a qualitative approach, with multiple case studies in industrial companies, being each company a unit of analysis. Eleven companies were studied and they were chosen knowing in advance that they purchased in international markets. The use of multiple case studies allows applying the replication logic, as a way of strengthening the findings (Yin, 2009). The leading method chosen to data collection was the semi-structured interview.

1 **Odete Lopes** (odete@estgv.ipv.pt)
Dept. of Mechanical Engineering and Industrial Management.
Polytechnic Institute of Viseu. Viseu, Portugal.

4 Results

This study reveals that the contribution of the Purchasing activity and particularly IP for the performance of industrial companies is felt, or can be felt mainly in terms of savings, flexibility and speed to market. None of the companies who have participated in this study makes a clear distinction between the general purchasing function and IP; this can be explained due to the fact that Portugal is a very small country with limited domestic supplier options which makes IP almost an inevitable decision, if companies aim to be competitive.

5 Conclusion

The ultimate conclusion that can be drawn from this study is that IP, in Portugal, is vital to companies' competitiveness and, for most industrial companies, IP is essential to their existence due to the lack of feasible domestic options.

References

Hultman J, Johnsen T, Johnsen R, Hertz S (2012) An interaction approach to global sourcing: A case study of IKEA, Journal of Purchasing & Supply Management, Vol. 18, pp. 9-21.

Knudsen MP, Servais P (2007) Analyzing internationalization configurations of SME's: The purchaser's perspective. *Journal of Purchasing & Supply Managemen,* Vol. 13, No. 2, pp. 137-151.

Nassimbeni G (2006) International sourcing: Empirical evidence from a sample of Italian firms. *International Journal of Production Economics,* Vol. 103, No. 2, pp. 694-706.

Quintens L, Pauwels P, Matthyssens P (2006) Global purchasing: State of the art and research directions. *Journal of Purchasing & Supply Management*, Vol. 12, No. 4, pp. 170-181.

Yin RK (2009) Case Study Research – Design and Methods, Fourth Edition, SAGE Publications

Conceptual methodology for handling unexpected events in hierarchical production planning

Vargas A[1], Boza A[1], Patel S[2], Patel D[2], Cuenca Ll[1], Ortiz A[1]

Abstract: An inter-enterprise architecture allows enterprises that make up collaborative networks to model holistically and integrally business processes, human resources, organizational structure and technology. Inter-enterprise architecture can be used to solve the different issues that collaborative networks face on a daily basis. The components of an inter-enterprise architecture are: framework, modelling language and methodology. A conceptual methodology that addresses the problem of unexpected events management in the context of hierarchical production planning to improve decision-making in collaborative environments is proposed and validated in a Spanish collaborative network of the tile sector.

Keywords: inter-enterprise architecture; collaborative network; hierarchical production planning, unexpected events, methodology.

1 Introduction

Enterprises need to involve in collaborative networks (CN) to effectively and synergistically overcome current global and dynamic environment. To enable this, inter-enterprise architecture (IEA) facilitates the integration of business processes with collaborative networks, in line with their information technology (Vargas et al. 2013).

Information technology improves the value chain by changing the way companies do business (Cuenca et al. 2011). Decision support systems (DSS) as part of information technology, support decision-making processes in different situations, such as: purchase planning, inventory control, production planning and distribution planning among others. In this paper and ongoing research, we focus on the use of decision support systems in the context of hierarchical production planning in collaborative environments.

Production planning is extremely complex, and therefore it is difficult to develop a single model to represent the complexity. Hierarchical production planning (HPP) facilitates decision-making by decomposing the problem into sub-problems, in the context of an organizational hierarchy where decisions of the higher levels impose restrictions at the lower levels (Alemany, 2003), which supports the development of manageable models. Even when DSS for HPP guide decision makers to assimilate information and ensure effective decision-making, these systems are designed without taking into account different unexpected events, because of the perceived difficulty of representing uncertainty in the models.

There is tiny evidence in the literature connecting the fields of IEA, HPP and DSS leading to solve the problem of unexpected event handling, finding a gap in the literature that our ongoing research is addressing. The main components of the IEA that address the specific problem of unexpected events in HPP are: framework, modelling language and methodology. Our previous work have focused in the framework and modelling language definition. In this paper our focus is the conceptual methodology that is applied to and validated on a collaborative network scenario based the Spanish ceramic tile sector.

1 **Alix Vargas** (alvarlo@posgrado.upv.es)
Centro de Investigación en Gestión e Ingeniería de Producción (CIGIP).
Universitat Politècnica de València.
Camino de Vera s/n Ed 8G -1o y 4o planta Acc D
(Ciudad Politécnica de la Innovación) Valencia Spain.
2 London South Bank University, School of Engineering,
103 Borough Road, SE1 0AA, London, United Kingdom

2 Objectives

The main objective of this paper is to describe the conceptual methodology that allows modelling the problem of unexpected events handling in the context of hierarchical production planning in collaborative networks.

3 Methods

The conceptual methodology is proposed and validated in a real case scenario.

4 Results

The proposed methodology has helped to validate the use of the framework proposed in our previous work and its applicability in a real case study.

Conclusion

This paper reports the need for a methodology that guides the framework of IEA allowing decision makers to model the problem of unexpected events handling in HPP that can be used by CN to support better and more efficient decisions.

References

Vargas A, Boza A, Cuenca L, and Sacala I, Inter-Enterprise Architecture and Internet of the Future, Technological Innovation for the Internet of Things, 394 (2013) 25-32.

Cuenca L, Boza A, and Ortiz A, Architecting Business and IS/IT strategic alignment for extended enterprises, Studies in Informatics and Control, 20 (1) (2011) 7-18.

M. Alemany, Metodología y Modelos para el Diseño y Operación de los Sistemas de Planificación Jerárquica de la Producción. Aplicación a una Empresa del Sector Cerámico, (PhD Thesis) Universidad Politécnica de Valencia, 2003.

A Flexible Model Approach for Production Planning

Sampaio RJB[1], Wollmann RRG[2]

Extended Abstract: Uncertainty in demand forecast and in production capacities through the planning horizon lead to serious drawbacks in production planning, since they generate nervousness and improvisations in shop floor. Thus it is highly desirable that the production planning incorporate some degree of flexibility to deal with these events that otherwise are almost present in every productive systems. To cope with variability in the planning processes the planner is often required to freeze its planning in the planning horizon. However, freezing the planning has important implications for production costs, and produces large imbalances in addressing the real demands. Therefore it is important to incorporate some mechanism into the production planning to enable flexible implementation of the planning in order to take into account, from period to period, updated information on demands and capabilities. The objective of this work is to turn the production planning models flexible enough to allow information updating whenever it requires, by modeling the production planning problem using linear programming models coupled with clearing function (Miss-bauer et al, 2010; Kacar et al, 2014) and then decomposing the model (Wollmann, 2012; Sampaio et al, 2014) using the concept of rolling planning (Chand et al, 2002). To solve this problem, a two-phase algorithm was developed and several numerical experiments were performed to illustrate it, and to support the proposed algorithm a theorem was enunciated. The proposed algorithm seems to perform well in rolling planning environments and allows data update at the beginning of each period over the planning horizon. This result is quite relevant in view of the fact that the flexibility was incorporated into the production planning model thereby avoiding freezing periods, which in turn increase costs.

1 **Raimundo José Borges de Sampaio** (raimundo.sampaio@pucpr.br)
2 **Rafael Rodrigues Guimarães Wollmann** (rafael.wollmann@pucpr.br)
Dept. of Industrial and Systems Engineering.
Pontifical Catholic University of Parana. Curitiba, PR 80.215-901, Brazil.

Production Planning and Control: Case study of a small dairy industry

Motta B[1], Sampaio F[2], Borges L[3], Mendonça L[4], Evangelista W[5]

Abstract: This paper is a case study developed in order to define the Production Planning and Control (PPC) of a small business in the dairy industry, located in Brazil's southeast region. The methods used to research were literature reviews on the PPC and mapping of the productive processes of the two production lines in the company through personal observations and semi-structured interviews with employees. The main activities of strategic planning and production scheduling were analyzed to define the ideal activities. As a result, the Production Planning and Control was defined and Operation Management was improved. This also resulted in optimized resources and reduction of stock formation of finished products, which in this case are extremely perishable. However, more research is needed to define the percentage of success of the suggestions made in other industries of the sector.

Keywords: Production Planning Control; Operations Management; Dairy Industry.

1 Introduction

The PPC is based on the performance of four overlapping activities, so that there is a balance between volume and time: loading, sequencing, scheduling, and monitoring and control (Slack et al. 2002). The PPC is an extremely important factor, since it allows greater understanding the real business of the company, and it is the source of information necessary for any intervention measures which ensure that company's performance is in harmony with their goals and strategies (Rodrigues & Oliveira 2009).

2 Objectives

The objective of this study is to propose an ideal definition of the Production Planning and Control (PPC) for a small dairy industry in Brazil's southeast region.

3 Methods

A literary review was performed. In addition, the research instruments used for data collection were personal observation and semi-structured interviews with the production line employees through on-site visits.

1 **Bruno de Barros Motta** (bdebarro@asu.edu)
Arizona State University, Tempe, AZ 85281,
USA - Bolsista da CAPES - Proc. No 17389/2013.
CAPES Foundation, Ministry of Education of Brazil, Brasilia, DF 70040020, Brazil.

2 **Fádua Maria do Amaral Sampaio** (faduasampaio@yahoo.com)

3 **Laureilton José Almeida Borges** (laureiltonborges@yahoo.com)

4 **Luciana Mendonça** (luciana.capitolio@hotmail.com)

5 **Wemerton Luís Evangelista** (wemerton.evangelista@ifmg.edu.br)
Instituto Federal de Minas Gerais - Campus Santa Luzia,
Érico Veríssimo St., 317, Santa Luzia, MG 33115390, Brazil.

4 Results

The company operates from Monday to Saturday and it was calculated that the loading limit for each machine is 45 hours per week. However, it was used only 24 hours, which demonstrates idle capacity. There was no sequencing of tasks. Therefore, the prioritization was defined so that the longer processes are of higher priority. The production schedule was established so that the production of yogurt occurs on the first day of the week, and then it alternates days. The bottling will happen on the following day, when the yogurt is ready, and this process will be simultaneous to the production of sweet milk. Therefore the dairy production programming will be backwards, since the products will be made at the last moment. The company needs to monitor its operations to ensure that the planned activities occur and that any deviation from plans can be rectified by some type of intervention.

5 Conclusion

This paper is relevant for the sector because during the literary review, it was observed that there are no published studies with relevant analysis of the PPC activities in the small dairy industry. In the studied company, the results obtained demonstrate the need to perform marketing campaigns to publicize the products, and thus reduce the idle capacity. Through the defined sequencing, there will be an optimization of resources. The established schedule will enable the company to meet the deadlines for deliveries to the consumers, thus avoiding unnecessary stock of finished products. The monitoring and control must be constant; however, if problems arise from the operations interventions and re-planning must be implemented to restore operations. Based on these settings, the dairy industry studied will improve its production process and will also have the possibility to expand itself on the market. However, more research is needed to define the percentage of success of the suggestions made in other industries of the sector.

References

Rodrigues, M. D, and Oliveira I. R. (2009). Production planning and control: A case study in a metallurgical company, Ingepro - Inovação, Gestão e Produção, vol. 02, n. 11, pp. 72-80.

Slack, N., Chambers, S and Johnston, R. (2009). Operations Management, 6th ed n. Prentice Hall

Greenness indicators for the Madrid-Lyon freight transport corridor

Benedito E[1], Corominas A[2], Olivella J[3], Pastor R[4]

Abstract: European Community policy promotes the so called freight transport “green corridors”. These corridors should allow accommodating rising traffic volumes while promoting environmental sustainability and energy efficiency. In order to achieve this objective, a set of proper indicators is needed to measure the performance of the corridors. A set of indicators for the Madrid-Lyon corridor are defined by means of an experts’ consultation.

Keywords: Green Corridor; Freight transport; Key Performance Indicator.

1 Introduction

Green Corridor for freight transport is a concept that still need a wide accepted definition (Demir et al., 2014). European Commission (2007) states that freight Green Corridors “rely on co-modality and on advanced technology in order to accommodate rising traffic volumes while promoting environmental sustainability and energy efficiency”. According to Psaraftis & Panagakos (2012) “Green Corridors aim at reducing environmental and climate impact while increasing safety and efficiency”.

Indicators for green corridors have been previously proposed by Supergreen project (Psaraftis & Panagakos, 2012) and East West Transport Corridor project EWTC II, 2012), between others. Social aspects and co-modality of the corridors were scarcely addressed by these works.

The aim of the work is defining key indicators to assess the green development of the Madrid-Lyon axis of the Mediterranean corridor.

2 Methodology

To determine appropriate indicators, we establish the more relevant factors to assess the actions intended to make a freight transport corridor green, by conducting an experts’ consultation. The experts interviewed are 20 members of shippers, operators of infrastructures, transport and logistic companies, public administration and environmental agencies. A set of indicators is defined by taking into account the factors obtained.

1 **Ernest Benedito** (benedito@upc.edu)
2 **Albert Corominas** (Albert.corominas@upc.edu)
3 **Jordi Olivella** (jorge.olivella@upc.edu)
4 **Rafael Pastor** (rafael.pastor@upc.edu)
Dpto. de Organización de Empresas.
Institut d’Organització i Control de Sistemes Industrials.
Universitat Politècnica de Catalunya. Avda. Diagonal 647, 08028 Barcelona.

3 Results

A total of 69 factors were identified from the experts' consultation: operational (21), environmental and climate impact (11), economic and social impact (22), and infrastructures renewal or construction (15). A set of indicators reflecting the general functioning of the corridor and based on the factors selected by the experts are defined. An overall of 16 indicators are proposed. A total of 9 indicators were previously proposed by SuperGreen project (Psaraftis & Panagakos, 2012), 2 by EWTC II (2012) project and 5 are first proposed (*Table 1*).

Table 1
Full set of indicators proposed.

Block	*Indicator*	*Proposed by*
Operations	Direct costs of transport	SuperGreen
	Frequency of service	SuperGreen
	Safety measures	ECTW II, modified
	Security measures	ECTW II, modified
	Proportion of co-modal transport	CLYMA
	Quality of service in intermodal transport	CLYMA
	Reliability of service	SuperGreen
	Transport time	SuperGreen
Environment and climate impact	Alternative fuels filling stations	ECTW II
	CO2 emissions	SuperGreen
	Engine standards	ECTW II
	SOx emissions	SuperGreen
Economic and social impact	Activity of the areas served	CLYMA
	Impact on physical environment	CLYMA
	Total goods volumes	ECTW II
	Use of capacity	CLYMA

References

Demir, E., Bektaş, Laporte, G. (2014) A review of recent research on green road freight transportation. European Journal of Operational Research, 237, 775-793.

EWTC II (2012). Green Corridor Manual Task 3. Final Report.

European Commission (2007). Freight Transport Logistics Action Plan. Brussels, EC.

Psaraftis HN & Panagakos G (2012). Green Corridors in European Surface Freight Logistics and the SuperGreen Project. Procedia - Social and Behavioral Sciences, 48, pp.1723–1732.

Identifying Interorganizational Relationships Through Theoretical Indicators: A Study In The Milk Production Chain

Okano MT[1], Vendrametto O[2], Santos OS[3], Fernandes ME[4]

Abstract: The literature on the interorganizational relationship between companies and organizations has increased in recent years, but there are still doubts about the various settings. The inter-organizational networks are important in economic life, the fact facilitate the complex interdependence between transactional and cooperative organizations. A need identified in the literature is the lack of indicators to measure and identify the types of existing networks. The objective of this research is to examine the interorganizational relationships of two milk chains through indicators proposed by the theories of the four authors, characterizing them as network or not and what the benefits obtained by the chain organization. The results showed that interorganizational relationships are small and largely limited to the sale of milk or dairy cooperatives. These relationships relate only to trade relations between the owner and purchaser of milk. But when the producers are organized in associations or networks, interorganizational relationships and increase benefits for all participants in the network.

Keywords: Interorganizational networks; dairy chain; Interorganizational Systems.

1 Introduction

The literature on the interorganizational relationship between companies and organizations has increased in recent years, but there are still doubts about the various settings.

The inter-organizational networks are important in economic life, the fact facilitate the complex interdependence between transactional and cooperative organizations.

2 Objectives

The objective of this research is to examine the interorganizational relationships of two milk chains through indicators proposed by the theories of the four authors, characterizing them as network or not and what the benefits obtained by the chain organization.

3 Methods

To achieve the objective of this work was carried out a survey of milk producers in two regions of the state of São Paulo (Avare and Fartura). To collect the information needed for the analysis, exploratory research, qualitative nature was used.

1 **Marcelo Tsuguio Okano** (marcelo.okano@fatec.sp.gov.br)
2 **Oduvaldo Vendrametto** (oduvaldov@uol.com.br)
Paulista University. São Paulo. SP. Brazil
3 **Osmildo Sobral dos Santos** (osmildosobral@yahoo.com.br)
Potiguar University. Natal. RN. Brazil.
4 **Marcelo Eloy Fernandes** (marceloeloyfernandes@gmail.com)
FATEC Barueri. São Paulo. SP. Brazil.

The research instrument of this work consists of a roadmap of semi-structured interviews with open questions. Some of the answers were directed by the interviewer in the form of performance notes aimed at detecting the degree of Importance, according to the perception of intensity to that regard.

4 Results

The results showed that interorganizational relationships are small and largely limited to the sale of milk or dairy cooperatives. These relationships relate only to trade relations between the owner and purchaser of milk. But when the producers are organized in associations or networks, interorganizational relationships and increase benefits for all participants in the network.

5 Conclusion

The various visits and interviews in several dairy farms in the regions of São Paulo (Avare and Fartura) indicated that the inter-relationships are small and largely limited to the sale of milk to cooperatives or dairy. These relationships refer only to trade relations between the owner and the purchaser of milk. But when the producers are organized in associations or networks, interorganizational relationships increase and bring benefits to all participants in the network.

References

AHUJA, G. The duality of collaboration: inducements and opportunities in the formation of interfirm linkages. Strategic Management Journal, Chichester, v. 21, n. 3, p. 317-43, Mar. 2000.

BAKER, E. , KAN, M, TEO, S.T.T. "Developing a collaborative network organization: leadership challenges at multiple levels", Journal of Organizational Change Management, Vol. 24 Iss: 6, 2011

BAUM, J. A. C.; INGRAM, P. Interorganizational Learning and Network Organization: Toward a Behavioral Theory of the Interfilm. In MARCH, J.G. AUGIER, M. (eds) A Tribute to Richard M. Cyert. Aldershot UK: Edward Elgar. 2000.

BORGATTI, S. P., HALGIN, D. S. On Network Theory. Organization Science. 2011

EGERSTEDT, M. COMPLEX NETWORKS - Degrees of control. Macmillan Publishers Limited. Nature. Vol 473. 2011

GULATI, R.; NOHRIA, N.; ZAHEER, A. Strategic networks. Strategic Management Journal, v. 21, n. 3, p.203-15, 2000.

HARLAND, C.M. , "Supply chain management: relationships, chains and networks", British Journal of Management, Vol. 7 No. 1, pp. 63-80. 1996

HOLM, D B.; ERIKSSON, K.; JOHANSON, J. Creating value through mutual commitment to business network relationships. Strategic Management Journal, Chichester, v. 20, n. 5, p. 467, May 1999

HUXHAM, C., "Theorizing collaboration practice", Public Management Review, Vol. 5, 2003

WASSERMAN, S.; FAUST, K. Social Network Analysis: Methods and Applications. Cambridge University Press, 2007Dod J (1999) Effective Substances. In: The dictionary of substances and their effects. Royal Society of Chemistry.Available via DIALOG. http://www.rsc.org/dose/title of subordinate document. Cited 15 Jan 1999

Slifka MK, Whitton JL (2000) Clinical implications of dysregulated cytokine production. J Mol Med, doi: 10.1007/s001090000086

Assembly lines for end-of-life products: improving their efficiency

Cardoso J[1], Xambre AR[2], Fernandes R[3]

Abstract: To compete in a global market, companies must be flexible and have high levels of responsiveness to changes in the demand (either in terms of types of products or volume). This means that traditional mass production systems, such as assembly lines, must be adapted and improved in order to incorporate the required flexibility.

Keywords: Assembly line; efficiency; production systems.

1 Introduction

The work presented in this paper is part of the final project integrated in the Master's Program in Industrial Engineering and Management (MIEM) from the University of Aveiro, Portugal. The project is being developed at a multinational company that produces electronic goods and operates in an unpredictable market.

The company produces based on forecasts but, since they have a low volume / high diversity environment, this can become quite volatile. Some numbers might help to illustrate the complexity of the system: the company has 22 production lines, 550 different products of which only 9% are runners (produced everyday), 65% of planned operation time (POT) is used by runners, and minimum lot size is 1 part and maximum is 96 parts. This means that, per day, only 35% of the POT is available to produce the remaining products (the non-runners).

The portfolio of this company is growing so the use of resources (such as space, workers and equipment) is becoming an issue. Also, high flexibility plays an important role in such a market since it is essential to be agile and to respond quickly to changes in customer requirements.

2 Objectives

The purpose of the project is to identify, study and compare strategies to help the company deal with the diversity of products that have low production volumes and are reaching their end-of-life stage, thus increasing its flexibility. In this work a specific analysis is described where the challenge was to release space on the shop-floor in order to build new assembly lines for new products.

1 **Jorge Cardoso** (Jorge.Cardoso2@pt.bosch.com)
Bosch Security Systems S.A, EN 109,
Lugar da Pardala, Zona Industrial de Ovar, 3880-728 Ovar, Portugal.

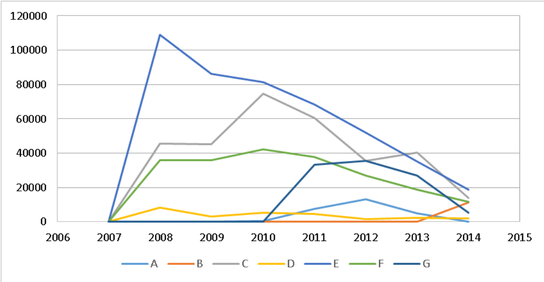
2 **Ana Raquel Xambre** (raquelx@ua.pt)
DEGEI / CIDMA – Universidade de Aveiro,
Campus Universitário de Santiago, 3810-193 Aveiro, Portugal.

3 **Rui Fernandes** (Rui.Fernandes@pt.bosch.com)
Bosch Security Systems S.A, EN 109,
Lugar da Pardala, Zona Industrial de Ovar, 3880-728 Ovar, Portugal.

3 Methods

The first step was to identify the assembly line that was dedicated to products in the decline phase of their life cycle. Assembly line number 2 was identified as a possible target since it occupied a lot of space (88m2) and presented frequent underutilization of some workstations. Figure 1 shows the production history of the product families assembled at this line.

Fig.1
Production history (number of parts per year, for each product family).

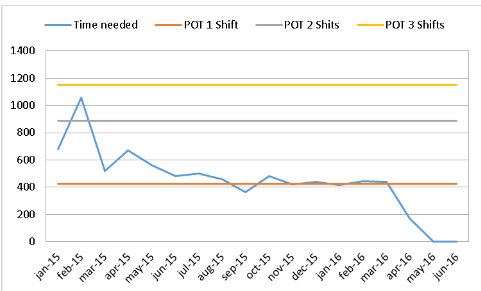


In a second stage, a work measurement study was performed to confirm the times of bottleneck workstations. Then, with this two sets of data, it was possible to determine the total time, per day, that is needed to produce the quantities for each product family (forecast/day*bottleneck) and check if the POT available (including 12% for unpredictable losses) is enough to meet costumer's needs.

4 Results

It was decided to reduce all the equipment of the line to 1 unit of each type and also reduce 2 workstations in the manual assembly. Taking this into account and considering the forecast for each family and the bottleneck operation time, identified through the work measurement study, it was possible to determine the time per day necessary to meet customer needs. Figure 2 shows those results and it is noticeable that two shifts are sufficient to face customers' demand (and also spike orders) with the exception of February 2015 when three shifts are required.

Fig.1
POT vs required time (in minutes).



The re-layout of the assembly line was then performed which led to several savings such as: (i) less 33m2 of used space, (ii) less equipment, and thus (iii) lower maintenance costs and (iv) less unpredictable stoppages due to equipment's breakdowns. Additionally the distances inside the line were reduce which helped in the development of a better solution for the balancing problem, in a way that the workload balance improved by 10%.

5 Conclusion

Companies must find ways to be competitive and, in this specific case, the strategy used was to get the same output with fewer resources while increasing the company's portfolio. Assembly lines with end-of-life products can be seen as an opportunity for improving the production system efficiency. The next stage of the project is to develop methods/strategies that companies could use, in a specific point in time, to predict this inefficiency instead of acting after the fact.

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Maturity models in supply chain sustainability: a literature review

Correia E[1], Azevedo S[2], Carvalho H[3]

Abstract: This paper aims to explore the different maturity models that have been used in the context of supply chain sustainability. Given the relevance of the topic a systematic literature review is performed to identity a set of maturity models that have been developed in order to assess the different levels of SC sustainability. Also, the main focus of analysis performed and the shapes of the maturity models are explored. The guidelines on conducting a systematic literature review were followed to ensure that an unbiased and valid evaluation was conducted. The novelty of this research lies in the methodology used for reviewing the literature and in the adoption of a dynamic perspective to analyze the theory developments.

Keywords: Maturity Models, Sustainability, Supply Chain, Systematic, literature, conceptual framework.

1 Introduction

Since its development, maturity models have been widely adopted and used (Bititci et al., 2014) in areas such as engineering or management (Pigosso et al., 2013). According Wendler (2012) the application of maturity models in diverse fields such as engineering or management justify the need to analyze the literature on these models in a more structured way.

Given its characteristics the maturity models seem to be a useful tool for the analysis and evaluation of supply chain's (SC's) sustainability, mainly because they presuppose an evolutionary perspective (Paes 2011) i.e. admit a temporal dimension which is inseparable from the concept of sustainability (Lozano et al., 2014). As stress Wendler (2012) and Becker et al. (2009), the development of new maturity models must take in consideration that there are existing models available and it is necessary a careful evaluation of them and analysis of their applicability. Doing so improves the quality and relevance of the development of new models (Wendler, 2012). In this line, this paper seeks to identify and analyse the maturity models that have been used in the context of sustainable SCs. This justifies a structured review of further literature focused on maturity models that connect these two areas: sustainability and SC.

2 Methodology

A systematic review of the literature, as opposed to a narrative literature review, shows how the investigation was conducted enabling to monitor the decisions, procedures and conclusions of the investigator. As pointed out by Rousseau et al. (2008) systematic reviews are: comprehensive through the inclusion of all relevant studies; use transparent analyzes; and apply the critical interpretation with specific criteria for providing the evidentiary value of a body of previous literature. This work follows a multidisciplinary integrative review according to the five phases proposed by Whittemore and Knafl (2005): 1) problem formulation; 2) literature search; 3) evaluation of research; 4) Research analysis and

1 **Elisabete Maria da Fonseca Correia** (ecorreia@iscac.pt)
Instituto Superior de Contabilidade e Administração de Coimbra (ISCAC).
Quinta Agrícola – Bencanta 3045-601 Coimbra, Portugal.
2 **Azevedo G. Susana** (sazevedo@ubi.pt)
CEFAGE-UBI - Departamento d eGestão e Economia,
University of Beira Interior, Edificio Ernesto Cruz, 6200-209 Covilhã.
3 **Helena Carvalho** (hmlc@fct.unl.pt)
UNIDEMI, Dep. de Engenharia Mecânica e Industrial, Faculdade de Ciências e Tecnologia,
FCT, Universidade Nova de Lisboa, 2829-516 Caparica, Portugal.

interpretation; and 5) presentation of results. The application of each one of these phases to a systematic literature review of maturity models in SC sustainability is described as follows.

Phase1 - Problem formulation

Although there are some frameworks that seek to assess sustainability in the SC (Chardine-Baumann and Botta-Genoulaz, 2014), there are a few that allow managers and other stakeholders to understand where the company and its SC are in terms of the evolution of sustainability and what actions should be made to maintain and promote it evolve (Reefke et al., 2014; Kurnia et al., 2014).

Despite the widespread use and adoption of maturity models (Bititci et al., 2014), Wendler (2012) points out that neither the meaning nor the elements of the maturity model are established and clear. For example, models can define different sets of levels or stages, and use different means for determining the maturity level (Pace, 2011). Thus, for the development of a conceptual model, the literature review can contribute to a better knowledge and understanding of the proposed maturity models previously in the context of the SC and sustainability. Therefore, the following research questions have been identified:

What kind of maturity models have been developed to assess the different levels of SC sustainability?

Which is the main focus of analysis of sustainability maturity models in the context of SC?

Which are the main shapes of the maturity models?

Phase 2 - Literature search

The next step is the selection of bibliographic databases to be used and then the definition of keywords and search strategy. For identification and selection of studies to analyze researched to the SCOPUS databases, Emerald Insight, EBSCO and Web of Science in March 2015. With this choice is intended to ensure the integration of the most important publications in the relevant sectors for the study, as the SCM and sustainability (e.g. Tachizawa and Wong, 2014), but also in areas such as information systems and software development, which dominated the maturity models research works (Wendler, 2012).

Phase 3 - Evaluation of research

To obtain the broadest possible range of papers for analysis synonyms for the term "maturity models" were identified using a small sample of some papers on the subject. Three classes of keywords were used as follows: i) "maturity" and maturity models "; ii) "sustainab*", "environment*" and "social"; iii) "supply chain" and "supply chain management". Various combinations of these keywords were used to search all databases the papers that contained in its title, abstract or keywords such terms from January 2000 to March 2015.

To ensure that only relevant papers entering the set of papers to be analyzed, several inclusion/exclusion criteria were established. Whereas it is intended to make the broadest possible review, it was decided to include all kinds of papers (conceptual, empirical, literature reviews, etc.). Given the goal of this study were considered as acceptable for further analysis all kinds of papers present in the databases either in academic journals as proceedings conference. Subsequently we compared the results between the databases and eliminated duplicate papers getting 69 papers. A reading in full of the remaining led to the conclusion about its focus on maturity models and their relevance to provide insights to answer to the research questions. From this process it were selected 20 papers for a deeper analysis.

Phase 4 - Research Analysis and interpretation

The fourth phase aims to summarize and document information extracted from the selected papers. In a first step it was analyzed the research strategy used by the different authors; in addition it was identified the main research objective, this is, maturity model development, application or validation, or other. Table 1 contains the result of this analysis.

An interesting element found in most papers is the absence of a definition of maturity model. In the 20 papers, the exception is made in 5 (Cuenca et al, 2013 Pigosso et al, 2013; Okongwu et al, 2013;Vanathi and Swamynathan, 2012; McCormack et al., 2008). Most of the reviewed papers aim to develop maturity models and its validation Note also that some of the developed maturity models are the basis for subsequent application. For example, McCormack et al. (2008) is an example of a paper whose purpose lies in the application of maturity models developed previously. On the other hand, there are papers which merely conceptual models developed, validated or not meeting the set of revised applied work (e.g., Reefke et al., 2014). The category "Other" also includes a reasonable number of papers.

The dominance of case studies as a research method is usually appointed as an indicator of immaturity "research stage" that field. Analyzing only the entered papers under the SCM or SSCM, many of them (e.g. Aryee et al, 2008; Netland et al, 2007) proposes models that were validated or applied to assess the maturity of a company, or applied to several companies but without considering the link between them, missing perspective in terms of SC.

Table 1
Research objectives and research strategy.

	Maturity model development stage			
Research strategy	Development	Application	Validation	Other
Conceptual	(5)			(14), (16), (19)
Surveys	(4) , (2), (17)	(18)	(4) , (17)	(6), (7) , (9)
Action research	(11)			(11)
Expert panels				
Case studies	(3) , (8) , (10), (13), (15), (20)	(2)	(3) , (8) , (10), (13), (15), (20)	
Other/ no method applied	(1)			(12)

Legend: (1) Huang and Handfield, 2015; (2) Souza et al., 2015; (3) Golinska and Kuebler, 2014; (4) Hynds et al., 2014; (5) Reefke et al., 2014; (6) Jabbour et al., 2014a); (7) Jabbour et al., 2014b); (8) Kurnia et al., 2014; (9) Jabbour et al., 2013; (10) Cuenca et al., 2013; (11) Pigosso et al., 2013; (12) Estampe et al., 2013; (13) Hameri et al., 2013; (14) Edgeman, 2013; (15) Okongwu et al., 2013; (16) Vanathi and Swamynathan, 2012; (17) Frederico and Martins, 2012; (18) Trkman et al., 2012; (19) Oliveira et al., 2012; (20) Meng et al., 2011.

Table 2 Summarizes the main characteristics of the maturity models in the revised papers.

Table 2
Main characteristics of maturity models.

	Main research focus											Models Shapes				
		Processes of SC	Broad Evaluation of the SC	SC Relationships	Systems and technologies	Sustainability	Others	Nº of maturity levels	Representative Standard	Definition of capacities	Identify /To relate capacities		Hybrid Models	Questionnaires Likert style	Maturity Grid	Others
(1)		X						5	a							X
(2)		X						5	a					X		
(3)						X		4	a							
(4)		X					XX	4	a							
(5)		X				X		6	a						XX	
(6)						X		3								n.a
(7)		X				X		3								n.a
(8)		X				X		4	a	XX	X				XX	
(9)						X		3	a				X			n.a.
(10)				X X				5	na						XX	
(11)						XX		5		XX						n.a.

	Main research focus											Models Shapes				
		Processes of SC	Broad Evaluation of the SC	SC Relationships	Systems and technologies	Sustainability	Others	Nº of maturity levels	Representative Standard	Definition of capacities	Identify /To relate capacities		Hybrid Models	Questionnaires Likert style	Maturity Grid	Others
(12)							XX	n.a								
(13)							XX	5								
(14)								n.a								n.a
(15)						XX		4	a							
(16)		X						5		XX						
(17)					Xx		XX	5								X
(18)		X						5	a		X					
(19)		X			XX			5	a							
(20)		X						5	a						X	

Legend: a) continuous; (1) Huang and Handfield, 2015; (2) Souza et al., 2015; (3) Golinska and Kuebler, 2014; (4) Hynds et al., 2014; (5) Reefke et al., 2014; (6) Jabbour et al., 2014a); (7) Jabbour et al., 2014b); (8) Kurnia et al., 2014; (9) Jabbour et al., 2013; (10) Cuenca et al., 2013; (11) Pigosso et al., 2013; (12) Estampe et al., 2013; (13) Hameri et al., 2013; (14) Edgeman, 2013; (15) Okongwu et al., 2013; (16) Vanathi and Swamynathan, 2012; (17) Aryee *et al*., 2008; (18) McCormack *et al*., 2008; (19) Standing and Jackson, 2007; (20) Netland *et al.*, 2007.

Table 2 shows that most mature designs within the SC focus is in the processes of SC (eg Garcia Reyes and Giachetti, 2010; Lockamy III and McCormack, 2004; McCormack, 2001). Fewer are the models that focus on the integration of SC (eg Aryee et al., 2008), relationships in SC (eg Cuenca et al., 2013) or have a broad SC approach (eg Meng et al., 2011). Many of the papers on the sustainability field focus on specific issues incorporating the concept of maturity. For example, Pigosso et al. (2013) perform a systematization of ecodesign practices that can help implementing the ecodesign process and that are useful in evaluating the company's maturity profile. Standing and Jackson (2007) suggest a maturity model to insert sustainability concerns in the IS system. Under the SC, Lockamy III and McCormack (2004) published one of the first studies that analyze the maturity of processes related to SCM, becoming a model oriented to the management of processes (Business Process Orientation - BPO) (Söderberg and Bengtsson, 2010).

Models that explore the two areas (SC and sustainability) focus mainly in processes and sustainability. These models help to establish a direction and strategy for the transformation processes required to achieve a sustainable SC. Thus, Reefke et al. (2014) pointed out that in order to be sustainable the SC must continu-ously improve its processes towards sustainability, to include performance measurement systems of sustainability. The main idea of maturity models is that they assume a path of development or evolution (Paes, 2011), which is drawn through a series of levels, stages or phases from an initial state to maturity (Becker et al., 2009). Achieving each maturity level allows incremental and lasting performance improvements (Estampe et al., 2013). Despite being proposed different maturity models within the SC, all share a common feature: define a number of maturity levels. As can be seen in Table III, maturity models considered in the papers referred oscillate between levels 3 to 6, the most common number five maturity levels.

The maturity models may have different ways to determine the maturity levels and can be classified, depending on how they are constructed in different groups: maturity grids (grids maturity), hybrid models and questionnaires Likert style (Likert -like Questionnaires). The maturity grids submit a description of activities for each level of maturity. Hybrid models are models that combine quizzes with maturity settings, which can be general descriptions of the maturity levels or contain an additional description for each activity. The models framed in the latter group are those using questionnaires that a practice is described and asked the respondent to answer that matches the performance of a 1 to n scale (Paes, 2011).

3 Conclusion

Maturity models have been widely adopted and used (Bititci et al., 2014) in areas such as engineering or management This paper has as main objective to explore the maturity models in the supply chain sustainability context using . After a systematic literature review it can be concluded that most maturity models that explore the two areas (SC and sustainability) focus mainly in processes and sustainability, They can be classified into maturity grids, hybrid models and questionnaires Likert .

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4 References

Available on request.

A tool to visually explain the zones of influence of several distribution centres in a network

Maligo C[1]

Abstract: The concept of zone of influence is bound to arise in a great variety of situations involving explanations about supply chain, logistics or distribution of goods or services. Although the concept itself is not particularly difficult to explain or understand, the classroom experience strongly recommends the use of drawing or any visual aid to obtain effective and fast results. This work is the result of the search for a tool which could not only provide the visual support teachers need for their explanations but also show – graphically – the effects on form and size of the zones of influence due to changes in the related variables. This work shows how the use of the conditional format resource in a Microsoft Excel spreadsheet makes it possible to construct such a tool, bringing to students, through a visual and simulation-like experience, a deeper understanding on the subject.

Keywords: zone of influence; logistics; simulation.

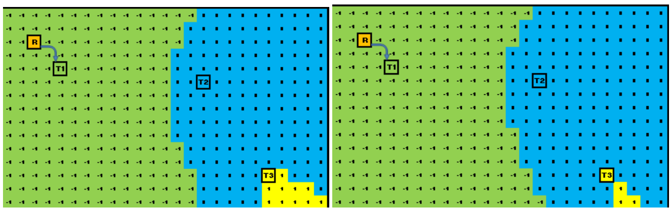
1 Introduction and objectives

The concept of zone of influence – ZoI – is not particularly difficult to explain but problems may arise when one has to explain the concept to a diverse audience, possibly with no background on logistics or on the industry being focused. Ensure a good understanding of the concept is key to move on and show the relationships lying under the figures and how they can influence each other. The objective of this work is to publicize a simple but efficient tool that can help teachers in this task. The tool was conceived and designed aiming a graphic result capable of catching the attention of the audience by being interactive. This simulation-like characteristic is vital, since it enhances the understanding of the concept as well as allows the explanation to go deeper into the complexities of real world examples.

2 Methods

The tool is a workbook where the last spreadsheet is to be kept visible to the public. In this work, a distribution chain pictures a main terminal (T1), a secondary terminal (T2) which receives product from T1 by rail, and a tertiary terminal (T3) which receives from T2 by big trucks – bT. Transportation from terminals to retail is done by small trucks – sT. The calculations took into account different transportation costs and different operational costs of the terminals, supposing they differ in size and throughput. Other costs can be easily added at will. The cost of sending product to each cell is calculated, considering the three possibilities: T1+sT, T1+rail+T2+sT, and T1+rail+T2+bT+T3+sT. After that, the three figures are compared, and each cell is associated with a value according to the result: 1, if the lower cost is via T1 only; 2, if via T2 is best, or 3, if T3 is the best option. The conditional format is then applied throughout the scenario to obtain the final result: colouring each cell with the same colour of the cell picturing its supplying terminal, thus creating the image of the three ZoI. Should further changes in cost components cause the change of any cell's supplying terminal, the cell's colour will change accordingly.

1 Carlos Maligo (cmaligo@imagelink.com.br, carlosmaligo@gmail.com)
Independent Consultant.
Rua Bambina, 134/606, 22251-050 Rio de Janeiro, Brazil.



The slight change in T1/T2 border and the loss for T3 due to a 5% reduction in sT cost.

3 Results

The tool was already used in lectures on logistics in the automotive fuel distribution market in Brazil. Audiences, composed by professionals of various areas, were struck by the visual results and interactivity and showed interest by bringing up comparisons with other scenarios and other markets, and suggesting other simulations and different changes in the variables to check for the consequences.

4 Conclusion

The proposed tool is cheap, easy to construct, and uses the hardware commonly available in today's classrooms and auditoriums. It is easy to handle and provides a visual aid to teachers dealing with supply chain, logistics or distribution subjects.

References

Bowersox DJ, Closs DJ (1996) Logistical management: the integrated supply chain process. McGraw-Hill.

Performance Measurement of Total Productive Maintenance in a Production Company

Tasan A.S[1], **Boztug U.A**[2]

Abstract: Total productive maintenance is very important to gain and sustain competitive power of service and manufacturing companies. Besides, the performance of total productive maintenance has to be measured and considered by managers. In this study, an integrated performance metric is proposed for total productive maintenance in a production company based on several performance metrics such as; spare parts availability, breakdowns, product quality and efficiency. The integrated performance metric is formulated using regression analysis.

Keywords: Performance measurement; total productive maintenance.

1 Introduction

Total productive maintenance has become very important in service and manufacturing industries due to increasing competition. Nakajima (1989) defined total productive maintenance as an innovative approach to maintenance that optimizes equipment effectiveness, eliminates breakdowns, and promotes autonomous maintenance by operators through day-to-day activities involving the total workforce. In today's business environment, managers have to consider not only total productive maintenance but also the performance of total productive maintenance. One approach to improving the performance of maintenance activities is to develop and implement strategic total productive maintenance programs (Ahuja and Khamba, 2007). Successful strategic programs are made based on accurate performance metrics. The performance of maintenance significantly affects production costs, efficiency and product quality and total productive maintenance process has to be managed based on predetermined performance metrics. In this study, an integrated performance metric is proposed for total productive maintenance in a production company.

2 Objectives

The aims of this study are to understand the maintenance performance perception of managers with different perspectives and to develop an integrated performance metric for measuring the performance of total productive maintenance efforts in a production company.

3 Methods

Interviews were conducted in a production company to understand how the managers evaluate maintenance results. The performance perceptions of managers were associated to some performance metrics based on these evaluations. The overall performance of total productive maintenance was determined using regression analysis.

1 **A.Serdar Tasan** (serdar.tasan@deu.edu.tr)
Department of Industrial Engineering,
Dokuz Eylül University, Izmir, Turkey

2 **Umman A. Boztug** (uboztug@hotmail.com)
The Graduate School of Natural and Applied Sciences,
Dokuz Eylül University, Izmir, Turkey

4 Results

Some maintenance performance metrics were obtained for considered production company. These metrics are related to spare parts availability, breakdowns, product quality and efficiency. An integrated performance metric was proposed based on the relative importance levels of these performance metrics and their historical values through regression analysis.

5 Conclusion

Performance management of total productive maintenance process based on some metrics is important for gaining and sustaining competitive power in means of lower production costs, higher efficiency and better product quality etc. In this study, an integrated performance metric for total productive maintenance was proposed for a production company.

References

Ahuja, I. P. S., & Khamba, J. S. (2007). An evaluation of TPM implementation initiatives in an Indian manufacturing enterprise. Journal of Quality in Maintenance Engineering, 13(4), 338-352.

Nakajima, S. (Ed.). (1989) TPM development program: implementing total productive maintenance. Productivity Press.

Analysis of Logistics Flows in an Urban Functional Area. Application to Cartagena

De-la-Fuente-Aragón MV[1], Ros-McDonnell D[2], Nyerges L[3], Bajor P[3], Ros-McDonnell L[1]

Abstract: The main priority of authorities is the constant search of fast, feasible and economical solutions in the Urban Transport Problems (traffic congestion and parking difficulties, freight distribution, public transport inadequacy, difficulties for pedestrians, loss of public space, environmental impacts, etc.) and it shows a clear trend towards increasing pedestrian areas in the city centres. But the city centre pedestrianization has also led to the appearance of problems such as limited parking areas, traffic access limitations, difficulties in delivering operations, as well as the access difficulty of the neighbours living in these areas. The main objective of this work is the analysis of the logistics flows in an urban functional area. Specifically, the studio has been focused on the city centre of Cartagena, characterized by the large number of pedestrian areas. For this purpose, the research team will perform the urban structure of the functional urban area under studio. The information gathered concerning urban flows allow modeling the behavior and performance of the study area, identify their main problems and outline a number of solutions to solve them.

Keywords: Urban functional area, freight transport, pedestrian zones, logistic flows.

1 Introduction

Cities are a big and increasing market for transportation companies. Different size of retail shops, warehouses, restaurants, food markets can be found there. Supplying them is a daily challenge, even because competition between supply chains (i.e. enterprises) is crucial. It is important to realize that the most of supply chains extend far beyond any single political boundary. By reason of globalization, big firms have extended their supply chains, sometimes through continents. Supply Chain Management (SCM) is responsible to handle these long supply lines.

The extended version of the Total Logistics Concept: “to treat many different elements that come under the broad category of distribution and logistics as one single system” (original Total Logistics Concepts), but SCM includes the supplier and the end user in the process of the upstream and downstream (Rushton et al., 2014).

Urban movement is the last echelon in the supply chain, mainly (except some cities with major ports or freight terminals) a mix of “last-mile” deliveries on the way to the final consumer or intermediate shipments. The Council of Supply Chain Management Professionals estimates that last mile movements accounts 28% of all transportation costs (Goodman, 2005). Decreasing costs in the last mile is the new challenge for distribution operators.

Why is important to support distribution within the company? Because distribution is a key driver of the overall profitability for a firm. Firstly, distribution directly impacts both the supply chain cost and the customer experience, and secondly, a good distribution can be used to achieve a variety of supply chain objectives ranging from low cost to high responsiveness.

1 **Ma Victoria de la Fuente-Aragón** (marivi.fuente@upct.es)
Lorenzo Ros-McDonnell (lorenzo.ros@upct.es)
Research Group “Industrial Engineering & Management”.
ETSII. Technical University of Cartagena, (Spain).

2 **Diego Ros-McDonnell** (diego.ros@upct.es)
Research Group “Project+City”.
ETSAE. Technical University of Cartagena, (Spain).

3 **Nyerges Lajos Roland | Péter Bajor** (p.22567@gmail.com)
Department of Logistics and Forwarding,
Széchenyi István University Gyr, (Hungary)

2 The Urban Area Definition

"An Urban Area (UA), also called built-up urban area, is a continuously built up land mass of urban development that is within a labour market (metropolitan area or metropolitan region). An urban area does not contain any rural land." (Demographia, 2015).

The Urban Area meaning differs amongst countries. This study uses the following categorization:

- Metropolises – the very largest urban areas with over 3 million inhabitants
- Other Large Urban Zones – urban areas with more than 500,000 inhabitants (excluding the metropolises)
- Smaller Heritage Urban Areas – smaller urban areas that are "sensitive" environments because of the importance of the town or city in cultural or heritage terms. Cartagena fits to this category.

More than one-half of the world population is living in Urban Areas. In 2015 there are around 34 megacities in the world (urban areas over 10 million population). A total of 75 urban areas are indicated with 5,000,000 or more population. This indicates that, it would be a big issue in the future (actually already) to supply and support of these urban centers (DG MOVE European Commission; 2012).

Negative Impacts of Logistics Flows in an Urban Area

Main problems with the freight transport in an Urban Area are quite similar to problems caused by the motorized mobility in UA. Because of their nature, the Urban Freight Transport should be handled apart from the passengers transport. Main leading problems are as follows (DG MOVE European Commission; 2012):

- Accessibility: Freight vehicles are mainly due to insufficient infrastructure, access restrictions or congestion. When they park they can reduce road capacity heavily even when there is not designated area to park.
- Environmental: Harmful emissions, noise, vibration and physical hindrance.
- Safety: Freight vehicles, due to their size, manoeuvrability and on-road loading/unloading operations, are significant cause of accidents.
- Energy Consumption: Urban freight transport is the major and rapidly growing sector of oil consumption.

Therefore, to improve the sustainability of urban freight operations three main solution-directions can be distinguished: technology, policy and logistics. These solutions, very of them implemented separately, but to achieve sustainable urban freight transport it is necessary to use a mix of them (Taniguchi et al., 1999).

3 Cartagena as an Urban Area

The city center of Cartagena has three main activities: leisure, commercial and business, besides the other industrial activities in its surroundings (industrial port, refinery, shipyard, and naval base). Most of the museums and famous heritage buildings are located in the old town. Moreover, local authority buildings and financial headquarters are based in the center. These establishments generate passenger traffic and around 600 different commercial establishments (restaurants, bars, clothing shops, supermarkets, etc.) generate freight flows to the city center.

Identifying Logistics Flows Problems in Cartagena

The freight transportation situation in the old town is briefly described:

- Restricted entry in the city center, since 2009, Cartagena's Council rebuilt and pedestrianized not of the streets. Commercial vehicles need a permission to enter into the pedestrian zone.

- Residential cars: residents in city center want to commute and this situation leads to compete for free spaces with freight vehicles.

- Congestion: main streets are busy in the morning,, because of the timetable, all commercial shops have to resupply heir stocks within 3 hours, and also at this time pedestrian commuters are using the streets.

- Parking hubs for freight vehicle and loading restrictions: the municipal ordinance limits parking in these hubs and limits loading/unloading operation to maximum 15 min. Usually these places are occupied by resident's or shop owner's cars, sometimes freight drivers leave their car for a long time (i.e hours), an another bad habit is the double parking.

4 Flow analysis results in Cartagena

During the development of this work, the research team applied the Taniguchi's methodology (Taniguchi, 1999), which suggests a systematic procedure to analyze the existing problems in logistics flows in an urban functional area and to propose solutions.

Measurement and Data Collection

Data collection in urban freight surveys is an expensive and difficult task without any standardized form, and a range of data is often required often required to provide a rational basis for decision-making (Taniguchi, 1999; Herce, 2009).

Surveys and other data gathering from freight operators and shop owners are difficult and time-consuming processes, so this project is focused on freight traffic flows measurement, in order to get exact information about vehicle-based operations. For this purpose, we used the Elli3 Moment application, an android-based application for mobile devices, with a variable measuring screen where you can define any kind of time based activities.

As detailed before, this study is only focused on the pedestrian zone which is highlighted with a red polygon in Fig 1. The area is approximately 0.35 km2. This urban functional area has different type of streets in it:

- Streets only for pedestrian commuting (and for those who have permission; e.g. resident cars, emergency vehicles, taxi cabs etc.). Every other commuter is prohibited to enter this area, except between 8:00 and 11:00 am, when it is opened for freight vehicles, so they can deliver goods to shops.

- Mixed streets, where cars and pedestrian commuting are allowed the whole day.

Flow Analysis Results

Two main measuring zones were implemented (see Fig. 1). One is called 'outer ring', these points (blue polygon) are located little further from the city center. These points were implemented to observe traffic flow directions to the center and to locate traffic hubs. To achieve these goals, 7 measuring points ('outer ring') were set up, in order to cover all of the main streets to the center.

Another measuring zone is called 'inner ring', this (red) polygon actually lay on the pedestrian zone. The seven measuring points were set up alongside the border of the pedestrian zone and we defined one measuring point inside. Reason of the implementation of that one point is to measure the traffic density along the main street.

Fig.1
Measuring points around the center:
the "outer ring" and the "inner ring".

The measurements were taken in three different time-range. Weekdays in the morning (8:00 to 11:00 am), weekdays in the afternoon (16:00 to 18:00 pm), and Saturdays in the morning (9:00 to 11:00 am). Morning's weekday is the busiest time: shops are going to open, offices also open, and freight deliveries take place. The reason of the afternoon measurements is because shops are going to open (around 17:00-17:30 p.m.), so the traffic will start to be busy again.

On table 1 are shown all the whole morning traffic flows going into the city center. The 80% of the entering vehicles are passenger cars, and 15% are the freight vehicles. Points nº 3-6-7 are the busiest entry points (more than 100 different vehicles passed through them). Point nº 3 is the most commonly used way for freight deliveries to reach directly the center in the morning.

A similar situation occurs during the exit traffic flows along the morning. In this case, only points nº 6-7 are the busiest, because of the traffic system directions.

Table 1
Outer ring entry vehicle distribution in the morning.

Vehicle	Nº 1	Nº2	Nº3	Nº4	Nº5	Nº 6	Nº 7
Bus	0	0	13	11	0	12	0
Cyclist	7	6	25	11	5	2	17
Moped	35	9	36	17	8	30	106
Car	444	168	1214	360	123	975	1688
Small Van	56	46	104	61	10	79	91
Large Van	22	26	72	42	5	71	110
Truck	23	20	25	12	0	29	17

In summary, we can note that in the morning time, a constant increasing number of freight vehicles are observed into the city center. Mostly of the time, the number of the entering vehicles was higher than the exiting vehicles (Fig. 2). Some reasons can be pointed out: drivers park their vehicles and left there, or also loading/unloading activities take more time than expected. We must remark that the measurement ends at 11.00 a.m., but a great number of vehicles are still operating inside the city center.

Fig.2
Total Freight vehicles distribution in/out of the outer ring.

The study of the logistic flows in the inner ring includes a new element: Pedestrians (see table 2), because it is supposed that in the pedestrian zone the traffic flows will be lower than in the outer ring.

An enormous peak of entry-activity was detected at point C. the 72% of freight vehicles used that way to reach the city center. A second peak is at point G, with the 25% of total share.

Table 2
Inner ring entry vehicle/pedestrian distribution in the morning.

Vehicle	A	B	C	E	F	G
Pedestrian	845	1261	663	177	121	189
Cyclist	14	17	20	11	0	0
Moped	1	0	71	4	0	2
Car	0	0	385	59	12	40
Small van	0	8	102	12	9	25
Big van	0	10	60	8	8	25
Truck	0	10	33	1	10	19

Regarding to the traffic flows in/out of the pedestrian area, figure 3 shows the same trends we could see as in figure 2. This means more freight vehicles entered the pedestrian zone than left it. Increasing of freight volumes are also similar, but during the last hour (10-11 a.m.) the entry freight vehicles were reduced and vehicles started to leave the inner ring.

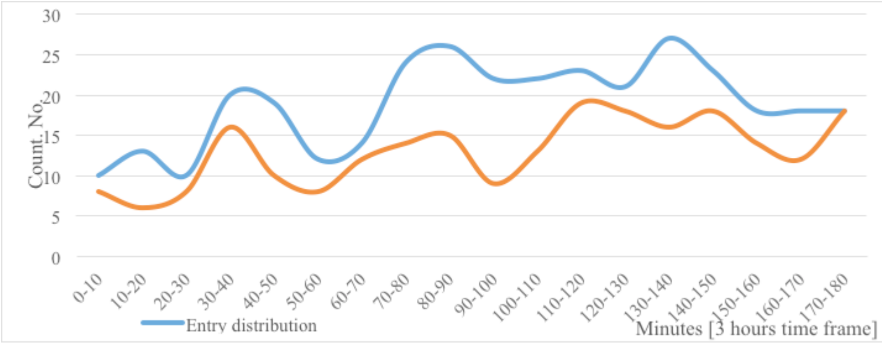


Fig.3
Total Freight vehicles distribution
in/out of the Inner ring (pedestrian zone).

Figure 4 shows the available times for freight deliveries. Through the E point, a vehicle has the highest chance to avoid congestion toward the center (11 empty time spans), but from here the way is quite uncomfortable with a truck (narrow streets and sharp turns). Another suitable entry site is the B (7 empty time spans). In general, most of the empty times spans are located in the first hour (12 empty time spans). While the last hour (10:00 am to 11:00 am) the city center is really busy, increasing pedestrian commuters and freight deliveries, the first hour (8:00 am to 9:00 am) is quite calm. It is a very useful information for further analysis.

	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	100-110	110-120	120-130	130-140	140-150	150-160	160-170	170-180
B point	■	■	■			■			■	■								■
C point			■															
E point	■	■		■		■		■			■	■	■		■		■	■
F point	■	■								■						■		
G point						■		■										

Fig.4
Empty time spans for freight deliveries
to the center in the morning.

6 Conclusions

The urban structure analysis has identified the city center of Cartagena as a functional urban area with a high occupancy rate (85%) of housing, and with a high concentration of commercial, business, leisure and tourism – cultural activities. The flow of people, vehicles and goods is affected by:

- Poor accessibility to the city centre (insufficient signposting)
- The continuous increase in pedestrian areas during the last decade.
- The collapse of loading/unloading areas by private and public vehicles, hindering the delivery activities.
- Incompatibility of delivery times with the opening hours of shops and stores

The analysis of urban flows has identified traffic density at different slots, conditioned by commercial and cultural activities, and also the weather conditions. Based on the context and according to local regulations the research group have defined a number of solutions that affect the different members existing in the functional area: transporters, receptors, residents and local government.

7 References

Demographia World Urban Areas – Built-Up Urban Areas or World Agglomerations 11th Annual Edition: January 2015, pp. 3.

DG MOVE European Commission: Study on Urban Freight Transport (April 2012), pp. 23-24.

Goodman R (2005). Whatever You Call It, Just Don't Think of Last Mile Logistics, Last. Global Logistics & Supply Chain Strategies, Dec 2005, pp. 1-6.

Herce M (2009) Sobre la movilidad en la ciudad. Ed Reverté, Barcelona

Rushton A, Croucher P, Baker P (2014) The handbook of Logistics and Distribution Management: Understanding the Supply Chain.(5th edition) Ed Kogan Page, UK

Taniguchi E, Thompson RG, Yamada T (1999) Modelling city logistics. Ed Institute of Systems Science Research, Kyoto

Implementation of a Manufacturing Execution System in the Natural Cork Stoppers Industry

Alves D[1], **Lopes RB**[2]

Abstract: This work details the methodology adopted for the implementation of a manufacturing execution system in a company of the natural cork stoppers sector. The main objective of the implementation concerned a correct information management, namely, regarding traceability of the product and process control.

Keywords: Manufacturing Execution System; Traceability; Process Control.

1 Introduction

The industrial sector has undergone enormous changes since the early twentieth century. Technology has helped break barriers and achieve parameters that were once unimaginable. The competition is becoming tighter and the mere survival of companies requires that all aspects of its business be continually monitored and improved (Olsen, P & Borit, M, 2013).

In this context Manufacturing Execution System (MES) may be crucial. MES systems are extended information systems that play an important role in identifying and solving some gaps at the shop floor level, possibly improving companies' operational performance. A manufacturing information system is therefore an enabler to reach higher levels of operational and financial performance.

However, the correct implementation of these systems is a complex and iterative process often facing several challenges ranging from information management aspects to human-related factors. It should be noted that a poorly designed and tuned information system definitely hinders the ability to serve the company's goal of sustaining and increasing profits (Vieille, J., 2007).

2 Objectives

The objective of this work is to present the methodology adopted for a real-life implementation of a MES system. Focus was on information management, more specifically, on the traceability of the natural cork stoppers and process control.

3 Methods

The implementation of the MES system was separated into five main steps, detailed as follows.

The first step consisted mapping the current flow situation, in order to under-stand and analyze the current information and materials flows around the shop floor. Then, a requirements specification report was developed. This report contained all functional and physical specificities that the MES system must incorporate/support.

1 **Diogo Alves** (diogodalves13@ua.pt)
Dpto. de Economia, Gestão e Engenharia Industrial.
Universidade de Aveiro. Campus Universitário de Santiago, 3810-193 Aveiro.

2 **Rui Borges Lopes** (rui.borges@ua.pt)
CIDMA / Dpto. de Economia, Gestão e Engenharia Industrial.
Universidade de Aveiro. Campus Universitário de Santiago, 3810-193 Aveiro.

The next step involved mapping the future situation, which will be necessarily different from the current situation. After this, operations on the shop floor must be adapted to the future situation, so that the implementation of the MES system faced the lowest possible resistance by employees.

The final step corresponded to the full implementation of the MES system and subsequent monitoring.

4 Results

Concerning the main objectives defined, most relevant results of the implementation of the MES are presented as follows.

Regarding traceability, initially this was ensured by collecting data manually. This originated numerous mistakes, which led to an inefficient traceability record. Main errors were incorrect information exchange, such as a disappearance of a batch or an increase in batch size. The MES system allowed the automation of the traceability process, from the collection of data to its registration into the appropriate system. In this new process, human interference only occurs in the validation of data collected. This led to the elimination of most traceability errors, and all records are updated and registered efficiently in real time.

Process control was initially guaranteed through the parameterization of the machines in the shop floor and completed by the analysis of the product in the lab. The main problem was that it was impossible to prevent the defects in real time, as products are analysed only when the full batch is produced. The implementation of the MES system allowed analysing some real-time data from machines, such as temperature or velocity. Furthermore, parameters may now be changed in real time, if needed. The main advantages of the MES implementation, was the shortening of the response time to an abnormality and a reduction of defects.

5 Conclusion

This work presents the methodology adopted in a real-life implementation of a MES system. Main objectives concerned the correct information management regarding traceability of the product and control of the process.

The implementation of a MES system is however an iterative and complex process that must be updated ever since there is a modification in the shop floor.

References

Olsen, P & Borit, M, 2013, How to define traceability, *Trends in Food Science & Technology*, vol. 29, no. 2, pp.142-150.

Vieille, J., 2007, Manufacturing information systems: ISA88/95-based functional definition, available at http://www.automationworld.com/maintenance-reliability/manufacturing-information-systems-isa8895-based-functional-definition, consulted in April 29, 2015.

QUALITY AND PRODUCT MANAGEMENT

[Extended Abstracts]

A Case Study of Photovoltaic Solar Energy in Brazil

Melo M[1], Nascimento A[2], MoreiraR[3], Campello S[4]

Abstract: There is a great need to reduce the costs of energy supply because it is the basis of all industrial production chain, of agriculture and also of the provision of services. Also, risks due to global warming are real and attitudes and actions should be concrete, especially those related to energy conservation and efficiency. Renewable energy sources are presented as the main alternative to meet the demands of society regarding the quality and safety of care of the electricity demand with sustainable development and with energy eco-efficiency. Brazil is a world power in terms of solar radiation and in recent years has conducted studies and research for the use of photovoltaic solar energy. This work aims to present a study of photovoltaic solar energy application case in Brazil in minigeneration ventures and show the potential and the implementation feasibility of this new form of renewable energy.

Keywords: Solar Photovoltaic Energy; Energy Management; Eco-efficiency and Sustainability.

1 Introduction

Electrical energy is the basis of all industrial production chain, of agriculture and also of the provision of services. There is a great need to reduce the cost of this input. This produces huge benefits not only for the supply chain, making companies more competitive, but also to the general population, because the final price of products ends up smaller (MELO *et al*., 2010).

On the other hand, it is noteworthy that all segments of society should contribute effectively to the improvement of our environment, because the risks due to global warming are real and attitudes and actions should be concrete, especially those related to conservation and efficiency energy. This paradigm shift will contribute substantially to future generations of our planet (MELO *et al.*, 2010).

In 2013, total anthropogenic emissions associated with the production and use of energy in the Brazilian energy matrix reached 459.0 Mt CO_2-eq (EPE, 2014) 7% above the value obtained in 2012. This fact leads to confirmation of the need to increasingly produce clean energy in order to have a sustainable development in the Brazil.

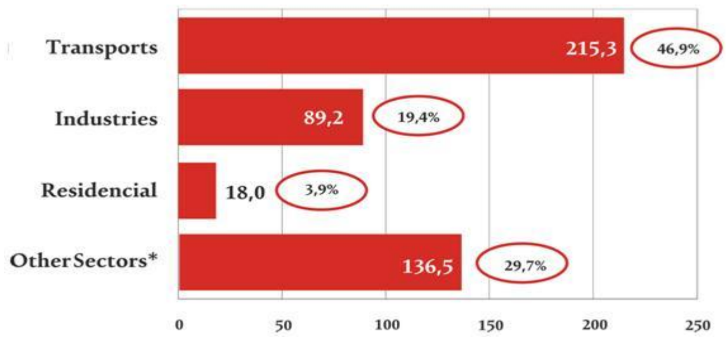


Fig.1
Total emissions(2013) in Mt CO_2.
Source: EPE, 2014.

1 **Miguel Melo** (mobcmelo@ct.ufpb.br)
2 **Adriana Nascimento** (adriana.souza.adm@hotmail.com)
3 **Ricardo Moreira** (ricardomoreira0203@hotmail.com)
Federal University of Paraiba,
Cidade Universitária, João Pessoa-PB. Brazil 58051-970
Center University ASCES, Caruaru, Brazil.
4 **Sergio Campello** (sergio@portaltecnologia.com.br)
Portal Tecnologia, Av Parnamirim. Recife-PE. Brazil.

However, concern about future power failure persists for humanity as well as the environmental impacts of many ways to capture it. Considerable positive fact for its availability are affordable, abundant, correct and with minimal environmental ecological risks associated with the production and use. This is one of the important factors for the desired improvement in quality of life (Nascimento, 2015).

Further demonstrating this fact that makes the growing scarcity of fossil fuels has aroused worldwide interest in the use of solar energy (Hasnain, 1995). According to WEO (2013), renewable energy will account for almost half of the increase in electricity generation in 2035 and these variables sources, wind, solar and photovoltaic will constitute 45% of the expansion of renewable sources. Substantially, the power industry has adapted globally to a new mode of existence, with the wind and solar energy (WEO, 2013). In Brazil, in 2012, the share of renewable energy matrix remained among the highest in the world, with a slight reduction due to lower supply of hydroelectric power, Figure 2.

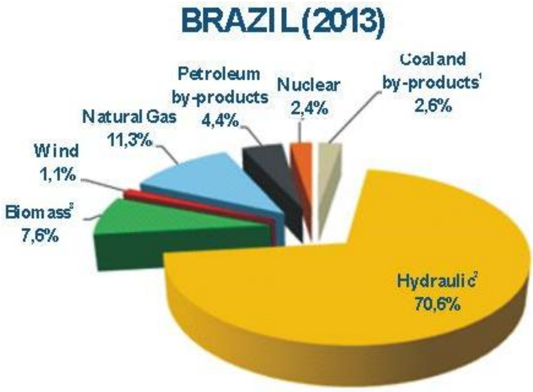


Fig.2
CurrentElectric Generation Matrix
Source: EPE, 2014.

In this scenario, renewable energy sources are presented as the main alternative to meet the demands of society regarding the quality and safety of care of the electricity demand by reducing the environmental impacts of energy consumption. Therefore, several studies in recent years have pointed to the social and environmental implications and impacts of energy consumption (Martins apud Nascimento, 2015).

It is noteworthy that more recently the federal government turned to this type of energy as a consequence of a water crisis, since most of hydropower in the country is working to "wire of water," that is, the level of dams are at critical levels and the national electrical grid began to show some limitations.

Thus, solar energy is experiencing strong techno- logical-progress in the world in recent years. This development reflects the exponential growth in the volume of production and photovoltaic (PV) and the fall of the cost of supply, caused by incentive programs for PV generation in the world, as demonstrated in Figure 3 (Nascimento 2015, EPE 2014).

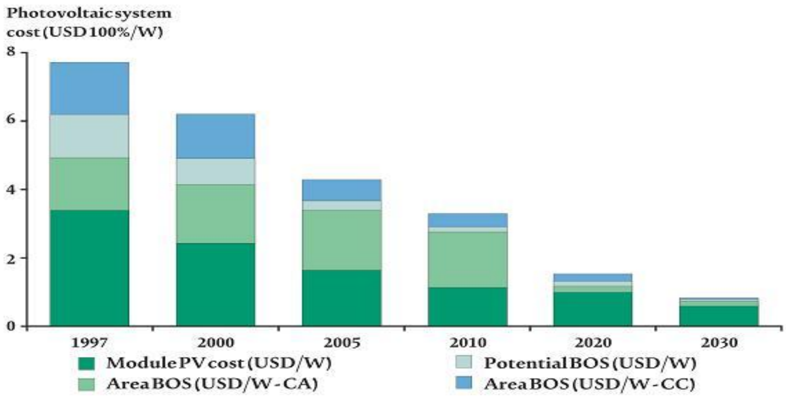


Fig.3
Variation in the cost of photovoltaicsystems(1997-2030).
Source: EPE, 2014.

2 Solar Energy In Brazil

The Brazilian program for solar time was focussing on the rural supply and isolated communities, but the Brazilian photovoltaic array tends to increase. There is a continuous cheapening of equipment, growing interest of investors, the emergence of new technologies and a tendency to solidification of incentive policies, which are already implemented worldwide (PERLOTTI, et al 2012).

The regulatory system in Brazil gave a great stimulus to the advancement of the sources of electrical energy incentive programs. General conditions for access were established and mini micro distributed generation allows access to generation at all levels of the production chain of the electricity sector (distribution, sub transmission and transmission), which may be a booster for solar generation in the country (ANEEL, 2008).

Brazil is a world power in terms of solar radiation and can be considered almost self-sufficient in energy due to a huge scanning capability of the various forms of energy from natural resources. To get an idea of the great potential, solar radiation in Germany, comprising the country with the largest installed capacity of solar energy in the world, is 40% lower than in the least sunny region of Brazil, which is the southern region (Ruther, 2010).

Figure 4 shows the solar metric index of Brazil where it is found that this radiation varies from 8 to 22 MJ (megajoules) per square meter (m^2) during the day. The data considered high highlighting the area of the region semi arid blue.

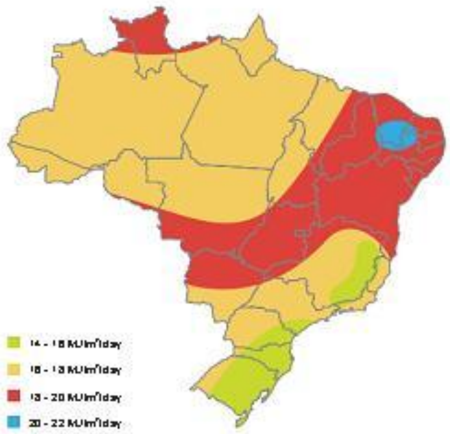


Fig.4
Solar RadiationMap in Brazil.
Source: EPE, 2014.

Figure 5 shows the projection of the photovoltaic market in Brazil by 2020, revealing an exponential growth from 2016 to 2020. This growth will contribute to a greater reduction in deployment costs in Brazil.

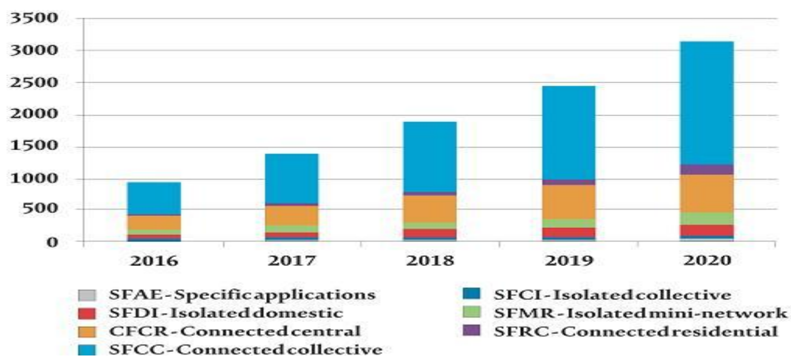


Fig.3
Projection: PhotovoltaicMarket in Brazil MW. Source: Projeto Carta do Sol.

3 Case Study: Results and Discussion

The methodology used to the implementation of this work was the case studying Brazil on asemi arid region. With all the data obtained, the Technical Feasibility Studies and Economic (TFSE) were used to help in the process of decision making. The local price of a complete Solar Photovoltaic Plant, provided on Turn-key, fully installed and commissioned, varies between installers power scheme to one micro distributed generation of 325kWp. The energy indicators analyzing the bills between August 2013 and July 2014 are:

Average Monthly Electric Consumptions	45920	kWh/month
Annual Total Electric Consumptions	551037	kWh/year
Unit Costs (kWh)	US$ 0.23111	/kWh

The total consumption of the project would be in mini generation On-Grid mode, where a power compensation contract would be signed, in which the surplus produced in sun hours would be provided to the distributor and measured in a second meter. The final bill to be paid would be the difference between the energy consumed and measured by current meter and the energy injected into the system and the distributor as the new meter. In these conditions, we would have the following results:

Type of Photovoltaic Module	Yngli245kWp	
Number of photovoltaic modules	1440	
Installation Area	3755	m^2
Peak Power	353	kWp
Electric Energy Production	568062	kWh/year
Unit Cost kWh	US$ 0.23111	/kWh
Annual Savel	US$ 131287	/year
Investment	759877	US$
Investment Operational Return (IOR)	5.8	years

The photovoltaic plant has inverters for connection to the internal three-phase power grid in the enterprise (380V - 60Hz). The operation thereof is made transparently to the user, that is, no human intervention is required. All the electricity flow control is automatic: there available energy in the photovoltaic panel is going to consumption and the surplus is injected into the distribution network.Carrying out the project with 80% financed by the bank within the specific program in 12 years, with 1 year grace period:

Amount Financed	US$607902	80%
Counterpart	US$151975	20%
Interest Rate	6.7%	/year
Period Financing	12	years
Vesting Period	1	year
Annual provision	221550	US$

The following cash flow statement shows that the project is self-financing, with positive cash from the18th month:

The financial indicators of this operation are:

Total Investment		759877	US$
Disbursing of Cash	(counterpart)	151975	US$
Investment Operational Return (IOR)	(on the counterpart)	17.4	months
Investment Rate of Return (IRR)		49%	/year
Net Present Value (NPV)	(attractiveness rate = 15%/year)	198177	US$

5 Conclusions

- Studies indicate that in Brazil today the use of solar photovoltaics for the industrial sector is already economically viable.

- The investment for the use of a 353kWp mini generation distributed is US$ 759877, which is approximately 2153U$/kWp.

- The Northeast of Brazil is a world power in terms of solar radiation and can be considered almost self-sufficient in energy due to a highsolar potential.

- Investment Operational Return (IOR)is 5.8years for and aplant of 353 kWp. With financing this value decreasing to1.45 year.

6 References

ANEEL. Agencia Nacional de Energia Elétrica (2008) Atlas de Energia Elétrica do Brasil. Ed.- Brasília: Cap.1- Energia no Brasil e no mundo.

Campello, Sérgio (2014) Energia Fotovoltaica. Portal energias. Dísponible in: http://www.clubedeengenhariadepe.com.br/20131114fotovoltaico.ppt.

Carta do sol. Relatório técnico (2011) Subsídios para o planejamento da promoção da energia solar fotovoltaica no brasil. rio de janeiro, 19 de agosto.

EPE (2014) Empresa de pesquisa energética/ Nota técnica - Análise da Inserção da Geração Solar na Matriz Elétrica Brasileira. Rio de Janeiro.

Hasnain S.; Elani U.; Alawaji S.; Abaoud H.; Smial M..(1995) Prospects and proposals for solar energy education program.Apply Energy, 52: 307-14.

Martins, M.; Cândido, G. (2011). Índice de desenvolvimento sustentável para municípios:uma proposta metodológica de construção e análise. Disponível em: <http://www.ecoeco.org.br/conteudo/publicacoes/encontros/ix_en/GT2-321-213-20110620202017.pdf>. Acesso em: 19 mai. 2012.

Melo, Miguel, Campello, Sergio, Silva L. B. (2012). Industry Energy Efficiency Analysis In Northeast Brazil: Proposal Of Methodology And Case Studies. *International Journal Of Industrial Engineering: Theory Application And Practice*, vol 19, no 11

Nascimento, Adriana. (2015).Solar Energy Photovoltaic: Cases Studies in Northeast Brazil. Master Dissertation (in Portuguese) in Production Engineering, Federal university of Paraiba, João Pessoa-PB Brazil..

Perlotti E.; Camargo F.; GranvilleA.; Cunha, G.; Pereira. M.; Kelman, R.(2012) Propostas para a Inserção da Energia Solar Fotovoltaica na Matriz Energética Brasileira; Estudo do grupo setorial de sistemas fotovoltaicos da Abinee.

Ruther, R.; Santos, I. P.; Montenegro , A. A.; Zomer , C. ; Nascimento, R. L.; Braun , P (2010) Relatório Estádios Solares: Opção Sustentável para a Copa 2014 no Brasil. UFSC, Instituto IDEAL. Brazilian-German Energy program, GTZ.

Weo (2013)World Energy Outlook (2012).Presentation to the press London, 12 november2012.>http://www.worldenergyoutlook.org/pressmedia/recentpresentations/PresentationWEO2012launch.pdf>

Environmental Tools in the Spanish Food Industry

Jaca C[1], Viles E[2], Santos J[3], Porras D[4], Ormazabal M[5]

Abstract: Concern about environmental management has increased considerably among companies, in part because of pressure from their various stakeholders, who are demanding products and services that minimize environmental impact. The Spanish food industry is one of the biggest sectors in the economy and hence contributes significantly to environment degradation. Although there are some companies that certify their environmental management and communicate their environmental improvements, work in this area is incipient and there have been no studies on whether a company's use of environmental tools is related to whether a company holds certifications and engages in external communication. Therefore, the aim of this study is to present an overview of the sector and analyse the above relations through a survey. The results show that small companies have evolved less than medium or big enterprises in terms of environmental issues, and that there is a close relationship between the use of environmental tools and certification and communication.

Keywords: food industry, survey, environmental tools, certification, communication.

1 Introduction

In recent years, the issue of economic and environmental sustainability has been of increasing concern among companies. Because of society's growth in awareness about the link between human activity and environmental impacts, environmental regulations that push companies to improve their environmental management have been enacted (Claver at al., 2007; Tsai et al., 2011). The food industry is one of the most important sectors in Spain. The Spanish food industry represents one of the most significant sectors of the Spanish economy, with over 30,000 companies and close to 450,000 employees (Muñoz Cidad and Sosvilla Rivero, 2014). From the environmental point of view, this sector contributes significantly to global carbon emissions from diverse sources such as product and machinery manufacture, the transport of materials, and direct and indirect greenhouse emissions from soil. Because of the Spanish food industry's large carbon footprint, it is also receiving increasing attention from products and services that minimize environmental impact (Foster et al., 2007).

It is important to highlight that not all the companies have reached the same stage of maturity in terms of environmental management (Jabbour, in press). In the academic literature, several classifications of the different maturity stages that companies might be in have been proposed. By way of illustration, Ormazabal et al. (2013) proposed an environmental management maturity model of six stages that move from low maturity to high maturity: legal requirements, responsibility assignment and training, systematization, ECO^2 (ecological and economic benefits), eco-innovative products and services, and leading green company. According to their research, many companies gradually reach the systematization stage thanks to environmental management certifications such as ISO 14000 (Emilsson and Hjelm, 2002), but only a few move on to the second half of the model, which is focused on minimizing environmental impact, process that involves a company's proactive attitude to using different environmental tools and worker participation (Ormazabal and Sarriegi, 2014). This paper is interested in this second half of the maturity model, in helping companies move forward. More specifically, the study is focused on some of

1 **Carmen Jaca** (cjaca@tecnun.es)
2 **Elisabeth Viles** (eviles@tecnun.es)
3 **Javier Santos** (jsantos@tecnun.es)
4 **Daniel Porras** (dporras@tecnun.es)
5 **Marta Ormazabal** (mormazabal@tecnun.es)
Tecnun. University of Navarra.
Management Po Manuel Lardizabal, 13, 20018 San Sebastian, Spain

the tools that are becoming widely used by companies in order to improve their environmental impact (Emilsson and Hjelm, 2002; Knight and Jenkins, 2009).

It appears that when a company systematizes and standardizes its environmental systems, it facilitates the application of tools that reduce the company's environmental impact. Moreover, since communicating environmental achievements to the public at large is part of a company's evolution towards environmental management (Ormazabal and Sarriegi, 2014), it is important to identify whether there is any relation between a company's capacity to communicate its environmental achievements and its use of environmental tools.

Because there are many different situations regarding the use of different environmental tools, the aim of this paper is to analyse via survey data how the food industry in Spain is applying these tools. Therefore, the following research question were formulated and examined through this study in relation to agro industries:

RQ1: Are there differences between certified and non-certified companies in their utilization of environmental tools?

RQ2: Are there differences between companies that do and do not report their environmental advances relative to their utilization of environmental tools?

2 Methodology

To get at the above research questions, a questionnaire was administered to Spanish food companies. The design of this questionnaire was based on environmental tools, policies and motivations presented the literature in connection with environmental management. The initial version of the questionnaire was revised based on the recommendations of academics and experts in the field (Ormazabal and Sarriegi, 2012). Furthermore, based on a pilot study, the questionnaire items were improved and modified in terms of clarity. The final version of the questionnaire includes general questions about company profile, motivations and barriers, processes, objectives and resources and environmental tools and indicators. This study undertook a descriptive analysis of Spanish food companies and their characteristics regarding environmental management, and more specifically, about their use of different tools for improvement and impact minimization. Based on a seven-point Likert scale (where 1 represented "low use" and 7 represented "high use"), the respondents were asked to indicate the degree of use in their companies for the different environmental tools.

The sample aimed to characterize the Spanish food sector. Although there are more than 30,000 companies in this sector, an initial sample of 900 companies was randomly selected. In the end, 99 completed questionnaires were received – a response rate of 11%, which is acceptable compared to the response rate of the research studies by Melnyk et al. (2003) or Nawrocka and Parker (2009).

3 Results

Most of the companies in our sample are micro and small sized enterprises; 37% employ fewer than 10 employees (micro), 35% have more than 10 and fewer than 50 (small), 21% have between 50 and 250 employees, and only 6% employ more than 250 people. This ratio corresponds to the distribution of agro industries, according to the Spanish Statistical Institute (INE, 2013).

In terms of environmental management, most companies claim to have some activity related to environmental management (71%), although a small percentage (39%) reports having certification via some environmental standard (ISO 14001, ISO 14006, EMAS or other). Regarding environmental management measures, only 29% of the companies control their efficiency by using indicators.

In order to understand how much companies are aware of the environment, we calculated the percentage of companies that have some activity in environmental management, that are certified or that use any indicators related to management, grouped by company size (see Table 1).

This table shows that medium and large companies have a higher percentage of environmental activity and certification, although the number of companies that responded (and which reflects the distribution of the sector in Spain) is proportionally higher in micro and small business. The results of McKeiver and Gadenne (2005) and Gonzalez et al. (2008) show similar results.

Table 1
Environmental activity and certification.

Company size	Environmental activity	Certified company	Control indicators
Micro (<10 employees)	51%	8%	11%
Small (10-50)	77%	26%	26%
Medium (50-250)	90%	48%	50%
Large (>250)	83%	83%	40%
Total	**71%**	**39%**	**29%**

The survey included questions to assess the degree of use for different tools related to environmental management, as described by authors such as Ding (2008), Finnveden & Moberg (2005), Ormazabal & Sarriegi (2014) and Wrisberg et al. (2002) and shown in Table 2 below.

Table 2
Use of environmental management tools.

Environmental tool	Mean	SD	Median	***Respondents***
Life Cycle Analysis (LCA)	4,63	2,06	5	***41***
Carbon Footprint	3,46	2,10	4	***37***
Ecodesign	3,89	2,00	4	***44***
Eco-learning tools	4,08	1,78	4	***51***
Suggestion System	4,67	1,98	5	***49***
Eco-efficiency tools	4,45	2,19	5	***40***
Recycling tools	4,85	1,84	5	***53***
Measurement Tools for Environmental Indicators	3,85	2,10	4	***39***
Tools to increase Consciousness	4,20	2,07	4	***45***

As the data show, the tools that are related to the measurement of environmental impacts, such as carbon footprint assessment tools or measurement tools for environmental improvement, are the less applied ones. However, the tools that are widely used are the ones related to recycling and that encourage the participation of people (such as suggestion systems, tools to increase awareness and Eco-learning tools). It is also worth noting that the LCA analysis tool is one of the most applied, even though it is related to environmental impact measurement.

Companies that have been certified according to an environmental standard like as ISO 14001 usually have a higher level of application of environmental tools (González-Benito and González-Benito, 2005; Bansal and Hunter, 2003). In analysing these differences in food companies, we compared the level of use of different tools by certified and non-certified companies, using an unpaired t test analysis. The results show that certified companies have a significantly higher level of tool use, except for Life Cycle Analysis and recycling tools, as shown in Figure 1 and Table 3.

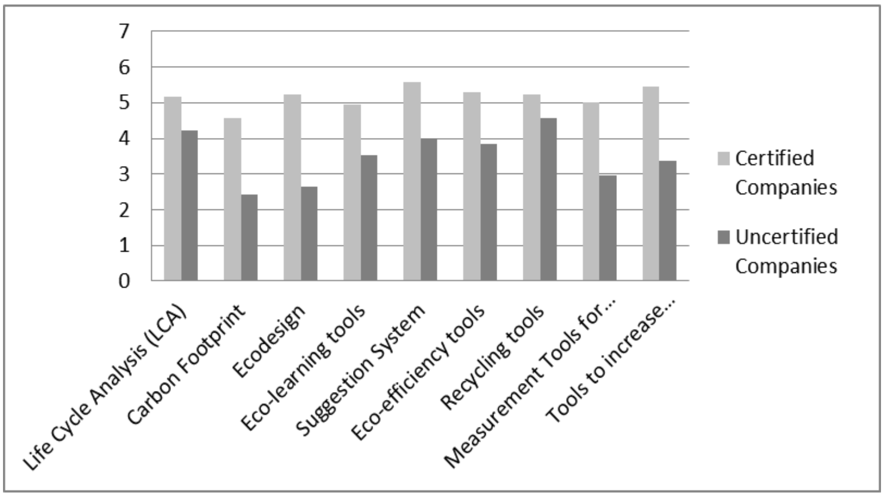


Fig.1
Use of environmental management tools comparing certified and non-certified companies.

Table 3
Use of environmental management tools and certification.

Environmental tool	Mean differences	p-value
Life Cycle Analysis (LCA)	0.95	0.121 *
Carbon Footprint	2.14	0.001
Ecodesign	2.59	0.000
Eco-learning tools	1.43	0.003
Suggestion System	1.57	0.004
Eco-efficiency tools	1.46	0.025
Recycling tools	0.65	0.195 *
Measurement Tools for Environmental Indicators	2.05	0,001
Tools to increase Consciousness	2.07	0.000

(*>0,05)

On the other hand, several authors have noted that one of the objectives of the tools related to environmental management is to communicate results (Wrisberg et al., 2002) (Ormazabal and Sarriegi, 2012). Consequently, this study analysed the relation between the companies that claim to report their environmental improvements and the use of the available tools in those companies(Table 4 and Figure 2).

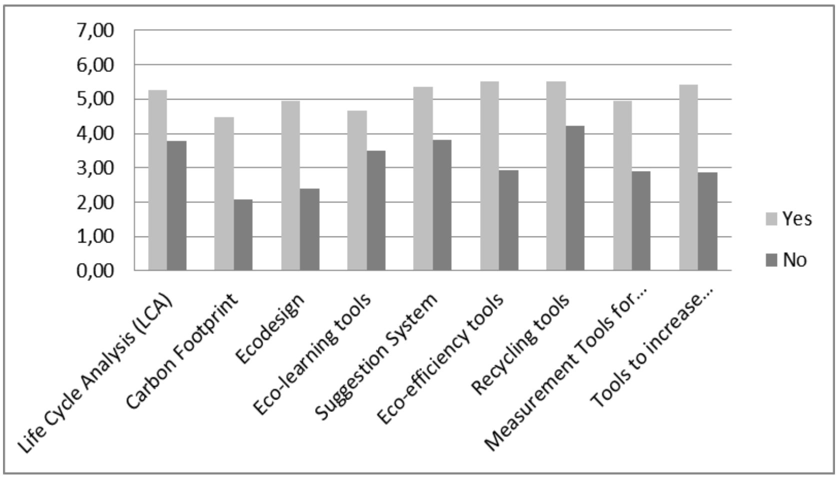


Fig.2
Use of environmental management tools comparing companies that communicate their results with those that do not communicate their results.

Table 4
Use of environmental management tools and communication of results.

Environmental tool	Difference	p-value
Life Cycle Analysis (LCA)	1.50	0.036
Carbon Footprint	2.41	0.000
Ecodesign	2.57	0.000
Eco-learning tools	1.17	0.018
Suggestion System	1.53	0.008
Eco-efficiency tools	2.58	0.000
Recycling tools	1.29	0.013
Measurement Tools for Environmental Indicators	2.06	0,001
Tools to increase Consciousness	2.57	0.000

The results show that there is a strong relation between the use of environmental tools and communicating environmental outcomes to the community. Using environmental tools might help companies to better manage their environmental impacts and in turn communicate their results to society at large.

4 Conclusions

As mentioned at the outset, the food industry represents one of the most important sectors in Spain. Consequently, it is important to identify how environmental management is carried out in this sector, so future improvements can be made.

Through this study we can conclude that big companies are the ones that have evolved more on environmental issues, as they carry out more environmental activities, have more certifications as well as use more control indicators. Moreover, certification and external communication are two aspects that are closely linked to the use of environmental tools. As a consequence, we can conclude that a company with a certification might be better prepared to use environmental tools, and that will lead to better communication with external stakeholders.

This research does not identify a relationship between a company's environmental performance and the application of certain environmental tools. Future research might be conducted in order to investigate ways in which firms can more effectively use those tools when implementing certifications and in their way to achieve sustainability. Another way not specifically explored as part of this study is how help companies to justify the implementation of environmental tools from an economic point of view, as some researchers have stated (Lee et al., 2010; Valentine, 2010). Future research might study this aspect.

Finally, it is important to highlight that policy makers and researchers have to do more to help small companies improve their environmental management since they are the ones that have evolved less and yet make up the bulk of companies in this sector.

5 References

Bansal P and Hunter T (2003) Strategic explanations for the early adoption of ISO 14001. J Busin Ethics 46(3): 289-299.

Bansal P and Roth K (2000) Why companies go green: a model of ecological responsiveness. Acad Manage J 43:717-736

Claver E, López MD, Molina JF and Tarí JJ (2007) Environmental management and firm performance: a case study. J Environ Manage 84:606-619.

Collins E, Roper J and Lawrence S (2010) Sustainability practices: trends in New Zealand businesses. Bus Strat Env 19:479-494

Ding GK (2008) Sustainable construction—The role of environmental assessment tools. J Environ Manag 86(3): 451-464

Emilsson S, Hjelm O (2002) Implementation of standardised environmental management systems in Swedish local authorities: reasons, expectations and some outcomes. Environ Sci & Policy 5:443-448.

Finnveden G and Moberg Å (2005) Environmental systems analysis tools–an overview. J Cleaner Prod13(12): 1165-1173

Foster C, Green K and Bleda M (2007) Environmental impacts of food production and consumption: final report to the Department for Environment Food and Rural Affairs

González-Benito J and González-Benito O (2005) An analysis of the relationship between environmental motivations and ISO14001 certification. British J Manag 16(2): 133-148

Gonzalez P, Sarkis J and Adenso-Diaz, B (2008) Environmental management system certification and its influence on corporate practices: Evidence from the automotive industry. Int J Oper Prod Manag 28(11):1021-1041

INE SNSI (2012) Las empresas en Espana. Companies in Spain

Jabbour CJC (2013) Environmental training and environmental management maturity of Brazilian companies with ISO14001: empirical evidence. J Clean Prod doi:10.1016/j.jclepro.2013.10.039

Knight P, Jenkins JO (2009) Adopting and applying eco-design techniques: a practitioners perspective. J Clean Prod 17:549-558

Lee, J., Suh, E. H., & Hong, J. (2010). A maturity model based CoP evaluation framework: A case study of strategic CoPs in a Korean company. Exp syst with Applicat, 37(3): 2670-2681.

Muñoz-Cidad C and Sosvilla-Rivero S (2014) Informe Económico 2013 de la Federación Española de Industrias de la Alimentación y Bebidas

Melnyk SA, Sroufe RP and Calantone R (2003) Assessing the impact of environmental management systems on corporate and environmental performance. J Oper Manage21(3): 329-351

Nawrocka, D., & Parker, T. (2009). Finding the connection: environmental management systems and environmental performance. J Clean Prod 17(6):601-607

McKeiver C and Gadenne D (2005) Environmental management systems in small and medium businesses. International Small Business Journal 23(5): 513-537

Ormazabal M, Sarriegi JM, Barkemeyer, R, Viles E and McAnulla F (2013) Evolutionary Pathways of Environmental Management in UK Companies. Corp Soc Responsib Environ Mgmt doi: 10.1002/csr.134

Ormazabal M, Sarriegi JM, (2014) Environmental Management Evolution: Empirical Evidence from Spain and Italy. Bus Strat Env 23(2):73-88

Tsai M, Chuang L, Chao S and Chang H (2011) The effects assessment of firm environmental strategy and customer environmental conscious on green product development. Environ Monit Assess 184:4435-4447

Valentine SV. (2010) The Green Onion: a corporate environmental strategy framework. Corporate Social Responsibility and Environmental Management 17: 284–298.

Wrisberg N, de Haes HAU, Triebswetter U, Eder P and Clift R (2002) Analytical tools for environmental design and management in a systems perspective: The combined use of analytical tools Kluwer Dordrecht, The Netherlands

Wrisberg N, de Haes HAU, Triebswetter U, Eder P and Clift R (2002). Linking supply and demand concerning environmental information. In Analytical Tools for Environmental Design and Management in a Systems Perspective (pp. 74-97). Springer Netherlands.

Ramp-up curves: A literature review

Bultó R[1], Viles E[2], Mateo R[3]

Abstract: The globalization, in other words, the incorporation of new markets with growing demand to be satisfied results in the expansion of new production centres all over the world. Therefore, the synchronization of the launches in different parts of the globe is necessary. Furthermore, the high expectations of the costumers on the quality and the on-going renovation of the products cause shorter product life cycles. The period since the production has started in a productive centre until has achieved the planned production rate becomes more frequent, and the specific importance regarding the model life greater. The objective of the present article is to provide with a thorough review of the bibliography over this concrete phase in the life cycle of a model in order to identify, compile and extract any relevant information. This information will enable us to build the theoretical framework of the Ramp-up curve. The article begins with a definition of the different launch phases of a new product. And it concludes with the evidence that this is a topical item of scientific interest where the 21% of the articles related to this item are focused on the automotive sector, being planning and management the most recurrent themes.

Keywords: Ramp-up, Start-up, Product launch, SOP (Start of production).

1 Introduction

The phenomenon of globalization in the automotive sector is leading to the expansion of production centres, thereby creating a map of the automotive activity which covers practically all the entire surface of the earth. Alliances among brands allow the appearance of the “multi-brand” factories. This combined with the fact that customers are increasingly demanding shorter product life cycles. Today, we find ourselves that launches of new products are becoming more frequent (Harvey and Griffith, 2007). As a result, the specific weight of the cost of losses during the period of time the ramp-up curve is last (period from the launch of the first series vehicle to reaching the maximum volume planning) becomes more significant in comparison with the total economic output of the model for its entire life (Carrillo and Franza, 2006). Economic losses caused by decreasing productivity are estimated at between $42 and $53 million and are concentrated within the ramp-up period (Gopal et al., 2013).

However, the research articles referred to the review of the literature on the ramp-up curve are scarce, and it is mentioned in many of these without being treated as the main theme of research, but as a circumstantial factor linked to the main problem. Thus, this article intends through an in-depth literature review to detect, extract and collect any relevant information enabling us to build the conceptual framework to clarify all these difficulties facing the launch of a new product to be addressed in the scientific environment.

Then it goes on to explain the methodology of the search, turning to a careful analysis of the data obtained to conclude with a discussion on points relating to the ramp-up curve which are ignored by the literature, thus opening up new fields of research in the future.

1 **Ramón Bultó** (rbulto@alumni.unav.es)
2 **Elisabeth Viles** (eviles@tecnun.es)
Dep. de organización. TECNUN Escuela de ingenieros,
Universidad de Navarra P° de Manuel Lardizabal,
13. 20018 Donostia- San Sebastián. Gipuzkoa (España)
3 **Ricardo Mateo** (rmateo@unav.es)
School of Economics & Business Administration,
University of Navarra, Campus Universitario. 31009 Pamplona, (Spain)

2 Definition of the term "ramp-up curve"

Ball et al. concludes that there is no agreement among the authors on chronological limits of a launch (Ball et al., 2011). This situation leads us to study the different interpretations about this period that exists in the literature with the aim of providing with a definition that will guide the rest of the article.

We now turn to the each different interpretation referred to the ramp-up curve found in the literature:

Some authors define the "Ramp-up period" or "Produktionsanlaufphase" to the period from the start of pre-series production to reaching the maximum production capacity (Buescher and Hauck, 2012; Hertrampf et al., 2008). But at the same time it is divided into two periods:

- Pilot series. The period from pre-cars are built to the start of production.

- Production ramp-up. The period from the start of production and reaching the maximum production capacity.

Other authors refine that in case the new product replaces an existing one, the ramp-up curve of the new product has to be distinguished from the rate of sales decline of the one is going to be replaced (Winkler and Slamanig, 2011).

- Launch of a new product. The period between the release of the pre-series production and the achievement of the maximum production capacity.

- Phase-out period. The period between the release of the pre-series production and the last manufactured unit of the replaced product.

Jürging introduces a new period during the ramp-up curve, it is the so called Start-up. The period covered from the production of the first unit for customer and a point from the ramp-up curve about a month later (Jürging, 2008). This point is important because the daily production volume increases substantially.

Other authors also use the term "start-up", but in a different way with regard to what we have seen so far (Almgren, 2000):

- Manufacturing Start-up. The period of time since the pilot series ends and the maximum capacity is reached.

- Low-Volume production. The period of time between the end of the pilot series and a point from the ramp-up curve where the slope increases.

- Ramp-up. The period of time since the ramp-up curve increases its slope and the maximum capacity is reached.

The "Ramp-up phase" starts with the first units produced in the production facilities according to the series conditions and ends once the ordinary productivity is reached, which coincides with the end of the ramp-up production (Scholz-Reiter and Krohne, 2008). Other definitions:

The work order for the first customer, the so-called "Job 1" begins the escalation (Ceglarek and Jin, 2004).

Ramp-up phase can be defined as the phase characterised by the increase in production and quality and a reduction in unit costs(Glock and Jaber, 2012)

Production ramp-up can be defined as the period of time from the end of the product design to reaching the maximum production capacity(Bohn and Terwiesch, 1999)

By summarising the different terms collected in the described research, we can conclude the definitions related to the launch of a product:

- Launch: a process composed of a set of activities whose aim is to take a daily amount of a new product, or an already existing product, which is produced in certain facilities for the first time to the series production. This set of tasks is developed since the first unit is produced in series facilities to reaching the planned daily production. This definition is considered more appropriate than the one, which defines the start of the launch in an indeterminate form "end of the phase of project design" (Bohn and

Terwiesch, 1999) and which, as is well known, many times it does not end until the product is put on the market (Almgren, 2000) (Milling and Jürging, 2008).

- Pilot series: a process composed of a set of activities whose aim is to manufacture a series of units of the new product with the goal of testing out the facilities, the manufacturing processes, operators training, check the components, and finally verify the product itself is ready for introducing on the market, with all the requirements this implies. The period of time within this process is developed goes from the manufacture of the first unit in series facilities to the manufacture of the first unit for customer.

- Pre-series: first units manufactured in series facilities that start the launch, which are characterised by not meeting the expected quality requirements for the series.

- Zero series: units manufactured in series facilities under series condition, which are characterised by meeting the minimum quality requirements to be introduced on the market. But the aim is to ensure the manufacturing process and the product itself both are sufficiently mature to start the series production.

- Ramp-up curve: the function that represents the number of units to be daily produced according to time elapsed since manufacturing the first unit for customer. It ends when reaching the planned daily production.

- Start-up: first period of the ramp-up curve, which is characterised by low and controlled production with the aim to solve problems in facilities and the product, and give operators time to develop the ability to carry out operations.

- Increased production: second period of the ramp-up curve during which the daily production is increasing gradually until reaching the planned production.

- Decline curve: the function that represents the number of units to be daily produced according to time elapsed during the end of product life phase.

- Start of production: The point at which the first unit for the customer is manufactured and coincides with the beginning of the ramp-up curve.

- End of production: The point at which the last unit of the product that ends its life cycle is manufactured. It coincides with the endpoint of the decline curve.

- Market introduction: The point from which the product is available to be purchased by customers.

3 Methodology of search

The bibliographic review started with the reviewed of the “Web of Knowledge” database from different searches based on the following criteria:

C1 “Web of Knowledge” was initially chosen and supplemented later with: “ScienceDirect”, ”Academic OneFile”, “Expanded Academic ASAP”, ”General OneFile”, “Literature Resource Center”, “Business Insights”, “NewsBank”, as researchable databases.

C2 The keyword used for different are “Ramp up” and “Start-up”, both related to “Production”, “Start of production”, “Production launch”, “Product launch”, “Time to volume” and “Series production”.

C3 Initially, publication dates are from 1990 to 2014. Later, and after finding an amount of articles from 2005, searches from that date to present day were restricted.

C4 The application sector is not specified.

C5 Academic publications were selected. Professional publications and electronic resources were included later.

After conducting searches, a total of 1448 articles were found, which were analysed in detail to avoid duplicity and be related to the subject, reducing the result to 293 interest articles.

In total 293 articles in some way related to the period since the first series unit is launched to reaching the planned daily production volume, which were summited to a final selection on the basis of the following criteria:

C1 The article contains any relevant information to build the conceptual framework of ramp-up curves.
C2 The article opens the way for further research to pursue the matter of building the conceptual framework of ramp-up curves further.
C3 The article should not refer to a specific problem of a specific industrial sector.
This new selection results in 143 articles met all the three criteria.

4 Data analysis

Following the analysis model of Houy, Fettke and Loos (2010), the 143 articles were analysed from three perspectives:

- Meta-perspective, that will allow us to see the development of the science in the field that we are concerned and will answer the following questions: number of contributions per year, number of contributions per magazine, number of contributions per country, language of publication, most productive authors and number of co-authors.
- Content-based perspective. The contribution of the article will be sought.
- Methodological perspective. What methodology has been used and which sectors have been analysed.

4.1 Meta-Perspective

The amount of contributions has risen sharply in the last few years. The magazines “International Journal of Production Research” and “Procedia CIRP” have published a significant number of articles, 8 and 9 respectively, in comparison with the rest of magazines.

The nationality of the publication is considered to be as the origin of the institution, in which the first author was registered by the time the article was published.

Germany and the United States lead the number of publications with 54 and 29 articles respectively, followed by the United Kingdom and France with 6 articles.

Almost all publications were written in English (123). Nevertheless, by searching German keywords we have found 19 articles published in the German language. Only one single publication was found in Portuguese. There are 297 co-authors in the 143 articles, which means an average of 2 co-authors for each article. Only 9 authors who have published more than 2 publications dealing with the subject matter have been found.

4.2 Content-based perspective

In order to classify the different articles according to its content we have established a range of themes, which have been somehow discussed in the publications. Then we present the relationship of the most representative themes: launch management, training, human resources, process, product, logistics, planning, simulation, revision, troubleshooting, changes, quality and design.

Different classifications of problems during the ramp-up were found (Van der Merwe, 2005). The addressed themes were present therein but no theme was outstanding for its importance.

The most used themes have been “Planning” with 51 and “Launch Management” with 41, that is, how a launch is prepared and, once immersed, how the situation is managed.

4.3 Methodological perspective

The phenomenon of a launch can be classified in the empirical sciences. This means that their statement must be properly supported by empirical basis.

The technique most used for research has been the case study, which makes sense since it is necessary to support the results of the study on the real world. The literature reviews, which based on the preceding research come to new conclusions, are also important.

Half of studies do not refer to the sector being studied and the rest is polarised in the automotive and electronics.

5 Discussion and Conclusions

The study of ramp-up curves is a current theme. This is demonstrated by the growing interest that arouses among researchers, more articles have been published in the year 2014 than over the entire period of the 1990s. In fact, most of the articles begin in the same way, recognising the pressure that currently exists on manufacturing to offer increasingly new products in less time.

In reference to the distribution of the articles in the different magazines, the magazines “Procedia CIRP” and “International Journal of Production Research” are the two most prolific. The first one publishes articles from conferences and curiously the 8 selected articles are from the year 2014, so it seems evident that launches have become a fashionable subject. In 2011 the first launch conference, “1st International Conference on Ramp-up Management”, was held in Aachen, and the second was in the year 2014, organised by the University of Aachen.

With regard to the origin of the authors there is a high preponderance of the German, followed by the Americans.

After the literature review it can be described the Ramp-up theoretical frame-work based on these three ideas:

1. The Ramp-up curve is a function between production capacity (of the final manufacturer and suppliers) and load (demand) (Almgren, 2000)
2. The demand is not limiting the Ramp-up curve (Stauder et al., 2014)
3. Capacity is limited due to three aspects (Goerke and Gehrmann, 2014).
   1. Technological. They are depending of the product and equipment complexity. (Tschöpe and Knüppel, 2013)
   2. Human. The knowledge of the operators, technician and managers (Minhas et al., 2012) and the coordination(Gross and Renner, 2010) and motivation(Kallis, 1997) are key factors
   3. Organizational. Although the organization during the ramp-up period is crucial for the launch results there is not a specific production system for that phase or the existing ones are poor (Winkler and Slamanig, 2011) the reason is the large period of time between launches (Slamanig and Winkler, 2010)

The planning of the launch and its management have been the most frequent research themes.

There is a lack of structured organization during the launch curve and specific in the start-up phase. How can be improve the launch results through a specific method in the start-up phase and how can be transferred the acquired knowledge in a product launch to a second launch of the same product in another factory are points that remain open for future researches.

References

Almgren, H., 2000, Pilot production and manufacturing start-up: the case of Volvo S80: International Journal of Production Research, v. 38, p. 4577-4588.

Bohn, R. E., and C. Terwiesch, 1999, The economics of yield-driven processes: Journal of Operations Management, v. 18, p. 41-59.

Buescher, C., and E. Hauck, 2012, Key Performance Indicators for the Impact of Cognitive Assembly Planning on Ramp-Up Process: Advances in Decision Sciences, p. 1-19.

Carrillo, J. E., and R. M. Franza, 2006, Investing in product development and production capabilities: The crucial linkage between time-to-market and ramp-up time: European Journal of Operational Research, v. 171, p. 536-556.

Ceglarek, D., and J. Jin, 2004, Introduction: Modeling and analysis for complex production systems. position statement: International Journal of Flexible Manufacturing Systems, v. 16, p. 5-9.

Glock, C. H., and M. Y. Jaber, 2012, Production planning for a ramp-up process with learning in production and growth in demand: International Journal of Production Research, v. 50.

Goerke, M., and J. Gehrmann, 2014, The Harada Method – A Method for Employee Development during Production Ramp Up: International Journal of Social, Education, Economics and Management Engineering, v.Vol:8 No:11, 2014, p. 6.

Gopal, A., M. Goyal, and S. Netessine, 2013, The Impact of New Product Introduction on Plant Productivity in the North American Automotive Industry: Management Science, v. 59.

Gross, U., and T. Renner, 2010, Coordination and Cooperation During Production Ramp-up: An Empirical Study of the European Manufacturing Industry: Production and Operations Management Society 21st Annual Conference 2010.

Harvey, M. G., and D. A. Griffith, 2007, The role of globalization, time acceleration, and virtual global teams in fostering successful global product launches: Journal of Product Innovation Management, v. 24, p. 486-501.

Hertrampf, F., M. Stirzel, and R. Eberspacher, 2008, A reference model for efficient planning of company-wide production ramp-up: Pps Management, v. 13, p. 49-52.

Jürging, J., 2008, Systemdynamische Analyse des Serienanlaufs in der Automobilindustrie: Schriftenreihe innovative betriebswirtschaftliche Forschung und Praxis. 209, Kovač.

Kallis, N., 1997, Defect Reduction in different periods of a fab's life: Conference on Process, Equipment, and Materials Control in Integrated Circuit Manufacturing III, p. 2-11.

Milling, P., and J. Jürging, 2008, Der Serienanlauf in der Automobilindustrie: Technische Änderungen als Ursache oder Symptom von Anlaufschwierigkeiten?: Spektrum des Produktions- und Innovationsmanagements, p. 67.

Minhas, S., C. Juzek, and U. Berger, 2012, Ontology Based Intelligent Assistance System to Support Manufacturing Activities in a Distributed Manufacturing Environment, *in* G. Chryssolouris, and D. Mourtzis, eds.: Procedia CIRP, v. 3, p. 215-220.

Scholz-Reiter, B., and F. Krohne, 2008, Änderungen im Serienanlauf zielorientiert managen : ein Konzept zur Effizienzsteigerung des technischen Änderungsmanagements, p. 255-276.

Slamanig, M., and H. Winkler, 2010, Wissenmanagement bei Produktwechselprojekten: ZWF.

Stauder, J., S. Buchholz, F. Klocke, and P. Mattfeld, 2014, A New Framework to Evaluate the Process Capability of Production Technologies during Production Ramp-Up: Procedia CIRP, v. 20.

Tschöpe, S., and K. Knüppel, 2013, Assessing and Improving Ramp-Up Capability, Germany, International Journal of Mechanical, Aerospace, Industrial and Mechatronics Engineering.

Van der Merwe, E., 2005, A conceptual framework for ramp-up manufacturing, University of Cambridge.

Winkler, H., and M. l. Slamanig, 2011, Der Produktwechsel als kritisches Problem des industriellen Managements: Wingbusiness, p. 6.

New product development typologies: An analysis of publications and citations between 1992 and 2012

Lopes AP[1], **Carvalho MM**[2]

Abstract: The new product development for decades has favored companies that can put their products to market quickly and efficiently, providing sustainable competitive advantage difficult to be achieved by their competitors. The main objective of this article is to understand the publication patterns of new product development, focusing on aspects related publications, citations and scientific collaboration, between 1992 and 2012. For this, the authors performed a bibliometric study with content analysis.

Keywords: project type, project typology, new product development.

1 Introduction

The increased competition between companies has required that products are increasingly innovative. Consequently, understanding the process of product innovation is essential. The collaborative relationships play an important role in product innovation (Nieto & Santamaría, 2007). Researches indicate that supplier involvement is an important variable in the process of new product development (Petersen, Handfield, & Ragatz, 2003). The supplier involvement in new product development can help to reduce the cycle time and increase the success, and some factors are very important in this process, such as: the selection of the supplier; the geographic proximity of the supplier, which favors reducing the time and cost of delivery; efforts of all involved to achieve effective exchange of information; the perception of all stakeholders of the importance of the continuity of the partnership (Bonaccorsi & Lipparini, 1994).

There is a typology for supplier integration in the new product development process: radical contribution, which leads to obtain radically new products; architectural contribution, which can lead to either significant improvement or re-engineering existing products; incremental contribution, which favors cost reduction and minor improvements to existing products (Lipparini & Sobrero, 1994). The level of technology (technological uncertainty and complexity) can influence the supplier involvement in the new product development process. The greater the complexity and technological uncertainty, most companies tend to share information with suppliers (Petersen, Handfield, & Ragatz, 2005).

There is a typology that classifies product regarding the type of innovation: incremental, which refines and extends an existing technology; modular, which modifies some essential concepts of an existing technology; architectural, which reconfigures a system established; radical, that establishes a new technology and therefore a new architecture (Henderson & Clark, 1990). Another typology classifies product regarding the type of project of research and development (Wheelwright & Clark, 1992): Projects “breakthrough”: involves significant changes to existing products and processes; Projects “platform”: are among the "breakthrough" and "derivative". Imply changes in products and processes, however, do not introduce new technologies or new materials; Projects “derivative”: are projects that vary the cost of existing products or carry out improvements to existing processes; Projects “research and technology”: creation of new knowledge, new materials and technologies that transform into developing marketable; Projects “alliances and partnership”: may include any of the above projects and, for this reason, the

1 **Ana Paula Lopes** (paulavlopes@outlook.com)
2 **Marly Monteiro de carvalho** (marlymc@usp.br)
Production Engineering Dept. Polytechnic Scholl.
University of São Paulo. Sao Paulo. Brazil.

management of these projects can vary greatly. In this context, there is a plethora of typologies that has resulted in an ambiguity in the way it is applied in new product development research.

The main objective of this article is to present a literature review on the new product development typologies, published from 1992 to 2012, focusing on aspects related to collaboration. The methodological approach selected was a systematic literature review mixing bibliometric with content analysis. The work is divided into three sections, which were methodology, finds and conclusions. In the methodology section, the steps are described for selecting the sample for analysis and the indicators to be analyzed. The results are presented the main findings and conclusions are strengthened most representative analysis as well as possible limitations are cited in the research.

2 Methodology

The research method used is a bibliometric study. One of the ways to conduct this kind of study is the publications analysis that allows the identification of the relevant group of journal, the evolution of the publications along the years and the related subject areas (Prasad & Tata, 2005). Some bibliometric works also analyze the citations, looking for finding the most cited works and authors, as well as the possible research trends (Neely, 2005). A bibliometric study can include content analysis and thereby allow the identification of the most important topics, approaches and methods, as well as the most important definitions of a theme (Ramos-Rodríguez & Ruíz-Navarro, 2004; White & McCain, 1998).

To obtain the initial sample a database was selected and it was searched with no restrictions relating to academic disciplines, journals or publication dates. The ISI Web of Science database was selected for this process because a search of this database includes papers from other databases (such as Scopus, ProQuest and Wiley) that were published in indexed journals with a calculated impact factor in the JCR (Journal Citation Report). Moreover, the ISI Web of Science database provides a set of metadata that is essential for the bibliometric analysis, including abstracts, references, number of citations, list of authors, institutions, countries and the journal impact factor.

The data were collected, using the keywords ("type of project" or "project type" or "project typology" or "project classification" or "project taxonomy" or typology or classification or taxonomy) AND ("product development" or "new product development"), resulting in 212 articles. Publications between 1992 and 2012 were analyzed in order to identify the journals with the highest number of publications, publications over time, subject areas related to the topic of study and citation analysis.

Considering that the number of the citations of one article is directly related to the importance of the work to the research area, an analysis of the most cited articles were made (Culnan, 1987; Culnan, Oreilly, & Chatman, 1990; Neely, 2005; Ramos-Rodriguez & Ruiz-Navarro, 2004). The citation analysis was conducted using several software programs including Sitkis 2.0 (Schildt, 2002), Ucinet for Windows 6.289 (Borgatti, Everett, & Freeman, 2002) and NetDraw (Borgatti et al., 2002). Sitkis made it possible to import and metadata from the scientific database. Ucinet and NetDraw were used to develop the network.

3 Findings

The 212 articles were published in 122 journals, which indicate that there is a multidisciplinary area (average of 1.7 articles per journal). The editorial scope of this relationship journal covers topics such as management, engineering, production, among others (see Table 1). Although the first publications date from 1992, there was much oscillation number of publications over time (see Figure 1).

Table 1
Publications per journal and year, considering only those journals with at least three publications.

Journal	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Total
Journal of Product Innovation Management					1			2	1	1	1			1	1		2	2	2			14
International Journal of Operations & Production Management				1						1		1					1	1	1	1		7
Journal of Engineering Design				1						1				1	1			1	2			7
Research Policy				1				2				1			1				1			6
IEEE Transactions on Engineering Management				1			1			1								1		1		5
International Journal of Technology Management				1					1					1	1				1			5
Proceedings of the Institution of Mechanical Engineers Part B								1								1	2				1	5
Expert Systems with Applications																		1	1	1	1	4
International Journal of Production Research				1									1			1					1	4
R & D Management															3			1				4
Technovation			1											1		1		1				4
Advanced Engineering Informatics																				1	2	3
Concurrent Engineering - Research and Applications									1						1					1		3
Decision Sciences								1									1		1			3
International Journal of Production Economics												1	2									3
Journal of Engineering and Technology Management				1			1									1						3
Journal of Intelligent Manufacturing			1					1		1												3
Journal of Operations Management											1								1		1	3

Note: Journals are listed in descending order of total of publication.

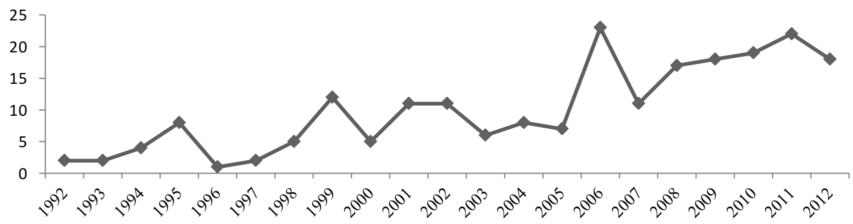


Fig.1
Publications per year.

After reviewing the publications, were performed the analysis of citations. The first was an analysis of the network of keywords that appeared in the sample more than 6 times (see Figure 2). This filter was made of citations respecting the nomination 1 to 10% of the sample suggested by the software manual Sitks. The stronger connections were between: management and product development; integration and product development; innovation and performance; resource-based view and competitive advantage.

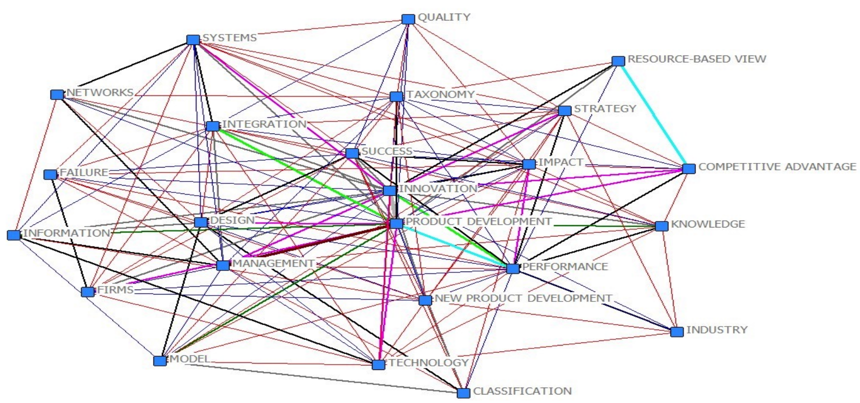


Fig.2
Keyword network.

Note: The thicknesses and colors represent the intensity of the relationship.

The second was an analysis of 17 articles with more than 40 citations (see Table 2 and Figure 3). Between 1192 and 1998 only six articles were cited (Adler, 1995; Griffin & Page, 1996; Lipparini & Sobrero, 1994; Nobeoka & Cusumano, 1997; Wheelwright & Clark, 1992). Between 1999 and 2003, seven more articles began to be cited (Childerhouse, Aitken, & Towill, 2002; Garcia & Calantone, 2002; Kostoff & Schaller, 2001; Pearce, 1999; Pich, Loch, & Meyer, 2000; Rosenkopf & Nerkar, 2001; Tatikonda, 1999). From 2004, the last four articles began to be cited (Bullinger, Fähnrich, & Meiren, 2003; Faller, Bracher, Dami, & Roguet, 2002; Flynn, Huo, & Zhao, 2010; Lindkvist, 2005).

Table 2
Articles with more than 40 citations.

Author (Year)	Journal	Number of citations
Ulrich (1995)	Research Policy	563
Rosenkopf & Nerkar (2001)	Strategic Management Journal	345
Garcia & Calantone (2002)	Journal of Product Innovation Management	317
Griffin & Page (1996)	Journal of Product Innovation Management	218
Adler (1995)	Organization Science	163
Kostoff & Scaller (2001)	IEEE Transactions on Engineering Management	141
Pearce (1999)	Research Policy	104
Pich, Loch & Meyer (2000)	Management Science	103
Childerhouse, Aitken & Towill (2002)	Journal of Operations Management	69
Wheelwright & Clark (1992)	Harvard Business Review	67
Lipparini & Sobrero (1994)	Journal of Business Venturing	65
Nobeoka & Cusumano (1997)	Strategic Management Journal	64
Bullinger, Fahnrich & Meiren (2003)	International Journal of Production Economics	54
Lindkvist (2005)	Journal of Management Studies	48
Flynn, Huo & Zhao (2010)	Journal of Operations Management	46
Tatikonda (1999)	Journal of Product Innovation Management	44
Faller, Bracher, Dami, & Roguet (2002)	Toxicology in Vitro	42

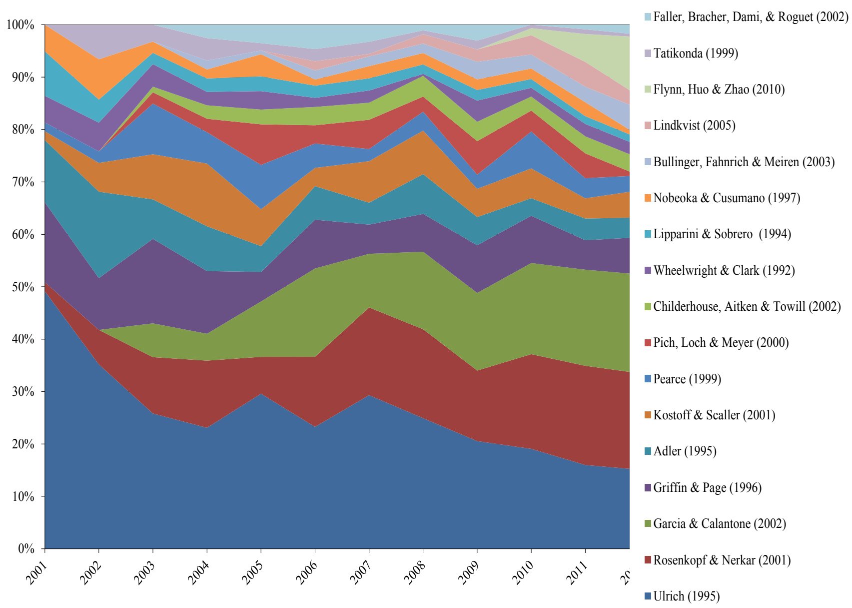


Fig.3
Evolution quote of the 17 most cited papers.

4 Conclusions

Companies seek to innovate in research and development with the goal of obtaining technological advancement; meet changing customer needs; shorten the life cycle of products and increase competitiveness (Cooper, 1994). Technological knowledge is a very important tool for achieving competitive advantage, since it helps reduce costs and differentiate the company from its competitors (Lichtenthaler, 2007). There was in the last two decades a growth related to technology licensing and many companies have adopted this type of activity in their business strategies. This research allowed us to analyze quantitatively and qualitatively the theory of new product development. The 212 articles were published in 122 journals in various areas. The journals that more published were: Journal of Product Innovation Management, International Journal of Operations & Production Management, Journal of Engineering Design and Research Policy. The analysis of keywords showed that the work was mainly directly related to new product development and management.

The citation network analysis showed that there is no concentration of work on specific authors, confirming the multidisciplinary of the subject. A limitation of this research is to use a single database, whose effects are minimized with the citation network analysis articles for references.

5 References

Adler, P. S. (1995). Interdepartmental interdependence and coordination - The case of the design/manufacturing interface. *Organization Science*, *6*, 147–167.

Bonaccorsi, A., & Lipparini, A. (1994). Strategic Partnerships in New Product Development: an Italian Case Study. *Journal of Product Innovation Management*, *11*(2), 134–145.

Borgatti, S., Everett, M., & Freeman, L. (2002). Ucinet for Windows: Software for social network analysis. Analytic Technologies.

Bullinger, H.-J., Fähnrich, K.-P., & Meiren, T. (2003). Service engineering—methodical development of new service products. *International Journal of Production Economics*, *85*(3), 275–287.

Childerhouse, P., Aitken, J., & Towill, D. R. (2002). Analysis and design of focused demand chains. *Journal of Operations Management*, *20*(6), 675–689.

Cooper, R. G. (1994). Perspective - Third generation new product process. *Journal of Product Innovation Management*, *11*, 3–14.

Faller, C., Bracher, M., Dami, N., & Roguet, R. (2002). Predictive ability of reconstructed human epidermis equivalents for the assessment of skin irritation of cosmetics. *Toxicology in vitro*, *16*(5), 557–572. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/12206823

Flynn, B. B., Huo, B., & Zhao, X. (2010). The impact of supply chain integration on performance: A contingency and configuration approach. *Journal of Operations Management*, *28*(1), 58–71.

Garcia, R., & Calantone, R. (2002). A critical look at technological innovation typology and innovativeness terminology: a literature review. *Journal of Product Innovation Management*, *19*, 110–132.

Griffin, A., & Page, A. L. (1996). PDMA Success Measurement Project: Recommended Measures for Product Development Success and Failure. *Journal of Product Innovation Management*, *13*(6), 478–496.

Henderson, R. M., & Clark, K. B. (1990). Architectural Innovation: The Reconfiguration of Existing Product Technologies and the Failure of Established Firms. *Administrative Science Quarterly*, *35*(1), 9.

Kostoff, R. N., & Schaller, R. R. (2001). Science and technology roadmaps. *IEEE Transactions on Engineering Management*, *48*(2), 132–143.

Lichtenthaler, U. (2007). The Drivers of Technology Licensing : *California Management Review*, *49*(4), 67–89.

Lindkvist, L. (2005). Knowledge Communities and Knowledge Collectivities : A Typology of Knowledge Work in Groups *. *Journal of Management Studies*, *42*(6), 1189–1210.

Lipparini, A., & Sobrero, M. (1994). The glue and the pieces: Entrepreneurship and innovation in small-firm networks. *Journal of Business Venturing*, *9*, 125–140.

Nieto, M. J., & Santamaría, L. (2007). The importance of diverse collaborative networks for the novelty of product innovation. *Technovation*, *27*(6-7), 367–377.

Nobeoka, K., & Cusumano, M. A. (1997). Multiproject strategy and sales growth: The benefits of rapid design transfer in new product development. *Strategic Management Journal*, *18*(3), 169–186.

Pearce, R. D. (1999). Decentralised R & D and strategic competitiveness : globalised approaches to generation and use of technology in multinational enterprises (MNEs). *Research Policy*, *28*, 157–178.

Petersen, K. J., Handfield, R. B., & Ragatz, G. L. (2003). A Model of Supplier Integration into New Product Development*. *Journal of Product Innovation Management*, *20*(4), 284–299.

Petersen, K. J., Handfield, R. B., & Ragatz, G. L. (2005). Supplier integration into new product development: coordinating product, process and supply chain design. *Journal of Operations Management*, *23*(3-4), 371–388.

Pich, M. T., Loch, C. H., & Meyer, A. De. (2000). On Uncertainty , Ambiguity , and Complexity in Project Management. *Management Science*, *48*(8), 7–12.

Ramos-Rodríguez, A.-R., & Ruíz-Navarro, J. (2004). Changes in the intellectual structure of strategic management research: a bibliometric study of the Strategic Management Journal, 1980–2000. *Strategic Management Journal*, *25*(10), 981–1004.

Rosenkopf, L., & Nerkar, A. (2001). Beyond local search: Boundary-spanning, exploration, and impact in the optical disk industry. *Strategic Management Journal*, *22*, 287–306.

Schildt, H. A. (2002). Sitkis: Software for Bibliometric Data Management and Analysis. Helsinki: Institute of Strategy and International Business.

Tatikonda, M. V. (1999). An empirical study of platform and derivative product development projects. *Journal of Product Innovation Management*, *16*, 3–26.

Wheelwright, S. C., & Clark, K. B. (1992). *Revolutionizing Product Development: Quantum Leaps in Speed, Efficiency, and Quality*. New York: The Free Press.

White, H. D., & McCain, K. W. (1998). Visualizing a discipline: An author co-citation analysis of information science, 1972–1995. *Journal of the American Society for Information Science*, *49*(4), 327–355.

Is the TQM Outdated?
- Four case studies

Bernardino LL[1], Teixeira FLC[2], Barbosa AS[3], Jesus AR[4], Lordelo MJ[5]

Abstract: The objective of this study is to try to understand what happened to the loss of highlight of TQM over the last 20 years. A multiple cases temporal and comparative approaches of four organizations from different companies in Brazil were accomplished. The results revealed that 19% of TQM practices, 28% of TQM tools and 57% of TQM methodologies are no longer being used. However, the principles revealed an average 96% utilization. It can be noted that the prevailing management philosophy is still in the organizational environment of organizations. Many of the practices, tools and methodologies were incorporated into the automated systems of the companies or also suffered nomenclature changes, but its essence remained.

Keywords: TQM, quality management, excellence management model, multiple case studies, Brazil.

1 Introduction

The 90s was characterized by a shock in the competitive environment of the Brazilian industries, initiating a process of intensive reforms and transformations. In this context many companies have adopted the total quality management (TQM) as its management model. Currently, we no longer hear so much about TQM both in academia and in business. The purpose of this present study is to analyze what happened to TQM, which aspects that are still present, those who have been discarded or are in disuse or those that have been modified.

2 The Model for Total Quality Management in Brazil

Total quality management focuses the majority of its principles, practices, tools and methodologies on a restricted group of formulators. These scholars are referred by several authors as masters or "quality gurus". Based on Zairi (2013), Brown (2013) and Wood Jr. and Urdan (1994), this study highlights Edward Deming, Philip Crosby, Armand Feigenbaun, Kaoro Ishikawa and Joseph Juran (1990).In Brazil, the professor and consultant Vicente Falconi Campos is referred by several authors as the "master of the quality of Brazil" for its efforts of absorption and scattering of the Japanese model in Brazil.

Falconi Campos employed the teachings of the Japanese Union of Scientists and Engineers (JUSE) to extend the Japanese model to a significant number of organizations. Four categories of analysis were developed: principles, practices, tools and methodologies (PPTM), that were collected in the studies developed by Campos (1989, 1992, 1994, and 1996). Detailed descriptions of the PPTM are presented in the following sections.

1 **Lis Lisboa Bernardino** (lis.admufba@gmail.com)
2 **Francisco Lima Cruz Teixeira** (teixeira@ufba.br)
Administration School,
Federal University at Bahia, Salvador, Brazil.
3 **Ava Santana Barbosa** (avasbarbosa@gmail.com)
4 **Abel Ribeiro de Jesus** (ajesus@ufba.br)
5 **Mauricio de Jesus Lordelo** (mauriciojl91@hotmail.com)
Mechanical Engineering Department,
Polytechnic School of the Federal University at Bahia, Salvador, Brazil.

2.1 Principles

Principles are concepts that are structured as mental symbols to provide an abstract notion of a set of characteristics that are common to a class of beings, objects or abstract entities. Within TQM, the following principles were identified: customer focus; systemic and holistic view; search for synergy; humanist vision; quest for continuous improvement and actions guided by facts, data and priorities.

2.2 Practices

The practices consist of techniques. Within TQM, the following practices were identified and categorized into sixty relevant practices, which are composed of five subgroups: general practices, marketing management, buyer/supplier relationship, and human growth management and auditing.

The first subgroup - general practices - comprises sixteen practices: participation in all areas by a company's employees in the study and conduction of the TQM; the use of tools and statistical techniques; training in quality control circles (QCCs); quality assurance; process control; automation; ISO certification; participation in national quality programs; failure analysis; standardization; blocking action; shake-down; brainstorming; action plan; study groups and the 5S program.

The six practices of marketing management primarily address issues such as: satisfying the needs of the customers and benchmarking and development of new products. The eleven practices buyer/supplier relationship primarily focus on reducing the number of suppliers; establishing relations of cooperation, trust and continuity; outsourcing processes; decreased inventory and increased frequency of purchases.

Human growth management consists of 21 practices related to training; employment stability; and motivation and remuneration. Six auditing practices were identified in the literature: external audits, audits of the vendor by the buyer, President Audits, audits for ISO certification, audits by a consultant and audits to obtain the Deming Prize.

2.3 Tools

The tools comprise resources to be used in the methodology. Within the framework of TQM, the following seven quality tools were identified in the literature as relevant tools and disseminated by Professor Kaoru Ishikawa: check sheet (checklist), stratification, Pareto chart, cause and effect Diagram, trend graph (correlation diagram), histogram and process control chart.

2.4 Methodologies

Methodologies include logical sequences to achieve a predetermined goal, i.e., steps that must be followed to achieve a particular effect. Within the framework of TQM, the following relevant methodologies were identified in the literature and categorized: statistical process control (SPC), method of analysis and problem shooting, PDCA (plan, do, check, and act) cycle and management by policies.

After exposure of the more relevant PPTMs, a brief analysis of the possible reasons for the decline of the TQM model is presented.

3 The Crisis of the TQM Model

The development of this study sought evidence in the literature to substantiate the premise that the model of TQM - the Japanese style - is not being used as a mean of improving organizational outcomes. The bibliometric study by Paulista et al. (2010) reveals a peak of publications on the subject between the years 1998 to 2001, followed by a sharp decline in subsequent years. In addition, hypotheses and arguments about the possible factors that motivated this process of decline have been identified in various studies. The formulated hypotheses are based on the analysis undertaken by various authors, such as Porter (1996), Wood Jr. (2001), Tolovi (1994), Cordeiro (2004, 2009), Wood and Caldas (1995), Campos, (1989), Jesus (2000); Vasconcelos and Teixeira (1997), Zilbovicius (1999) Pyzdek (2001), Brown (2013), Antony (2013), Mosadeghrad (2013, 2014), and Zu et al. (2010).Some of the authors and their main assumptions are summarized in Table 1.

Table 1
Main assumptions for the "crisis" of the TQM model.

Emphasis on operational effectiveness and not on strategic positioning; lack of integration of operational programs and global strategies.Weak objective definition of expected returns by the program.	Porter (1996); Asif et al (2009); Pyzdek (2001)
Vision and treatment provided by some organizations or academia and gurus of TQM as a management fad and not a management philosophy, i.e., lack of understanding about the broader significance of the TQM model.	Wood Jr (2001); Cordeiro (2004); Campos (1989); Wood and Caldas (1995); Brown (2013)
Barriers encountered in the western management culture; emergence of new managerial wave that accelerated the decline of the model	Wood and Caldas (1995); Cordeiro (2004)
Lack of emphasis given by the TQM model to the phenomenon of leadership as the driver of innovative processes and value creation.	Jesus (2000); Anthony (2013); Brown (2013)
Lack of commitment and involvement of senior management	Tolovi (1994); Mosadeghrad (2013, 2014); Zu*et al*. (2010)
Negative perception for workers in relation to the TQM program (resistance to the proposed changes) and lack of appropriate technical and academic training at the operational level.	Vasconcelos and Teixeira (1997); Mosadeghrad (2014)

4 Excellence Management Model

The National Quality Foundation is a Brazilian research center that was founded in 1991.Their mission is to "spread the foundations of excellence in management for increasing competitiveness of the organizations and Brazil" (FNQ, 2011, p.9).It disseminates the Management Excellence Model (MEM) that has many similarities with the Baldridge Prize of the US. The two approaches (TQM and MEM) have many similarities and some differences that are summarized in Table 2.

Table 2
Similarities and differences between TQM and MEM approaches.

TOTAL QUALITY MANAGEMENT	MANAGEMENT EXCELLENCE MODEL
Prescriptive model	No prescriptive model
Driven to the productive system	Driven to the management system
Emphasis on quality	Emphasis on excellence
Driven to medium and large companies	Driven to companies of all sizes
Focus on the internal environment	Focus on the external and internal environment
Emphasis on formal standardization	Minimal emphasis on formal standardization
Does not evaluate management or confer awards	Focus on management evaluation and awards
Employment of statistics tools	Does not prescribe tools
Missing term	Emphasis on democratic and participative leadership
Missing term	Visa sustainability and environmental responsibility
Missing term	Emphasis on strategic planning

5 Methodology

The motivation to perform this research derived from the curiosity to explain the question "Where did TQM go since it was so prevalent in the 1990s?" or "Why are TQM programs limited?" The qualitative analysis is better suited to the purpose of this research because it provides a detailed analysis. The choice of a multiple case study approach is justified by the possibility of performing a temporal analysis and comparative approach.

The construction of the interview scripts and semi-structured questionnaires was based on one analysis model which considers the TQM dimensions and the MEM deploys indicators that represent the following categories: principles (a total of six), practices (a total of 60), tools (a total of seven) and methodologies (a total of four), as presented in section 2 of this study.

Data were primarily collected via exploratory interviews, followed by document analysis. The exploratory interviews revealed that many of the professionals who were involved in the implementation of TQM in the 1990s currently use the MEM; their companies also employ the MEM.

After the completion of exploratory interviews, we conducted documentary research to verify the consistency of the data, that is, the objective was to determine whether the companies that adopted TQM in the1990s had migrated to the MEM, which was confirmed.

The document analysis was conducted by collecting raw data from files of the Bahia Association for Competitive Management (ABGC, 1995) fromthe1990s, and the most current files (98-2011), which include winning companies of the Quality Bahia Award (PGQB).After exclusion of companies that no longer exist and companies that competed for the award with different units, four cases remained.

A total of eight interviews were conducted, in which eight semi-structured questionnaires in the areas of quality were completed by managers, employees and former employees of the selected companies. Four interviews were conducted with people who participated in the implementation of TQM in the 1990s, and four interviews were conducted with the quality managers in 2013. Two respondents from each organization were interviewed.

6 Analysis and Results

This section presents the data from the four organizations and a comparative analysis of the data. Adoption - use or disuse – of the principles, practices, tools and methodologies in the 1990s and in 2013.

6.1 Company "X"

The unit named "Company X" has operated in the field of mining (smelting and refining of primary copper) since 1982.Company X implemented total quality management in 1991.With this new management model, the organization envisioned an opportunity to survive the crisis caused by falling import barriers. According to one interviewee (who was responsible for the implementation of TQM in the1990s), the program achieved improvements of significant gains in productivity and profitability during that period. It benefitted from the commitment and involvement of senior management, a generalized motivation for the program and even received praise from one of the Japanese consultants from the Japanese Union of Scientists and Engineers (JUSE) as the best implementation of TQM in Brazil at the time.

Company X began the deployment of the MEM in 1998, when it won the Bahia Quality Management Award. It won this award because it intensively implemented TQM beginning in 1991 and the MEM until 2003. In 2001, the company began implementing Six Sigma.

In 2003, top management was replaced, which caused a break in the management model. As a management option, the new directors disregarded most of all other points proposed by the MEM.

The analysis of the relationship between the PPTM implemented by company X in the 1990s and the PPTM implemented by company X in 2013 compared with the total number of principles recorded in the literature suggests that Company X continues to adhere to the principles and tools of the TQM adopted in the 1990s.However, the same results were not obtained for the practices and methodologies. The percentage of practices implemented in the 1990s decreased from 67% to 45%.Regarding the implementation of methodologies, the reduction is even sharper - from 100% implementation to only 25% implementation.

According to the person responsible for quality management in company X, the quality of the processes and products is currently managed and controlled by indicators via automated systems, such as the "SAP, CORPWEB, and the Integrated Management System (SIP),which includes ISO 9001, ISO 14001, OHSAS 18000 and other certifications, in which the focus is very similar to the balanced scorecard (BSC). The seven quality tools are incorporated within these systems. Although the tools are not disseminated by employees, they remain prevalent within the automated systems.

6.2 Company "Y"

The organization named "Company Y" has operated since 1991 in the manufacture of organic chemicals and is responsible for approximately 95% of the consumption of detergent in the Brazilian industry. In 2013, its annual production capacity consisted of 220,000 tons of linear alkyl benzene (LAB) and 80,000 tons of linear alkyl benzene sulfonate (LAS).Company Y is categorized as a medium-sized private company because it has approximately 200 employees. Company Y began the implementation of TQM in 1990 due to pressure from the external market. According to the person responsible for implementation in the1990s, external clients began to demand a quality management system that was certified by ISO standards. To ensure the closure of new supply contracts, the company's board decided to implement a comprehensive TQM instead of adopting only the ISO 9000because they already had a number of elements that resembled the Japanese style system of quality management.

The deployment of MEM in Company Y began in 2003 and aimed to improve the internal processes of the organization and win awards. Company competed for the Quality Bahia Award and was awarded the Silver Trophy in 2003 and the Gold Trophy in 2004.Using a managerial option (cost of external consultants and efforts of the workforce), Company Y stopped using the MEM as a reference management model in 2006 because the company "had already achieved the expected results. "However, the person responsible for quality management in Company Y in 2013 noted that "today the company's management has many convergences with the MEM."

The analysis of the relationship between the PPTM implemented by Company Y in the 1990s and the PPTM implemented by Company Y in 2013 compared with the total number of principles cited in the questionnaires suggests that Company Y continues to adhere to the principles proposed by the literature on TQM and general practices, as demonstrated by a slight decrease in adherence from 73% to 68%.However, the same result was not obtained regarding the tools and methodologies as demonstrated by the percentage reduction from 71% to 57% and from 100% to 50%, respectively. According to the person responsible for quality management of Company Y in 2013, the quality of processes and products began to be managed and controlled by indicators and various automated failure management systems. These systems contain many fragmented practices, tools and methodologies from TQM. The company believes that many practices employed during TQM remain in use, which is consistent with the organizational culture and demonstrates their ability to satisfy the demands of the company. As an example, she cites the PDCA and some statistical problem solving tools. She notes that "the principles of TQM, for example, were incorporated as values or actions within our Strategic Planning."

6.3 Company "Z"

The unit named "Company Z" was established as one of 28 regional offices responsible for implementation and administration of postal services within the state of Bahia. Company Z is a public company and is associated with the Ministry of Communications, which were founded in 1969.

Company Z began implementation of a comprehensive program of TQM in 1993.According to one of the persons responsible for implementation of TQM in the 1990s, TQM resulted from the fear of being surpassed by other organizations that were "embarking on wave of the quality."

According to the person responsible for coordinating the MEM between the years 2002 and 2009, each regional board individually performed quality actions by applying a particularly model - the Post-Excellence Model - which was inspired by the criteria of excellence for the MEM. In this context, company Z applied for the Bahia Quality Award and was awarded the Bronze Trophy in 2007 and 2008. In 2010, senior management of the central office - who controls all regional boards, including Company Z - opted for corporate adoption of the MEM in its complete version.

The analysis of the relationship between the PPTM implemented by Company Z in the 1990s and the PPTM implemented by Company Z in 2013 compared with the total number of principles in the questionnaires indicates that company Z continues to adhere to the principles proposed by the literature on TQM. However, the same results were not obtained regarding general practices as demonstrated by a decrease in adherence from 92% to 53%.The employed tools also showed a significant reduction of implementation - from 100% to 43%.The methodologies demonstrated a more significant reduction - from 100% to 25% of implementation.

When asked about the main differences between the current quality management system (based on MEM) and the model of TQM implemented in the 1990s, the interviewee explained that a specific area is no longer responsible for quality or TQM throughout the company. However, quality remains embedded throughout the company management using the MEM as part of their organizational culture in a manner that is integrated in the corporative strategy.

6.4 Company "W"

The unit named "Company W" has operated in the business of distribution of electricity in the state of Bahia since 1960, which is the date of its creation. The Company began to implement a comprehensive program of TQM in 1992. According to one of the persons responsible for implementing the TQM in the 1990s, top management chose to adopt the TQM of professionals from the University of São Paulo (USP), who were teaching courses to the executives of Company W during that period. The interviewee explained that one of the major problems of TQM was linked to the creation of expectations, which was not confirmed in practice.

The adoption of the MEM began in 2002 with the goal of creating value for the company's business. The company competed for the Bahia Quality Award and was awarded the Bronze Trophy in 2003, the Silver Trophy in 2004/2005 and the Gold Trophy in 2006.

The analysis of the relationship between the PPTM implemented by Company W in the 1990s and the PPTM implemented by Company W in 2013 compared with the total number of principles in the questionnaires indicated that the company continues to adhere to the principles proposed by the literature on TQM. However, the same results were not obtained regarding general practices, as demonstrated by a decrease in adherence from 70% to 58%,a reduction from 86% to only 43% for tools, and a reduction from 75% to 50% for methodologies.

When asked about the main differences between the current quality management system (based on the MEM) and the model of TQM, the respondent explained that the main difference is the form used to understand quality. At the time of TQM, the employees believed that they needed to perform their work and the quality aspect. Thus, the quality focused on a specific sector that coordinated the quality movement. After the adoption of the MEM, it has changed; the employees began to regard quality as a value, i.e., "it is not seen as a plus, it turned to be transversal".

7 Comparison of Results

In this section, the comparative analysis of the results for the four cases is presented. All surveyed companies showed strong adherence to the PPTMs of a program of total quality management. The analysis of the aspects that have changed compared with the current corporate management model identified some similarities. The current managers of the four cases no longer lead a program of total quality management throughout their companies. The companies claim to have an "integrated quality management system." Regarding the aspects that were eliminated, we highlight the QCC and the 5S Programs. Only one case (Company Z) retained Program 5S.

Although some practices are no longer performed in the same manner of the period in which the TQM was adopted, its objectives are maintained. For example, the practice of monitoring the indicator of morality with organizational climate surveys based on the monitoring of other indicators and the old "suggestion box", which was replaced by more modern methods, are currently used.

The increased use of automation and the PDCA cycle has been described in all four companies. In addition, some principles that were not part of company management in the 1990s but were integrated with the adoption of the MEM were included: focus on leadership, emphasis on excellence and strategic planning, and search for sustainability and environmental responsibility. These three principles were not part of TQM. The programs of environmental responsibility gained more prominence and became complex in all cases. The empirical research discovered that three of the four cases are currently certified by ISO 9001: 2008, with the exception of Company Z, which never achieved certification. This finding is attributed to the realization that the ISO standards have achieved significant credibility in the market.

Regarding the adoption of the MEM, only 50% of the companies (Companies Z and W) continue to use it as a management reference model. The two companies that employ other management models declared that the MEM was abandoned due to strategic decisions of senior management. The surveyed companies that continue to adopt the model MEM include service companies, unlike the industrial firms X and Y, which discontinued its use. The average percentages of disuse of the PPTM by the surveyed companies are listed in Table 3.

Table 3
Average % of disuse of PPTMs by the Companies.

	Total	Average Decade 90	Average 2013	Average% Disuse
Principles	6	96%	96%	0%
Practices	60	75%	56%	19%
Tools	7	89%	61%	28%
Methodologies	4	94%	37%	57%

The analysis of the compliance with the principles obtained from the literature on TQM revealed that the four companies continue to show strong adherence to them. The reports collected during semi-structured interviews demonstrated that the principles supported by data were substantially disseminated and integrated in the values, mission, vision, and strategic formulations of these organizations.

Considering the attendance to the practices, the four cases showed adherence to more than 60% of the practices during the 1990s. This context has changed in the current scenario. Only the Company Y currently exceeds this percentage. Thus, the percentage of practices that were implemented by Company X, Company Y, Company Z and Company W during the 1990s decreased from 67% to 45%, from 73% to 68%, from 92% to 53%, and from 70% to 58%, respectively.

Analysing the current spread of tools of quality, the results indicated that all companies reported adherence of more than 70% during the 1990s, which has also changed in the current administration. One exception is Company X, which featured the use of 100% of those surveyed in the two reference periods, and Company Y, which disused only one quality tool. In company Z, the percentage decreased from 100% to 43%, whereas the percentage decreased from 86% to 43% for company W. In the case of this study, the use of quality tools remained more constant over the years for the industrial type of companies (X and Y) compared with service providers (Z and W).

A comparative analysis was performed with respect to the methodologies. In the 1990s, the four cases showed adherence to more than 75% of the methodologies, which has also changed in the current context. The methodologies showed the largest reduction among the surveyed companies - from 100% to 25% implementation in companies X and Z, from 100% to 50% in company Y, and from 75% to 50% in company W. The use of the PDCA cycle remains valid for the four cases.

Considering these analyses, this paper proposes the argument that some of the current practices, tools and methodologies from the TQM model, which were employed during the 1990s by the surveyed companies, are not more prevalent. However, most of the principles, i.e., the prominent management philosophy during that period, remain part of the organizational environments of these companies.

8 Conclusions

According to the data analysis, although many practices, tools and methodologies are not described or named in the same manner in which they described during TQM, its essence remains preserved. In this case, some programs have been fragmented within integrated management systems, such as 5S, bonuses, methodologies that have been replaced by software that is capable of performing with greater complexity and agility and statistical analyses, and new programs and tools for ideas and suggestions.

In addition, several PPTMs were incorporated into the automated systems of the companies. This phenomenon fosters the suspicion that the training and the dissemination of various tools and practices of TQM stopped circulating within the operators and migrated to automated systems. Corporate managers are aware of this phenomenon but operators are not familiar with it. This suspicion is strengthened by the disuse of practices such as QCC, the focus on problem solving, "Quality Study" groups, the practice of shake-down to solve problems, the declining use of methods for solving problems, the reduction of training in tools and statistical techniques, and other aspects that required significant involvement and effort by operators in relation to continuous quality improvement.

On the other hand all practices, tools and methodologies that remain in use should be considered, even after twenty years since the beginning of its implementation, especially considering the volatility of managerial waves in the field of administration. Thus, TQM is not a management fad that experienced a "crisis" and disappeared based on the four cases. The findings from this study indicate an expansive dissemination of the principles of this model in the current management of the surveyed organizations, influencing and inspiring them to utilize new practices, tools, methodologies, models and systems that are considered to be more "modern".

The results of this study indicate that the models or "managerial waves" that are successful in the field of administration contributed to the evolution of the management of organizations despite a period of great dissemination (referred to as the "leading edge" by some authors) followed by a stage of decline. They provide teachings and important legacies, which are consistent with their different contexts for continuous improvement, for managing people and processes to produce better products and services.

References

Antony, J. (2013), “What does the future hold for quality professionals in organizations of the twenty-first century?”, The TQM Journal, Vol. 25 No. 6, pp. 677-685.

Asif, M. et al. (2009), “Why quality management programs fail: a strategic and operations management perspective”, International Journal of Quality & Reliability Management, Vol. 26 No. 8, pp. 778-794.

Brown, A. (2013), “Quality: where have we come from and what can we expect?”, The TQM Journal, Vol. 25 No. 6, pp. 585-596.

Campos, V. F. (1989), *Total quality management: strategy to increase the competitiveness of Brazilian company*, Fundação Cristiano Ottoni, Belo Horizonte.

______. (1992), *TQC: total qualitycontrol* (no estilo japonês), Bloch, Rio de Janeiro.

______. (1994), *Management of Work Routine Day-to-day*, 1 a. ed., FundaçãoChristianoOttoni, UFMG, Bloch Editores S.A.

______. (1996), *Management by Guidelines*, Fundação Cristiano Ottoni, Belo Horizonte.

Cordeiro, J. V. B. de M. (2004), “Reflections on Total Quality Management: end of another fad or incorporation of the concept through new management tools?”, Rev. FAE, Curitiba, Vol.7 No.1.

______. (2009) “Toyota and Grandma’s cake”, available at: http://www.trabalhosfeitos.com/ensaios/a-Toyota-e-o-Bolo-Da/133571.html (accessed 26 April 2013).

FNQ.(2011), *Towards Excellence Criteria*, Evaluation and diagnosis of organizational management, 6.ed. São Paulo: National Quality Foundation, São Paulo.

ISO AND INTERNATIONAL STANDARDIZATION, (2009), “Selection and use of the ISO 9000 family of standards”, ISO/TC 176.

Jesus, A. R. de.(2000), “Diagnostic Management System for Total Quality (GQT/TQC/TQM) of CaraíbaMetais”, Dissertation (Professional Master in Business Administration), School of Administration, University Federal of Bahia, Salvador.

Juran, J. M. (1990), *Juran on leadership for quality: a guide for executives*, Pioneira, São Paulo.

Mosadeghrad, A. M. (2013), “Obstacles to TQM success in health care systems”, International journal of health care quality assurance, Vol. 26 No.2, pp.147-173.

______. (2014), "Why TQM programmes fail? A pathology approach", The TQM Journal, Vol. 26 No.2, pp.160-187.

Paulista, P. H. et al. (2010), “Bibliometric analysis of quality management: search for titles”, Electronic Journal Production & Engineering, Vol. 3 No. 1, pp. 263-271.

Porter, M. (1996), “What is strategy?”, Harvard Business Review.

PROGRAM Quality Bahia.(1995a), *Bahia declaration*, ABGC, Salvador.

______. (1995b), *Sustaining entities PQB*, ABGC, Salvador.

______. (1995c), *Organization*, ABGC, Salvador.

______. (1995d), *Sectorial committees*, ABGC, Salvador.

Pyzdek, T. (2001), “Why Six Sigma is Not TQM”, available at: https://www.sixsigmatraining.org/pdf/2001-02.pdf (accessed 22 August 2014).

Tolovi JR., J. (1994), “Why do quality programs fail?”, Journal of Administration, São Paulo, Vol. 34 No.6, pp.6-11.

Vasconcelos, N.and Teixeira, F. L. C. (1997), “Total quality: what they think workers”, Organizations and Society, Vol. 4 No.8, pp. 143-167.

Wood JR., T. (2001), *Spectacularorganizations*, FGV, Rio de Janeiro.

Wood, JR., T. and Urdan, F. T. (1994), “Total Quality Management: a critical review”, Journal of Administration, São Paulo.

Wood, JR., T. and Caldas, M. P. (1995), “Who's afraid of electroshock: identity, convulsive therapy and organizational change”, Journal of Administration, São Paulo, Vol. 35 No. 5, pp.13-21.

Zairi, M. (2013), “The TQM legacy – Gurus’ contributions and theoretical impact”, The TQM Journal, Vol. 25 No. 6, pp. 659-676.

Zilbovicius, M. (1999), *Models for production, production models: a contribution to the analysis of the genesis, logic and dissemination of the Japanese model*. Annablume/ FAPESP, São Paulo.

Zu, X., Robbins, T. L. and Fredendall, L. D. (2010), “Mapping the critical links between organizational culture and TQM/Six Sigma practices”, International Journal of Production Economics, Vol. 123 No. 1, pp. 86-106.

Sales performance management: a strategic initiative to the growth of micro and small enterprises

Galvão E[1], Cotrim S[2], Leal G[3], Aragão F[4]

Abstract: Micro and small companies are increasing in number and economic importance in the Brazilian market. In the sector of services they already account for 27% of the Country's GDP. Given this importance, the goal of the case study is to analyze how the integration of the production engineering tools with performance management, through indicators, can boost strategically these organizations achieve and exceed their sales goals and so become increasingly competitive and growing in size and quality of service. This proposal was applied in a micro company, and the target reached was 121% of the primary goal, in the first four months of the year of 2014.

Keywords: Performance Management; Quality Tools; Sales Strategy; Goals.

1 Introduction

World Bank data (2013) shows that the service sector has been growing its share to the economic development of countries. It can be seen that in 2009, this sector represented 80% of France's Gross Domestic Product (GDP) and 71% of Germany's GDP in 2010. In Brazil, despite being a developing country, the contribution of this sector reached 67% of the national GDP in 2011.

Negri and Kubota (2006) emphasize that the service sector is of utmost importance with regard to the creation of firms and jobs in Brazil. According to IBGE (2011), more than a third of the national production (36.3%) of the Services sector, come from small business. Since micro and small businesses have been growing in the country and already account for 27% of its GDP.

However according to Fontes and Pero (2009), the consolidation of institutions and the creation of favorable conditions for increasing productivity and formalization of these businesses, are still challenge for countries development, as the case of Brazil. This is what hinders the development of a model to increase access to markets.

To survive these challenges, it is essential that the companies know how to identify customer needs, so that they can determine strategic ways to reach sales targets while maintaining quality of service.

Ledingham et al. (2006) highlights that effective and efficient operation of a sales force is a critical element for the success of many companies. And leverage sales can be an effective operational strategy to boost revenues and the growth of profit.

Thus, this article aims to analyze how the Performance Management can help strategically the increasing of sales for micro and small enterprises, through the case study of a micro company representative of products for Animal Nutrition.

The paper is structured in four sections, including this introduction. Section 2 presents the literature review that supported the development of the proposal. Section 3 characterizes the research and describes the method adopted. In Section 4 the results are posted. Finally, in Section 5 presents the final considerations, highlighting the difficulties, limitations and future work.

1 **Evelyn de Morais Galvão** (Evelyn.mgalvao@gmail.com)
2 **Syntia Lemos Cotrim** (syntialceng@gmail.com)
3 **Gislaine Camila Lapasini Leal** (cammy.leal@gmail.com)
4 **Franciely Velozo Aragão** (fran-aragao@hotmail.com)
Dpto. de Engenharia de Produção. Universidade Estadual de Maringá.
Av. Colombo, 5.790 Maringá, Paraná - Brasil

2 Literature Review

2.1 Strategy

According to Kaplan (1940), "strategy is not an isolated management process; is one of the steps in a logical continuum that moves all organization." To Calvcanti (2007), every company must have a reason to exist, establishing targets to be achieved, and to reach these goals it is necessary to think more fragmented and strategically.

Thereby, the strategy starts the discussion of issues related to threats, opportunities, risks and worries about the customer areas, suppliers and competitors. From there on, plans and objectives are drawn so the organization can achieve its expected results.

2.2 Prevision of Demand

According to Slack (2009), "without an estimate of future demand it is not possible to plan effectively for future events, only reacting to them." Thereby, the demand forecast is critical to the definition of a production system.

Tubino (2007), states that the demand forecast can be evaluated from quantitative and qualitative methods, and serves as a basis to strategic planning of the company in production levels, sales and finance.

Furthermore, it is important to understand and correct interpretation of the data obtained and what were the technical bases and restrictions used for the calculation of orders, to facilitate communication between the PCP (Planning and Control of Production) and the Marketing sector.

2.3 Quality Tools

Ishikawa (1968) *apud* Fernandes and Souza (2013), states that 95% of quality issues can be solved by using simple tools, such as the basic tools of quality.

Also according to Paliska *et al.* (2007), highlight the use of quality tools in the phases of both product development, as in the production, so that a target can be set to reduce costs and enhance customer satisfaction.

However, it is important first to diagnose what process needs priority in improvements deployment, helping with the justification for selection of a particular process improvement.

Miguel (2001) addresses some of the tools used in the research: Cause-effect Diagram, Pareto Chart, Control Chart and Check Sheet, addressed as follow:

The cause-effect diagram is a graphical tool that allows you to represent the causes of a problem (effect). According to the Netherlands and Pinto (2009), it can detect a large number of causes for this fact and it can be divided into categories or families. The diagram should suit the situation studied and thus seek to relate what are the real causes and motives.

The Pareto chart is based on Pareto's Law which states that 80% of effects relate to 20% of the causes. Campos (1999), points out that by Pareto analysis can be obtained dividing the method into smaller problems and simple resolution, and assist in establishing concrete goals and achievable.

The Control Chart according to Miguel (2001) consists of a graph whose purpose is to follow process over a period of time, and monitoring under the same as the variations of the calculated control limits and detection of the reasons of its variations.

The check sheet for Aguiar (2002) aims to organize, simplify and optimize keeping the information of the registered data collected and in addition, the sheet can be adjusted depending on the type of information to be obtained from it.

2.4 Performance indicators

To Melnick (2004) *apud* Sellito and Mendes (2006), the performance measurement is a way of connecting the strategy to reality, the fact that the strategy without measurement is useless without measurement, strategy makes no sense. According to Lima (2001) *apud* Costa (2002), the indicators promote a communication link between the performance of certain activities or actions, integrating the results-or measures of the goals set by the strategy. And Rodrigues, Schuch & Pantaleon (2003) also point out that the indicator systems are reasoned to lead actions such business improvement.

According to Carvalho et al. (2005), the indicators are defined in quantitative bases. These indicators are drawn from a logic composition, which evaluate two sets of information: its basic features and components that make up its structure. These indicators should be precisely defined, and be understood by all, and they need to be suitable for the context that are being applied.

3 Methodology

The purpose of this applied research was to identify how the performance management, through indicators, can help micro and small companies to act strategically to achieve their sales targets. On this account, as stated by Carvalho et al. (2005), the role of indicators is to take the thought of objective way to achieve certain results and analyze the situations on an emergency basis.

For the research the following steps were taken:

Determining a target, which would become the indicator; collection of historical sales data for the realization of a demand forecast; identification of the sales pattern of behavior in order to determine the growth projection; preparation of line graphs for study and analysis of demand and projections; implementing spreadsheet, with a check sheet for daily entries, where from these daily data it is possible to are generated line graphs for tracking sales, and comparative chart monitor the achievement of the target set. As well as good indicators for follow-ups of two types of annual targets, divided monthly: one established for the representative by the company, and the other which was established by the own representative.

4 Results and discussion

To increase sales beyond the set targets, there was a study for a representative of an animal nutrition company sought to establish a new strategic means that could boost sales increasing.

In this context, the demand forecast was set for the year 2014 using data from years 2012 and 2013, and after it was applied the percentage increasing that the representative ought to achieve.

To have a more accurate monitoring, and that generates a matter of urgency regarding the implications of these targets, a check sheet was prepared in a spreadsheet, with indicators that were designed to measure the performance and get the comparative goals ranges, both the company representative, as the represented company.

New sales targets and the creation of electronic spreadsheet for monitoring indicators can be identified by analyzing the check sheet and line chart generated by it, days of the week with sales peaks and the presence of gaps, wherein days, most weeks, significant losses in the sales occur. Since those days of high peaks and sales casualties were unknown until then by the representative.

The results obtained in the first quarter in which the study was conducted were satisfactory. Although the new targets were reached in just one month of the quarter, it was found that in the whole study period in 2014 there was a range of more than 65% of the new target set by the company representative and a range of at least 105 % of the goals set by the company represented.

It was possible to observe in the months of January, February and April, that these months exceeded all sales of the same period the years 2012 and 2013. In fact, it is noteworthy that the month of April was the only month in which the new target, the first time, was overcome reaching a range of 116%. Only the month of March has not passed the same month sales in 2013.

5 Conclusions

Thus, concludes with the case study that the establishment of growth targets and follow-up by a performance management system, using indicators, contributed to boost and overcome all the company's goals represented in the first four months of the year 2014, reaching 121%.

Therefore, it has been clearly applied the benefit of using indicators, serving the purpose of directing the organization to set priorities, meet the indexes from them and together generate emergency character to situations and consequently bringing improvement and quality to the processes by means of action plans that are drawn and applied.

6 References

Aguiar, S. (2002) Integração das Ferramentas da Qualidade ao PDCA e ao Programa Seis Sigma. Belo Horizonte: Editora de Desenvolvimento Gerencial.

Calvacanti, M. (2007) Gestão estratégica de negócios: evolução, cenário, diagnóstico e ação. 2.ed. rev. e amp. São Paulo: Thomson Learning.

Campos, V. F. (1999) TQC – Controle da Qualidade Total (no estilo japonês). 8.ed. Belo Horizonte, MG: Editora de Desenvolvimento Gerencial.

Carvalho, M. M de. [et al]. (2005) Gestão da qualidade: teoria e casos - 4ª reimp. Rio de Janeiro: Elsevier.

Costa, E. J. S. C. (2002) Avaliação do desempenho logístico de Cadeias Produtivas Agroindustriais: um Modelo com Base no tempo de ciclo. 182 fl. Dissertação de Mestrado – Programa de Mestrado em Engenharia de Transportes, Universidade Federal do Ceará, Fortaleza, CE.

De Negri, J. A., & Kubota, L. C. (2006). Estrutura e dinâmica do setor de serviços no Brasil. Ipea.

Fernandes. Fabio A.;Sousa Sergio D.; Lopes, Isabel. (2013) In: Proceedings of the World Congress on Engineering 2013 Vol I, WCE 2013, July 3 - 5, 2013, London, U.K.

Fontes, A., & Pero, V. (2009). In: Determinantes do desempenho dos microempreendedores no Brasil. Seminário de Pesquisa, IE/UFRJ. http://www. ie. ufrj. br/datacenterie/pdfs/seminarios/pesquisa/texto0906. pdf. Acess 19 Feb 2015.

Holanda, M. A.; Pinto, A. C. B. R. F. (2009) Utilização do Diagrama de Ishikawa e Brainstorming Para Solução de um Problema de Assertividade de Estoque em uma Indústria da Região Metropolitana de Recife. Anais do XXIX Encontro Nacional de Engenharia de Produção – Salvador, 2009. de Produção – Salvador, 2009. Disponível em: <http://www.abepro.org.br/biblioteca/enegep2009_TN_STO_103_685_13053.pdf> Acess: 13 apr. 2014.

Kaplan, R. S.(1940). Mapas estratégicos - Balanced Scorecard: convertendo ativos intangíveis em resultados tangíveis. 8ª reimp. Rio de Janeiro: Elsevier, 2004.

Ledingham, D., M. Kovac, and H. L. Simon.(2006) The new science of sales force productivity.

Harvard Business. Rev., pp. 124-133 (September).

Miguel, P. A. C. (2001) Qualidade: enfoques e ferramentas. São Paulo: Artliber Editora.

Palisk, G., Pavletic, D. and Sokovic, M. (2007) Quality Tools – Systematic use in process industry - Journal of Achievements in Materials and Manufacturing Engineering, November 25(1), 2007, pp. 79–82.

Rodrigues, L. H., Schuch, C., & Pantaleão, L. H. (2003). Uma abordagem para construção de sistemas de indicadores alinhando a teoria das restrições e o Balanced Scorecard. Encontro da Associação Nacional dos Programas de Pós-Graduação em Administração, 27.

Slack,N; Chambers, S; Johnston, R. (2009) Administração da Produção. 3.ed. São Paulo: Atlas.

Sellito, M.A.; Mendes, L.W. (2006) Avaliação comparativa do desempenho de três cadeias de suprimentos em manufatura. Revista Produção, São Leopoldo, v. 16, n. 3, 2006

Tubino, D. F.. (2007) Planejamento e controle da produção: teoria e prática. São Paulo: Atlas.

World Bank. In: <http://databank.worldbank.org/data/home.aspx#>. Access: 15 apr. 2014.

Metrics for Quality Assessment Systems

Dias, Raquel[1], **Cabral, A. S**[2]

Abstract: The aim of this work was to show a set of quality metrics to control the system quality. This central focus of this proposal is the end user. The success requirements are defined as utility, accessibility and quality indicators during the cycle of system development and cover two most important dimensions in the development process, which is the quality of service and quality of products. The assessment process describes the procedures needed by the auditor to quantify the quality criteria. The method to aggregate measures resulting from criteria assessment is also proposed. The significance of this work is that it constitutes the effort to obtain an instrument to dimension the success of system development process in organizations for assessment and consecution their purposes. In terms of its application in research, this model can be used in measuring system engineering requirements in experimental research.

Keywords: quality control, quality measurement, metrics, system assessment, quality model.

1 Introduction

A program of measures for the management of the area of systems must include three basic parameters: utility, accessibility and quality. These three aspects of the program are supposed to be simultaneously implemented. The information obtained from programs of measures is important for the strategic planning of many companies. Therefore, it exerts some influence on the decision regarding programs for the quality of processes, so as the quantify productivity and total quality.

2 Theoretical background.

In an evaluation process several aspects are observed, such as ease of use of the tool in use to the decision maker. The impact of information linked to the need to resolve the problems, the effect caused by the frequent use of the system, the system value perceived by the user and finally, to verify the effect of non-interruption of consultation (Newell, 1972).

Ahituy (1990) stressed the importance of the existence of relevant information as an aspect to be measured. The processed information circulating should be evaluated in terms of usefulness, quality and quantity. Lancaster, (1996), reported to databases on CD ROM, Jacsó (1992) analyzing the management of data showed that no evaluation information systems should focus on Hardware aspects, System and Dataware as distinct aspects decision-making process. The appearance aesthetic, or the way in which it presents information, also this approach should be observed, as well as the cost.

When users become more demanding, the technology is more complex, and the quality control becomes a critical factor ever. Verifiable evaluation criteria, considering the whole process - from creating requirements for testing - should target the appearance, engineering and services offered to the user. The notice of appearance aims a standardized and consistent product. Regarding the engineering specifications must be accurate and appropriate. For the services offered to the user, quality means fitness for purpose; the main issue is the fulfillment of the users need. To do this, it is important to identify the profile of users. Researches on engineering systems have focused on possible indicators for supporting quality requirements. The quality of products has been the main subject. Engineering requirements can be seen through at least three dimensions. The first relates to the utility of the system, that is, the operation

1 **Dr. Raquel Dias** (raqueldias2006@gmail.com)
2 **Dr. Arnoldo Souza Cabral** (Cabral@ita.br)
Dpto. of Mechanical Engineering - Production.
Technological Institute of Aeronautics, Brazil.

made by the user for information. The second one is related to the facility of access to the information. The last one is the quality, approached in the view of engineering, but also to be approached when considering the content of the information to be obtained.

3 Method and Quality Model: Criteria for Assessment

The model presented in this article is based on three principles that are essential for the assessment of implementation, as well as the explanation of the feedback of the team responsible for the development of a system and its users.

The utility principle is associated with factors determining the level of extension of a system regarding the user's functional needing to be met.

The principle accessibility associated with the factors determining the facility of operation of the system and, therefore, allowing access to the information.

The principle of quality is associated with the level of end-user satisfaction, regarding products and services in the area of Technology information.

When someone is faced with a problem to be solved needs some information about the question, and to do this, in general, it made a search the information through a system, whether automated or not. This step is based on the principle of utility, because the information searched must be useful for solving the problem. In other words, factors associated with the extension of the system are responsible for the fulfillment of the user's necessities.

The first indicator to be considered in order to know about the possibility of finding the requested information, is the extent, or coverage of the procedures already implemented in the system, thus, the base variable for to assess the utility is the extension, or the coverage and functionality of a system.

The second principle to be analyzed is how to get the desired information. This issue is related to the principle of accessibility, i.e. flexibility and ease of use. The third principle - quality- answers the question: How satisfied with the product and the obtained information are the users? It is important consider the level of knowledge about computers and even the level of engagement of the user with the staff responsible for the development of the system. It is also necessary to notice the user's computer skills, including high level commands to generate reports, for instance, strongly influence in the final user's satisfaction.

The search for a simple and level-headed method for the assessment of the impact and usefulness of a system, according to the final user´s conceptions, is really significant for the definition of variables related to the utilization, which, in this case, are facility of use and accessibility. Moreover, they are also linked to the user, seen as utility in relation to contents and quality of the obtained information. All these aspects provide an assessment of how successful an information system has been. (Basili, 2012a, b)

This model can be summarized as shown by this figure 1, below:

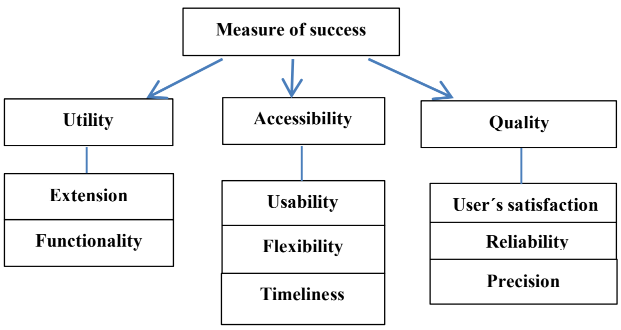


Fig.1
Model of quality system evaluation.

3.1 Focus on the Utility Factor.

The utility principle is associated with the variables: extension and functionalism.
Thus, utility is a result of the arithmetical average of the total score attributed to those variables.

3.1.1 Measuring the Extension

This is about the capability of a system to execute all the routines that are responsible for the functioning of the final user´s operating unit. The item to be assessed is the correlation between procedures executed by the system and the purposes formally described as needing by the user. The factor can be a result of the ration of the amount of automatic routines, which contribute to meet the user´s needing, to the total amount of routines requested by the user.

3.1.2. Measuring the Functionality

The functional quality of the system and the procedures used to develop it constitute the critical group of measures so as to have an adequate functioning of the business operating unity. Each requested service or change in a system application means the existence of a functional deficiency and the necessity to make it up. The requested services will presume different complexities and extensions. each requirement can be scored as a way to measure and give support to the impact those changes will have upon the whole system. Amount of functional corrections can be a result of the ratio of the amount of fulfilled requirements and the amount of requirements made by the user minus the amount of requested corrections.

3.2 The Accessibility Principle.

When an application program is made available to a user, it is supposed to be able to offer you much use. That is why documentation and adequate training should be included in that. Without those items, an application might be undermined in its use. Moreover, those deficiencies would bring about several demands to the help desk and to the staff of support services. Great amounts of calls and doubts may lead to the necessity of some changes in the application system and/or alterations in the documentation as well as further training for the users. An analysis of the requirements may be useful to detect whether interface reengineering will be necessary. Therefore, great amounts of calls may lead to new implementation, consequently, as soon as the amount of calls has dropped, one can conclude that those problems had been caused by a lack of experience and training in the new system. The accessibility is a result of the arithmetical average of the total score attributed to the former variables.

3.2.1 Measuring the Usability Factor.

This variable reassures that the system offers mechanisms to be easily operated by the users. The aspects to be analyzed are (Nielsen, 1993):

- Whether the entries made by the users are minimized by defaults;
- Whether there is any routine that verifies the correction of any data before they are processed;
- Whether it is possible to update the already entered data;
- Whether there are options of data output layout to be chosen by the user;
- Whether data output is standardized and properly identified by headlines;
- Whether there is a help desk;
- Whether the help mechanism brings any troubleshooting guide in which solutions are proposed;
- Whether the procedures described in the manual are sufficient to perform the tasks;
- Whether there is proper material for training the users;
- Whether that material is an approach of the whole system.

This variable is a result of the ratio of the number of available items regarding specifications of human interface to the amount of analyzed items.

3.2.2 Measuring the Flexibility Factor.

It means the adaptability of a system to the settings in which it will be operated and its use in other operational systems, as well as the facility to aggregate/replace/deactivate products. To assess this item, one should check:

- Whether open solutions are used.
- Whether the system is multiplatform.
- Whether it is compatible and adaptable to the settings.
- Whether it is possible to aggregate/replace/deactivate sub products and functions easily.

This variable is a result of the ratio of the total of available items to the total of analyzed items.

3.2.3 Measuring the Timeliness Factor.

Information needed must be available whenever it is requested; otherwise its usefulness would be questionable. Thus, the amount of time necessary for the search and processing of data must be considered. The observation of this factor reassures that the solution presented meets all the user´s needing, taking a high performance into account. One must verify.

- Whether the amount of time needed for an answer is suitable for the user.
- Whether the solution given meets all the user´s needing.
- Whether there is a plan for possible eventualities.
- Whether the system is not interrupted by system troubles.

This factor is a result of the ratio of the total of available items to the total of analyzed items.

3.3 The Quality Principle.

Quality may be a result of the arithmetical average of the total score attributed to factors such as the user´s satisfaction , recovery and precision.

3.3.1 Measuring the User´s Satisfaction.

In order to measure the quality of a system, one must establish efficient criteria, according to how important they are for the user. The indicator of quality demonstrates the efficacy with which the process that has been assessed meets the user´s necessities. In view of that, the best way to have the right criteria in order to measure quality is to know the user´s opinion about products and services and then, search for related indicators.

How to measure the user´s satisfaction? How extensive must be a survey about the user´s satisfaction? Firstly, it should investigate how the users have felt about the products and services they have dealt with. The survey should not intimidate the users, that is, if possible, it should be private and anonymous and offer the user the opportunity to answer the questions honestly. It should also lead to useful answers in order to identify any lack and possibilities for any improvement in the application system. Companies are encouraged to contrat specialized organizations to conduct such surveys.

Statistical criteria must be rigorously used in order to select a sample of users which represent the universe of users and bring about an adequate analysis. Measuring the reliability factor.

Actually, this is a sub factor that reassures whether the system operates properly, for a period of time , in the hardware for which it has been designed. The items to be analyzed are. This factor may be assessed having in mind:

- Whether it is easy to initialize and shut down the system.
- Whether the safety mechanism of access is simple and easy to deal with.
- Whether initialization takes too long.
- Whether the entries on the screen are readable.
- Whether the use of different kinds of fonts and styles improves readability on the screen.
- Whether the screen lay out is clear and easy to visualize.
- Whether the messages on the screen are easy to read.
- Whether the commands and/or objects shown on the screen are easy to Understand.
- Whether all the screens are consistent in function, mouse and keyboard.
- Whether there is a considerable variety of colors and characters.
- Whether the error messages are easy to correct.
- Whether information is always available in the application.
- Whether data is up-to-date enough to be useful.

The satisfaction factor is a result of the ratio of the amount of available items to the amount of analyzed items.

3.3.2 Measuring the Reliability Factor

The reliability factor is a factor that measures whether the system operates properly for a period of time, the hardware for which it was designed. Items to be discussed are:

- Whether the system provides self-protection mechanisms against any unexpected situation.
- Whether there is any routine that checks the correction data.
- Whether data processing is only executed after data validation.

3.3.3 Measuring the Precision Factor.

The best way to measure this factor is to consider the error rate. This should be kept minimal. To analyze this factor, the information should be focused on two aspects: regarding the procedures followed by the system, and the relevance of the information obtained with the process. The accuracy of the system procedures ensures that the system provide a satisfactory level of precision in calculation and results. This factor is a result of the arithmetic average of the following measures: ratio of the amount of processes that are not based on accuracy requirements for the input data processing and output to the total amount of processes.

- Ratio of the amount of processes that are not base on precision requirements
- for the data input, processing and output to the total amount of processes.
- The ratio of the number of algorithms that have not confirmed their accuracy by mathematical analysis for the total number of existing algorithms.
- The ratio of the number of routines that have no confirmation that they meet the accuracy requirements for the total amount of routines.

In relation to the relevance of the information, it is important to notice that precision may vary, according to how the information will be used. Information based on forecasts will not be as accurate as information based on historical facts. Equally, long term estimates may be less precise than short-term ones. Basically, the exactness must be enough to match to each situation. In conventional inference methods, the total absence of information is more acceptable than some imprecise information. In this case, rules regarding IF...AND... SO are based on strict answers such as YES/NO. However, considering fuzzy inferences, when require YES/NO decisions or intermediate values are allowed, precision is not as relevant as it would be, since it is involved in a complex context. Therefore, it is difficult to quantify the effectiveness of some information and make it part of the final decision.

4 Collection of the Measures

The total results must be situated between 0 and 1. The adequacy of a system should result in approximately 1. The collection of the measures is objective and allows the quantification of factors as well as the score collection. Thus, the results obtained from the arithmetical average of the sub factors extension and functionalism constitutes the utility factor. The average of utility, accessibility and quality will determine the level of perfection achieved by the development of the applicative system.(Mendes, 1999).

5 Conclusions

This is a conceptual model for the assessment of the quality of system. The assessment focus is on the end user because this is the key factor in the design of the quality goals of products and services. In order to control quality patterns, it is necessary to have a system engineering staff and much discipline during the development of the system. The quality indicators will lead to an evaluation of the efficiency of the system development. Besides, opportunities of improvement and reduction of costs are other benefits.

The indicators will be situated between 0 and 1, getting near 1 as long as the service or service reaches perfection. The indicators will be situated between 0 and 1, getting near 1 as long as the service or service reaches perfection. The resulting from Evaluating indicators provide insights into the quality of the observed system, and the identification of opportunities for improvement in both the process and the observed product.

6 References

Ahituy, N. (1990) Principles of Information System for Management. 3nd.ed. Dubuque, EUA: WCB, 1990. 653 p.

Basili, Victor R. at al (2012a) The Role and Quality of System Safety. in: the NASA constellation Program. Center for experimental system engineering Maryland, USA. June, 2010.

Basili, V. at al. (2012b) System Quality Modeling Experiences at an Oil Company. ESEM 12, September and Sweden. 2012.

Jacsó, P. CD-ROM (1992) System, Dataware and Hardware: Evaluation, Selection, and Installation. Englewood, CO: Libraries Unlimited, 1992.

Lancaster, F. Wilfrid et a (1996) Evaluation of Interactive Knowledge - Based Systems: Overview and Design for Empirical Testing. Journal of the American Society for Information Science.[S.1.],v.47,n.1p.57-69, 1996.

Mendes, Raquel Dias(1999) Um modelo simplificado para avaliação do nível de utilização de sistemas de informação. UNB, 1999.

Nielsen, Jacob (1993) Usability Engineering. New York: Academic Press, 1993.

Newell, A; Simon, H. A.(1972) Human Problem Solving. Englewood Cliffs, Prentice-Hall, 1972.

Integrated Management Systems: An Exploratory Survey

Trierweiller AC[1], Gisi MFS[2], Spenassato D[3], Bornia AC[4], Peixe BCS[5], Rotta MJR[6]

Abstract: The purpose of this paper is to analyze publications about Integrated Management Systems (IMS) and identify research opportunities. A bibliographic study uses the EndNote to index the articles. We identified features related to IMS based on a systemic analysis. The interest of firms in implementing standards for Quality, Environmental and Occupational Health and Safety, respectively, ISO 9001, ISO 14001 and OHSAS 18001 is increasing, however, managing three separate systems is a challenge. Some of the reasons for implementing IMS include satisfying customers' requirements and responding to government appeals. We identify the most cited authors and articles, barriers and difficulties for implementing IMS.

Keywords: Integrated Management Systems, ISO 9001, ISO 14001, OHSAS 18001.

1 Introduction

According to Rocha et al (2007), over the last two decades, the number of international Management System Standards (MSS) has grown rapidly. Since the introduction of the ISO 9001 Quality standard in 1987, other standards have been developed including that for Environmental Management (ISO 14001), Occupational Health and Safety Assessment Standard (OHSAS 18001), and Corporate Social Responsibility (AA1000). ISO 9001 is a Quality Management System that focuses on operational efficiency and its organization occurs in the form of requirements. Its objective is to increase customer satisfaction by ensuring that products meet their actual needs (Lo et al, 2009).

To reduce the negative environmental impacts and maximize the positive, the EMS based on the ISO 14001 standard establishes a set of responsibilities, practices, procedures, policies, reviews, processes and resources that are required for its implementation. An EMS brings a production process into accordance with an environmental policy, enables the implementation of sustainable processes, reduces costs through better use of natural resources and applies the concepts of cleaner production (Arimura and Akira, 2008).

The Occupational Health and Safety Assessment Standard (OHSAS) is a systematic and proactive way to face the challenges of reducing risks and problems in the workplace. OHSAS 18001 specifies the requirements for a Health and Safety MS through procedures, policies, goals and objectives, planning, identification and monitoring of risk of accidents, seeking compliance with legal requirements (Rocha, 2010, Vinodkumar and Bhasi, 2011). Companies have expressed increasing interest in the integration of MS; however, implementing these standards in parallel requires many duplicate management tasks (Fresner and Engelhardt, 2004).

1 **Andréa Cristina Trierweiller** (andreatri@gmail.com)
2 **Maria Fernanda Sobierajski Gisi** (mfsgisi@gmail.com)
3 **Débora Spenassato** (e-mail: debospenassato@gmail.com)
4 **Antonio Cezar Bornia** (e-mail: cezar.bornia@gmail.com)
Production Engineering Department, UFSC,Trindade,
Florianopolis, SC, Brazil, POBox 476, 88040-900.
5 **Blênio Cezar Severo Peixe** (blenio@ufpr.br)
Accounting Department, Federal University of Paraná,
Avenue Prefeito Lothário Meissner, Jardim Botânico,
Curitiba, Paraná, Brazil, PO Box 476, 88040-900.
6 **Maurício José Ribeiro Rotta** (maurotta@gmail.com)
Program of Post-Graduate Knowledge Engineering and Manager,
Federal University of Santa Catarina, Brazil, Trindade, Florianopolis,
Santa Catarina, Brazil, PO Box 476, 88040-900.

Based on common definitions of Management Standards (MS) the ISO 9001, ISO 14000 and OHSAS 18001 systems are part of an organizational system used to implement their policies and manage their aspects and impacts. Providing elements of a management model in conjunction with other management requirements, since the structures of the management standards are similar and can be combined in a single management model, organized with a basis in the PDCA cycle. That is, continuous improvement is at the core of this methodology (Pombo and Magrini, 2008).

The MS have the following structure in common: (1) Management Policy, (2) Planning (3), Implementation and Operation, (4) Performance Evaluation, (5) Improvement, and (6) critical analysis. Although each MS standard has specific requirements, these six categories can guide the integration of the standards. Abad et al (2014) based on a literature review conducted a study with purpose was to analyse and empirically characterize the integration levels of IMS adopted by Spanish certified firms (ISO 9001, ISO 14001 and OHSAS 18001). They did a review about taxonomies used by several authors with two, three and four level of analysis (Bernardo et al, 2009, Jørgensen, 2008). Abad et al (2014) showed the usefulness of their taxonomic proposal for managers by exploring the relationship between the integration level achieved and subsequent corporate benefits: level 1 (documental harmonization), level 2 (partial integration) and level 3 (full integration). The authors considered the impact of IMS on Internal benefits linked to the firm, and the external benefits, which are oriented to market. Results reveal that significant heterogeneity across integration levels is concentrated in the group of internal benefits, e.g., reduction in bureaucracy, reduction of costs of internal audits. This indicates that managers perceive the IMS as a process that significantly enhances organizational and operational business areas.

Bernardo et al (2012) investigated the difficulties found in the integration process and the level of system integration. They investigated a sample of 362 organizations, at least, to both ISO 9001:2000 and ISO 14001:2004. The organisations with three implemented MS showed difficulties in the integration process that influence the level of integration, while this relationship is not significant for those organisations with two MS. The IMS translates into a significant competitive advantage for organizations that generally have a very competitive market shares characterized by intense competitiveness, constant technological progress, new market requirements, and scarce natural resources (Oliveira, 2013). The challenge of integration is to overcome the grouping of requirements and achieve the mind-set of synergy, this means that a focus on the customer, environment, health, safety and social responsibility must be balanced in order to serve all stakeholders (Jørgensen et al, 2006).

This study used a bibliometric survey that allows the identification of specific research gaps. We analysed publications about IMS and identified opportunities for research according to the following structure: (1) Introduction, (2) Research Method, (3) Results and discussion, and the (4) Conclusions.

2 Research Method

This paper presents literature review using EndNote X7 software to identify, select, and index scientific articles. We conducted our search in six steps (Fig. 1).

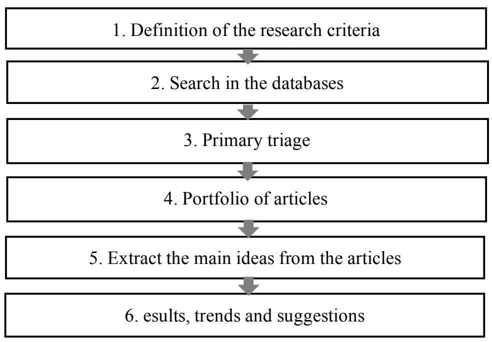


Fig.1
Methodological design of the research and suggestions.

Step 1. Definition of the databases, keywords and dates for the research. We defined the criteria for the research, to analyze the topic "Integrated Management Systems" using the keywords "ISO 14001", "ISO 9001" and "OHSAS 18001". The period was from 2000 until 2014.

Step 2. In the Web of Science we selected the field Topic and entering the terms "ISO 14001", "ISO 9001" and "OHSAS 18001", the period was "2000 to date." In Scopus, terms "ISO 14001", "ISO 9001" and "OHSAS 18001" in the fields Article, Title, Abstract and Keywords. Period "2000 to date", the type of document was Article or Review, and the area Physical Sciences. In the Science Direct, we selected Advanced Search, Journals, and inserted the terms "ISO 14001" and "ISO 9001 AND OHSAS 18001", in Title, Abstract, Keywords and selected Engineering and Environmental Sciences, period "2000 to date".

Step 3. We retrieved 88 articles, but there were books, articles outside the period studied and repeated articles. We conducted a primary triage, 48 articles remained. We read the titles and abstracts and removed articles outside the scope of the search.

Step 4. Portfolio of articles. We retrieved only 21 articles, many of them did not have free access or were unavailable; we read them and extracted the main ideas.

Step 5. We read the articles, integrally.

Step 6. We present some results and suggestions for future research.

3 Results and Discussion

In this topic, we present the result of the analysis made of the articles in the portfolio. We conducted a systemic analysis to identify features of interest related to the topic studied and thus checked in the 21 items in the portfolio, and in some articles cited by the authors of the articles in the portfolio, those elements related to IMS, and identified opportunities for research in this area. We chose this approach to provide greater support for the development of this work.

The most cited article, with eight citations, "Integrated management systems - three different levels of integration" was written by Jørgensen et al (2006) and published in the Journal of Cleaner Production (Table 1). Discuss the different levels of integration of MS (ISO 9001, ISO 14001, OHSAS 18001 and SA 8000), which due to the tendency toward increasing compatibility between systems has stimulated discussions about how to understand the different aspects of integration. The focus of this article is to discuss three levels of integration (1 - compatibility, 2 - coordination, 3 - strategy), which encompasses the increased compatibility of system elements, the coordination of generic processes for insertion of IMS in the learning culture and continuous improvements. The author compares the development of IMS in Denmark and Spain and highlights the need to broaden the focus of the organization to the entire product chain and all the stakeholders.

Table 1
Portfolio of articles.

Authors	Titles
Bamber C.J., Sharp J.M., Castka P.	Third party assessment: the role of the maintenance function in an integrated management system
Celik M.	Establishing an Integrated Process Management System (IPMS) in ship management companies
Izeppe F.R., Oliveira J.O.	Guidelines for the collective and semi-presence-based implementation of certifiable management systems
Jørgensen T.H.	Towards more sustainable management systems: through life cycle management and integration
Jørgensen T.H., Remmen A., Mellado M.D.	Integrated management systems - three different levels of integration
Karapetrovic S., Casadesús M.	Implementing environmental with other standardized management systems: Scope, sequence, time and integration
Maekawa R., Carvalho M.M, Oliveira O.J.	Study on ISO 9001 certification in Brazil: mapping the motivations, benefits, and difficulties
Mendes P., Santos A.C., Nunes L.M., Teixeira M.R.	Evaluating municipal solid waste management performance in regions with strong seasonal variability
Merlin F.K., Pereira V.L.D.V, Pacheco Júnior W.	Sustainable development induction in organizations: a convergence analysis of ISO standards management tools´ parameters
Oliveira O.J.	Guidelines for the integration of certifiable management systems in industrial companies
Pheng L.S., Kwang G.K.	ISO 9001, ISO 14001 AND OHAS 18001 management systems: integration, costs and benefits for construction companies
Pun K.F., Hui I.K.	Integrating the safety dimension into quality management systems: a process model
Qi G., Zeng S., Yin H., Lin H.	ISO and OHSAS certifications How stakeholders affect corporate decisions on sustainability
Qi L., Qingling D., Wei S., Jine Z.	Modeling of Risk Treatment Measurement Model under Four Clusters Standards (ISO 9001,14001,27001,OHSAS 18001)
Salomone R.	IMS:experiences in Italian organizations
Santos G., Mendes F., Barbosa J.	Certification and integration of management systems: the experience of Portuguese small and medium enterprises
Shaw O.	Hot tips for implementing an integrated management system
Singh S.	An integrative approach to management systems and business excellence
Zeng S.X., Shi J.J., Lou G.X.	A synergetic model for implementing an integrated management system: an empirical study in China
Zeng S.X., Tam C.M., Tam V.W.Y.	Integrating Safety, Environmental and Quality Risks for Project Management Using a FMEA Method
Zeng S.X., Tam V.W.Y., Khoa N.L	Towards Effectiveness of IMS for Enterprises

The second most cited article is by Zeng et al (2007), "A synergetic model for implementing an integrated management system: an empirical study in China". It proposes a multi-level synergy model (strategic synergy, organizational structural and cultural -resource synergy, synergy and documentation) for an effective implementation of IMS. The IMS is a symbol of success and a prerequisite for the survival of companies. However, the difficulty is to operate multiple MS in parallel, and seek alignment with the organization's strategy. They concluded that the main problems of the companies that operate parallel MS are complexity and reduced efficiency in management, cultural incompatibility, and increased management costs.

We identified the country of origin of the lead author of each article of the portfolio. There is predominance of authors from China: (1) Zeng SX, (2) Pun KF, (3) Qi G, (4) Qi L. Brazil has the second highest number of articles, with four authors, but each author has only one article: (1) Izeppe FR, (2) Oliveira OJ (3) Merlin FK, and (4) Maekawa R.

We identified many studies in the portfolio that investigated difficulties and benefits of the implementation of IMS, and we present some of them in Table 2.

Table 1
Benefits and difficulties in implementing of IMS.

Authors, benefits and difficulties to implement IMS Heading
Benefits
Zeng et al (2010) - There is a simplification of the certification process, reducing management costs and documents.
Santos, Mendes and Barbosa (2011) - Reduced costs, improved training, easer to comply legislation.
Simon et al (2012) - Increased cohesion, better use of systems, focus on organizational strategy.
Salomone (2008) - Optimization / unification of internal and external audit, reduction of documentation, timesaving, optimization/unification of training activities, reduction of bureaucracy.
Zutshi, Sohal (2005), Rocha, Searcy, Salomone (2008), Asif et al (2010), Khanna, Laroiya, Sharma (2010), Simon et al (2012), Zeng et al (2010) - Decreased costs, operational improvements, better external image, increased customer satisfaction and employee motivation.
Difficulties
Salomone (2008) - Risk of not assigning the appropriate level of importance to each variable: quality, environment, safety, Difficulties in organizing an IMS.
Santos, Mendes and Barbosa (2011) - Insufficient integration of standards, very long time for the process integration, difficulty in the training of staff and in changing the organizational culture.

Operating multiple systems effectively is difficult (Zeng et al, 2007). Zeng et al (2010) affirm that it is challenging to deal with three separate management systems and ensure their alignment with the organization's strategy. According to Oliveira, (2013, p. 124), "Multiple certifiable management systems can function separately. However, they are counterproductive, difficult to manage, and involve employees who invariably question whether they should prioritize the productive processes or the excessive bureaucracy they [the management systems] generate". However, the integration process is complex, according to Jørgensen, et al (2006) the IMS should consider the entire product chain and all the stakeholders increase a company's social and environmental responsibility, thus create competitive advantages for the organization, and contribute to sustainable development.

The certification of the MS ISO 9001, ISO 14001 and OHSAS 18001 represents an important competitive advantage for companies. However, one of the biggest barriers to the implementation of these systems are the high costs. Brazilian researchers, Izeppe and Oliveira (2013), and Pinto et al (2006), suggest that the collective and semi-face-to-face development of these systems –with no active participation of a consultant or specialist in these systems directly at the company – can be one way to reduce these costs.

4 Conclusion

The aim of the study was to analyze publications about Integrated Management Systems and identify research opportunities. We analyzed articles from 2000 to 2014, and identified a tendency to focus on the difficulties and benefits of implementing the IMS. The articles highlighted the importance of strategically positioning the IMS in the organizational context, which is a prerequisite for implementing any MS especially when considering the integration of Quality, Environmental, Occupational Health and Safety standards, confirming the relevance of IMS, which involves all stakeholders.

This literature survey contributed to a better understanding of the academic research related to IMS, as well as identified the need to study further this subject in a strategic perspective. Other approaches could have been explored in the literature survey such as the methodological approaches used by the authors in the portfolio, detailing the types of qualitative and quantitative studies. Limitations of this article include the bibliometric criteria used, i.e. period and key words. This literature survey contributed to a better understanding of the academic research related to Integrated Management Systems, as well as identified the need to study further this subject in a strategic perspective. Other approaches could have been explored in the literature survey such as the methodological approaches used by the authors in the portfolio, detailing the types of qualitative and quantitative studies.

Despite the still incipient research about implementation of IMS in Brazil, there is a limited amount of articles written in English, and thus, with a limited reach, the international and academic literature.

5 References

Abad J, Dalmau I, Vilajosana J (2014) Taxonomic proposal for integration levels of management systems based on empirical evidence and derived corporate benefits, J Clean Prod, 78, 164-173

Arimura TH, Akira H, Hajime K (2008) Is a voluntary approach an effective environmental policy instrument? A case for environmental management systems, J Environ Econ Manag, 55, 281-295

Asif M, Fischer OAM, Joost de Bruijn E, Pagell M (2010) An examination of strategies employed for the integration of management systems, The TQM Journal, 22, 648-69

Bamber C, Sharp J, Hides M (2002) The role of the maintenance organization in an integrated management system, Managerial Auditing Journal, 17, 20-25

Bernardo M, Casadesus M, Karapetrovic S, Heras I (2009) How integrated are environmental, quality and other standardized management systems? An empirical study, J Clean Prod,17 (8), 742-750

Bernardo M, Casadesus M, Karapetrovic S, Heras I, (2012) Do integration difficulties influence management system integration levels? J Clean Prod, 21, 23-33

Celik M (2009) Establishing an integrated process management system (IPMS) in ship management companies, Expert Syst Appl, 36, 8152-8171

Fresner J, Engelhardt G (2004) Experiences with integrated management systems for two small companies in Austria, J Clean Prod, 12, 623-631

Izeppe FR, Oliveira OJ (2013) Guidelines for the collective and semi-presence-based implementation of certifiable management systems, Gestão & Produção, 20, 603-613

Jørgensen, T. H., Remmen, A., Mellado, M. D. (2006) Integrated management systems-three different levels of integration, J Clean Prod, 14, 713-722.

Jørgensen T (2008) Towards more sustainable management systems: through life cycle management and integration, J Clean Prod, 16, 1071-80

Karapetrovic S, Casadesus M (2009) Implementing environmental with other standardized management systems: scope, sequence, time and integration, J Clean Prod, 17, 533-40

Khanna KH, Laroiya SC, Sharma DD (2010) Integrated management systems in Indian manufacturing organizations: some key findings from an empirical study, The TQM Journal, 22, 670-86

Lo CKY, Yeung ACL, Cheng TCE (2009) ISO 9000 and supply chain efficiency: empirical evidence on inventory and account receivable days, International Journal of Production Economics, 118, 367-374

Maekawa R, Carvalho MM de, Oliveira OJ de (2013) Study on ISO 9001 certification in Brazil: mapping the motivations, benefits, and difficulties, Gestão & Produção, 20(4), 763-779

Mendes P, Santos AC, Nunes LM, Teixeira MR (2013) Evaluating municipal solid waste management performance in regions with strong seasonal variability, Ecol Indic, 30, 170-177

Merlin FK, Valle Pereira, VL, Júnior, WP (2012) Sustainable development induction in organizations: a convergence analysis of ISO standards management tools' parameters, Work: A Journal of Prevention, Assessment and Rehabilitation, 41, 2736-2743

Oliveira JO (2013) Guidelines for the integration of certifiable management systems in industrial companies, J Clean Prod, 57,124-133

Pheng LS, Kwang GK (2005) ISO 9001, ISO 14001 and OHSAS 18001 management systems: integration, costs and benefits for construction companies, Architectural Science Review,48, 145-151

Pinto SHB, Carvalho MM., Ho LL (2006) Implementação de programas de qualidade: um survey em empresas de grande porte no Brasil, Gestão & Produção, 13, 191-203

Pombo FR, Magrini A (2008) Panorama de aplicação da norma ISO 14001 no Brasil, Gestão & Produção, 15, 1-10.

Pun, K.F., Hui I. K. (2002) Integrating the safety dimension into quality management systems: a process model, Total Quality Management, 13, 373-391

Qi G, Zeng S, Yin H, Lin H (2013) ISO and OHSAS certifications: How stakeholders affect corporate decisions on sustainability. Management Decision, 51, 1983-2005

Qi L, Qingling D, Wei S, Jine Z (2012) Modelling of Risk Treatment Measurement Model under Four Clusters Standards (ISO 9001, 14001, 27001, OHSAS 18001), Procedia Engineering, 37, 354-358

Rocha M, Searcy C, Karapetrovič S (2007) Integrated sustainable development into existing management systems, Total Quality Management & Business Excellence, 18, 83-92.

Rocha RS (2010) Institutional effects on occupational health and safety management systems, Human Factors and Ergonomics in Manufacturing & Service Industries, 20, 211-225

Salomone R (2008) Integrated management systems: experiences in Italian organizations, J Clean Prod, 16, 1786-806

Santos G, Mendes F, Barbosa J (2011) Certification and integration of management systems: the experience of Portuguese small and medium enterprises, J Clean Prod, 19, 1965-1974.

Simon A, Karapetrovic S, Casadesus M (2012) Evolution of Integrated Management Systems in Spanish firms, J Clean Prod 23, 8-19.

Shaw O (2004) Hot tips for implementing an integrated management system, Engineering Management

Simon A, Bernardo M, Karapetrovič S, Casadesus M (2012) Integration of standardized environmental and quality management systems audits, J Clean Prod

Singh S (2011) An integrative approach to management systems and business excellence, African Journal of Business Management, 5, 1618-1629

Vinodkumar MN, Bhasi M (2011) A study on the impact of management system certification on safety management, Safety Sci, 49, 498-507

Zeng SX, Xie XM, Tam CM, Shen LY (2010) An empirical examination of benefits from implementing integrated management systems(IMS).Total Quality Management & Business Excellence,22,173-86

Zeng S, Shi J, Lou G (2007) A synergetic model for implementing an integrated management system: an empirical study in China. J Clean Prod, 15, 1760-1767

Preliminary study of the processes at the laboratory of the Instituto dos Vinhos do Douro e do Porto

Araújo J[1], Xambre AR[2], Alvelos H[3], Simões JT[4]

Abstract: This study examines the weekly pattern of arrival of samples to a sector of the IVDP laboratory in order to assist the decision making process concerning the scheduling of the required chemical analysis.

Keywords: Quality improvement; ANOVA; Laboratory.

1 Introduction

The Instituto dos Vinhos do Douro e do Porto, I.P. (Douro and Port Wine Institute - IVDP), is the certifying authority of Porto and Douro Wines. Certification is the process of checking the conformity of those products and is also a process of quality assurance based on the principles of objectivity and impartiality.

This paper addresses part of the work that is being developed in the scope of a final project of the Master's Program in Industrial Engineering and Management (MIEM) from the University of Aveiro, Portugal. Its aim is to study the processes, propose improvement actions, implement them and measure their impact in terms of time of response and operating costs of the Laboratory Services of IVDP.

The Laboratory of IVDP is divided into six sectors (Chemistry I, Chemistry II, Gas chromatography, Liquid chromatography, Mineral analysis and Microbiology), according to the type of analyses that need to be performed. These sections have distinct capacities to process the wine samples, resulting in different cadences of progress of the samples' analyses. Additionally, the wine samples are not all subjected to the same set of analyses, since these depend on the objective of the wine submission performed by the client of IVDP (usually a wine producer). Furthermore, in some sectors, samples are grouped before being analysed in order to reduce the unit cost per analysis (use of reagents, gases, electricity and consumables).

As there are a lot of analytical properties of the wines that are being analysed in the six laboratory sections, a particular chemical compound from the Liquid Chromatography section – Ochratoxin A – was selected as an example, in order to describe the methodology followed and the type of results obtained.

1 **João Araújo** (joaoaraujo@ua.pt)
DEGEI – Universidade de Aveiro,
Campus Universitário de Santiago, 3810-193 Aveiro, Portugal.

2 **Ana Raquel Xambre** (raquelx@ua.pt)

3 **Helena Alvelos** (helena.alvelos@ua.pt)
DEGEI / CIDMA – Universidade de Aveiro,
Campus Universitário de Santiago, 3810-193 Aveiro, Portugal.

4 **José Tomás Simões** (tsimoes@ivdp.pt)
Instituto dos Vinhos do Douro e do Porto,
I. P., Rua Ferreira Borges, 27, 4050-253 Porto, Portugal.

2 Objectives

The main objective of this particular study included in the MIEM project, is to understand the pattern of samples' arrivals to the IVDP laboratory sectors, whose work rate is variable, to assist the decision-maker with the scheduling of parameters' analyses. The purpose of this paper is to present an example of the referred study, in order to understand the weekly pattern of wine sample arrivals that require that specific analysis (Ochratoxin A).

3 Methods

Data collection was performed on the software used in the IVDP, which has information regarding all the samples that arrive at the above mentioned sectors. The examined variable was the samples' entry date in the mentioned sectors during the year 2014. The variables were then grouped according to the underlying method (each method corresponds to one or more analytical parameters) and the data were evaluated according to the respective weekly trends. A one-way ANOVA was done in order to study if there are statistical significant different levels of samples' arrivals between the various days of the week and, when appropriate, Tukey tests were used to determine between which means those differences occurred.

4 Results

The example selected for this paper (Ochratoxin A) uses the number of arrivals along 215 days from the year 2014, during which 135 samples came in (Figure 1).

Table 1 depicts the respective ANOVA results that show that there is at least one significant difference between the means of the number of sample arrivals along the week days (F>F crit).

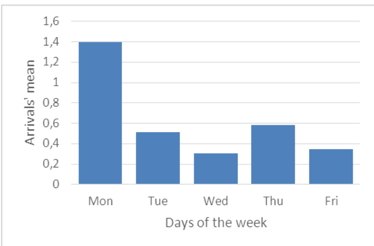


Fig.1
Arrivals of samples to be analysed (Ochratoxin A) per day of week

Variation Source	*df*	*MQ*	*F*	*P value*	*F crit*
Between groups	4	8,48	3,14	0,02	2,41
Within groups	210	2,70			
Total	214				

Table 1
One-way ANOVA results

The Tukey tests show that these differences are between Monday and Wednesday as well as between Monday and Friday.

5 Conclusion

This paper described a small part of the work that is being developed at IVDP, which aim is to help improve the decision-process in what concerns the scheduling of parameters' analyses, taking into account the response time and the daily capacity in terms of number of analyses.

It can then be concluded that the pattern of arrival of samples requiring the Ochratoxin A analysis is not random, with a higher probability of occurring a larger number of arrivals of samples on Monday than on Wednesday or Friday. With this in mind, a more informed decision and a better use of the equipment can be implemented.

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Designing new products and engineering supply chain systems with SoSE

Martín-Rubio I[1], Grau-Olivé JB[2], Andina D[3]

Abstract: The concept of designing smartness of new products and systems from a business perspective has been investigated in operations literature. The problem of understanding, designing, engineering and governing the technologies behind these new products requires new concepts. The emergence of these modern technologies causes a myriad of interconnected systems, which are working together to satisfy the necessities of modern life. Development of System of System Engineering (SoSE) is an attempt by the systems engineering and science community to fulfill this requirement.

Keywords: Product Development, Supply Chain, SoSE.

1 Introduction

The literature has signaled a change in buyer-supplier relations in the context of new product/service development, since, as Chesbrough (2006) explains suppliers' proposals may be equal to or better than those that occur internally in the organization. The main purpose of a System of Systems (SoS) model is to understand a very complex system by studying not only its components, but also the system as a whole.

Design is a systematic process for identifying, exploring and exploiting value opportunities (Lee & Paredis, 2014). Such value opportunities continually can and go, within a global context. There is a constant evolution, due to exogenous influences in the global context, but also due to the participants in the global context introducing new systems and changing the context. In addition, whether a particular company can take advantage of a value opportunity depends also on managing not only its systems engineering capabilities, its ability to generate efficiently and effectively a new system in response to a value opportunity, but also the System of Systems architecture, where all suppliers interact with the manufacture and assembler.

Connected Industry, also called Industry 4.0, offers companies numerous opportunities for new business and improved competitiveness (Kageman et al. 2013). In conjunction with fast data networks and software, sensors on components and machines enable objects to exchange information with one another without the need for human intervention (internet of things). In the future, even objects that up to now have not contained any electronics will be able to communicate with each other.

The emergence of modern technologies caused a myriad of interconnected systems, which are working together to satisfy the necessities of modern life. The problem of understanding, designing, engineering and governing these technologies requires new concepts. Development of Systems of Systems is an attempt by the systems engineering and science community to fulfill this requirement.

1 **Irene Martín-Rubio** (irene.mrubio@upm.es)
Dpto. Ing.de Organización, Admón. de Emp. y Est.,
GASC Research Group ETSIDI, Universidad Politécnica De Madrid.
Ronda de Valencia, 3 28012 Madrid, Spain

2 **Juan B. Grau-Olivé** (j.grau@upm.es)
Dept. Matemática Aplicada Ing. Agronomica.,
GASC Research Group, ETSI Agrónomos,
Universidad Politécnica de Madrid.
Campus de Moncloa, 28040 Madrid, Spain

3 **D. Andina** (d.andina@upm.es)
Depto. Señales, Sistemas y Radiocomunicaciones,
GASC Research Group, ETSI Telecomunicaciones.
Universidad Politécnica de Madrid.
Campus de Moncloa, 28040 Madrid

Our objective is to examine the potential of System of Systems Engineering (SoSE) in Supply Chain Management when designing new products. The main contribution of our study is to analyze the strategic approach of SoSE when leveraging innovation opportunities. SoSE improves organization's supply chain competence. Our findings unfolds as follows: After, briefly review the state-of-art of supply chain management and product development, we consider the SoSE as a methodological approach to consider innovations in complex supply chains architectures. Subsequently, we describe how to construct Connected Industry.

2 Supply Chain Management and Product Development

Relying on the definition of Wang et al. (2008), product innovation in customer-supplier relationships refers to the rate of generating novel and improving products from collaborative inter-organizational relationships. In terms of innovation-performance relationships, the literature offers conflicting results. While some studies show that innovation generation is beneficial for firm performance, others find no relationship or even a negative impact on financial performance (Jean et al. 2013).

Supplier involvement refers to the extent to which a supplier is involved in co-designing and new product development processes with their customers in exchange relationships (Thomas, 2013). Supplier in new product development has been documented as an important factor behind successful innovation through inter-firm cooperation. This is particularly salient in the automotive industry, in which assemblers involve their first-tier suppliers on in the co-design and co-development of product development processes. Literature has identified potential benefits of supplier involvement in a new product, for both manufacturers and their suppliers. Knowledge and intellectual property are at the core of the competence of the firm (Tekic et al. 2014). Firms may use certain knowledge protection processes, such as patents, trademarks and trade secrets, to protect their IP. In addition, knowledge protection can codify each party's rights, duties, obligations, and responsibilities, as well as specifying goals, by creating forma operating procedures that require communication and knowledge sharing. While prior work has suggested that knowledge protection may be detrimental to product innovation because it hinders knowledge sharing (Nielsen and Nielsen, 2009), Jean et al. (2013) confirm that knowledge protection can help innovation generation in emerging markets, by providing and effective platform for knowledge sharing within the process of inter-firm innovation. Thus, firms that employ appropriate knowledge protection may gain a competitive advantage in inter-firm innovation (Zhang et al. 2009, Subroto and Sivakumar, 2011).

2.1 Concurrent Product Development and System of Systems Engineering

In product development, existences of industrial wastes are inevitable and it would be wise to minimize as much as possible in order to obtain sound profit. Some of the most common wastes are over processing, transportation, motion, inventory, waiting time, defect, overproduction and etc. Most of them are time and process dependent and that are expressed in terms of additional costs, time, rework, defect rate and etc. Great approaches (like lean, JIT, TQM, concurrent engineering, six sigma, etc.) have been proposed for the last few decades in order to tackle such challenge. In the light of concurrent engineering, there are activities that could be executed in parallel while developing a new product.

The major step is identifying the processes or activities that can be done sequentially and in parallel. Individual systems, activities or steps can be designed as the overall processes have been designed.

Recently all types of business concepts as New Product Development have become under extreme pressure to provide products to the client/customer quicker than ever before. With such an extreme pressure being applied to respond, companies that provide product services and products can no longer afford to survive to perform work in a sequential manner. According to Martin et al. (1998), one way of breaking down these barriers and improving communication and teamwork among functional groups is by using Concurrent Engineering (CE) methodologies.

A product development process with more cost/budget allocated or invested before design comes up with a reduction of total cost by almost half. In addition, the total time for developing a product is improved by 17%.

System of Systems (SoS) are large scale concurrent and distributed systems that are composed of complex systems (Kotov, 1997). The System of Systems concept originally evolved in the defense sector, but now it being widely applied in various fields of space exploration, healthcare, logistics, software integration, etc. The emerging SoS concept describes the large-scale integration of many independent, self-contained systems in order to satisfy a global need. Each system affects the other.

The synthesis of the individual complex systems into a larger SoS results in additional complexity and challenges to keep the system working. A supply network chain is made up of various entities and nodes in the chain which are working together to achieve one single task, which is providing the final consumer the required product or service. The optimization of one part of the chain doesn't necessarily provide and optimised supply chain. The various entities have to be considered together from the perspectives of the interdependencies and the dependency on time to achieve the desired output and thus assure the flow (Ghadge et al. 2010).

During the product development process, change may happen in any stages and the ultimate cost required may vary accordingly (Port et al. 1990). As the changes go later, the total cost will go higher and that affects the profit and time to market. Andersen (2014), presented that by the time a product is designed 80% of the cost, by the time a product goes into production 95% of its cost is determined, so it will be unmanageable to remove cost at that late a date. Belay et al. (2012) in their model of system dynamics consider 80% of the cost committed before the design state.

Traditionally, the product development process was finalized prior to the start of the production development. This results in a lengthy time to market, especially when the production system is not able to produce the designed product. These two development stages are therefore currently often executed in parallel, so called concurrent engineering. In the development of complex products and production systems, concurrent engineering methodology has been claimed not only to reduce time to market for products, but also to increase efficiency in the management of non-SoS complex systems. The network model of a concurrent engineering process can be thought of as a bi-directional link between the product development system and the production development system. Furthermore, the development process for both the product and production can in their own right be considered as densely populated networks. Therefore, these networks can be seen as a bi-directional interaction of two networks (Jamshidi, 2008).

The primary difficulty in the assessment process is the complexity associated with large-scale Systems of Systems and the integrated nature of models required to study complex phenomena. Many techniques exist for resource allocation, an approach based on modelling and simulation is usually required to quantify technology potential with respect to System of Systems level Measures of Effectiveness (MoEs). The modelling and simulation environment relies on a linked suite of variable fidelity models that calculate the impact of technologies across a System of Systems hierarchy. Similar to any other evolving practices, SoS Engineering (SoSE) needs concepts, methodologies, methods, and tools to engineer and design SoS.

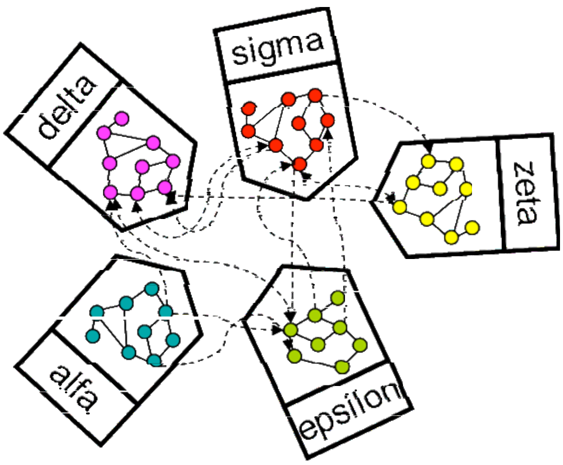

Fig.1
Methodological illustration of SoSE.
Production and Product Development of different components interact with the assembler requirements.

Ge et al. 2014, proposed a novel executable modelling approach for System of System architecture. This methodology provides more flexibility and adaptability for the automated construction of executable models directly from the architectural data rather than from static models. Based on initial values, the optimal design increases product performance from different parameters. The optimal investment plan considers different budgets, components and resources through simulations at each SoSE level. A dynamic resource allocation problem is proposed for developing improved designs.

3 Discussion

As information science and technology continues to evolve, the paradigm of SoSE has emerged as a popular choice for being an economic and strategic approach for enhancing existing system capabilities and developing new capabilities to address challenging systems engineering and management problems in the military, academia, industry, and elsewhere (Hipel et al. 2007).

Optimal design products consider components and resources through simulations from the level o products to the inter-organizational service capability level. It is not just an approach to product development. SoSE consider the limits of available technology and manage the risks in the interaction among different components and suppliers.

Connected industry, also called Industry 4.0, offers companies numerous opportunities for new business and improved productivity. SoSE enable the high flexibility that Industry 4.0 promotes in production that makes customized products possible in cost-effective mass-production. Smart products know the details of how they were manufactured and how they are intended to be used. Martin-Rubio et al. 2015, show that business process could be even more distributed since smart meters, in energy industry, may trigger an external internet service which will go advance the process itself.

4 Conclusion

This paper studies the dynamic behaviour of the complex system of the product development process while applying Concurrent Engineering in SoSE approach. SoSE approach is used as it helps to visualize and it is based on its capability to incorporate several subsystems and parameters. From the model and simulation, valuable findings are noted. When it is changed the cost fraction before and after design with the same amount, the total cost of the systems varies significantly at different stages of the development processes. This variation indicates that there are some hidden costs that need to be optimized systematically, for instance doing some activities in parallel or overlap each other.

5 References

Anderson DM (2014) Design for Manufacturability: How to use Concurrent Engineering to rapidly develop low-cost, high-quality Products for Lean Production.
CRC Press, Boca Raton-Florida

Belay AM, HeloP, Welo T (2012) System of Systems thinking in product development: A System Dynamic Approach. Proc. of the 2012 7th Intern. Conference on System of Systems Engineerig, Genoa, Italy, 16-19 July: 549-555

Chesbrough H (2006) Open business models. how to thrive in the new innovation landscape. Harvard Business School Publishing, Boston

Eskandarpour M, DEjax P, Miemcyk J, Péton O (2015) Sustainable supply chain network design: an optimization-oriented review. Omega 54:11-32

Ghadge A, Dani S, Kalawsky R (2010) A framework for managing risks in the aerospace supply chain using systems thinking. 5th Intern. Conference on System of Systems Engineering

Ge B, Hipel KW, Yan K, Chen Y (2014) A novel executable modeling approach for System-of-System Architecture. IEEE Systems Journal, 8(1):4-13

Haskins, C. (2010) Systems Engineering Handbook: A Guide for Systems Life Cycle Processes and Activities.
Sand Diego, CA: INCOSE

Jamshidi M (Ed) (2008) Systems of Systems Engineering. Principles and applications. CRC Press, Boca Raton-Florida

Jean RJB, Sincovics R R, Cavusgil ST (2010) Enhancing international customer-supplier relationships through IT resources: A study of Taiwanese electronics suppliers. J Int Busi St (JIBS) 41:1218-1239

Kageman H, Washler W, Helbig J (2013) Recommendations for implementing the strategic initiative INDUSTRIE 4.0. Forchungsunion, German National Academy of Science and Engineering. Federal Ministry of Education and Research. Frankfurt

Kotov V (1997) Systems of Systems as communicating structures. Hewlett Packard Computer Systems Laboratory, Paper HPL-97-124, pp. 1-15

Lee BD, Paredis CJJ (2014) A conceptual framework for Value-Driven Design and Systems Engineeering. 24th CIRP Design Conf 21: 10-17Martin-Rubio I, Florence A, Jiménez A, Andina D (2015) From Smart Grid to Business Intelligence, a Challenge for Bioinspired Systems. IWINAC Conference, Elche 2-5 June

Nielsen BB, Nielsen, S (2009) Encouraging innovation in business relationships-a research note. J Aca Mark Sci 34 (1): 63-73

Peterson B, Pedersen T, Lyles M.A. (2008) Closing knowledge gaps in foreign markets. J It Busi St (JIBS) 39: 920-937

Port, Otis, Zachary Schiller, King R. (1990) A smarter way to manufacture: How "Concurrent Engineering" can reinvigorate American Industry. Business Week, April, 20: 110-117

Subroto R, Sivakumar K (2011) Managing intellectual property in global outsourcing for innovation generation. J Prodt Innov Mgt 28(1):48-62

Tekic Z, Drazic M., Kukoloj D, Vitas M. (2014) From patent data to Business Intelligence –PSALM Case Studies. 24th DAAAM Int Symp Intelligent Manufacturing and Automation, 2013

Thomas E (2013) Supplier integration in new product development: Computer mediated communication, knowledge exchange and buyer performance. Ind Mk Mgt 42:890-899

Wang Q, Bardford K, Xu J, Weitz, B, (2008) Creativity in buyer-seller relationships: The role of governance. Int J Res Mark 25(2):109-118

Zhang, Ch., Henke JW; JR, Griffith, D.A. (2009) "Do buyer cooperative actions matter under relational stress? Evidence from Japanese and U.S. Assemblers in the U.S. Automotive industry". J Oper Mgt 27(6):479-494

KNOWLEDGE AND PROJECT MANAGEMENT

An application of the Innovation Radar in a micro and small companies in the Campinas Metropolitan Region

Piasentine LC[1], Ayres F L[2], Serra PMM[3], Moura EC[4], Assis L[5]

An application of the Innovation Radar in a micro and small companies in the Campinas Metropolitan Region

Abstract: The article's goals were to identify the business innovation degree present at five small companies in the Campinas city. Sawhney, Wolcott and Arroniz (2006) developed a model called the Innovation Radar, which has related about twelve dimensions: (1) Offer, (2) Platform, (3) Brand, (4) Customers, (5) Solutions, (6) Relationship, (7) Aggregation of Value, (8) Processes, (9) Organization, (10) Supply Chain, (11) Presence and (12) Network. Besides the prior mentioned dimensions the authors decided to include another one, which is the (13) Innovative Ambience, defined by the authors Bachmann e Destafani (2008) in order to aggregate more value to the authors research. The methodology used to collect and consolidate the dates was made through a questionnaire, that enable the researches applied the Innovation Radar and then to discuss the obtained results. The obtained results showed that the innovation processes in the studied organizations was not a structured and systematic set of actions.

Keywords: innovation, process innovation, radar of innovation.

1 Introduction

The organizations to face the challenges and changes that are determinate by the changing nature of markets, seek to respond or be ahead of this scenario of competitiveness and, consequently, the companies moves to develop alternatives, which positioned them differently to its competitors. The paradigm of the competition for the future challenges is associated with both the speed of change of the environment as well as in the easy to operationalize the internal changes to the necessary adjustments in relation to these demands and, thus, reinforce the leadership reinvention, which has a significant influence in this changing process (PRAHALAD and HAMEL, 2005). It is understood that one of the alternatives that support to break paradigms present to the business and associated with competitiveness of complex markets, have their reflexes in driving innovation management in these organizations. Schumpeter (1988) establishes that technological innovation is the engine that drives the capitalist economy and acts as the mainstay of the regional development of a country. Specifically, the micro and small enterprises play a great role in economic growth-competitive countries and should be consider the fact that the way in which these organizations are able to disseminate innovation. That capacity is expected by their expected behavioural characteristics that generate benefits in relation to large corporations, such as greater flexibility and capacity to adapt forward markets extremely volatile (LA ROVERE, 1999). Among the technological regions of Brazil, Campinas stands out to be one of the most important technological poles

1 **Camila Piasentine Lopes** (camilla.piasentine@gmail.com)
Bel. Business Administration
2 **Luiz de Freitas Ayres** (luiz.ayres@mackenzie.br)
3 **Márcia Milena Pivatto Serra** (marcia.serra@mackenzie.br)
4 **Luciano de Assis** (Luciano.assis@mackenzie.br)
Universidade Presbiteriana Mackenzie (UPM – CCSA)
Campinas - Brasil, CEP13073-148.
5 **Cassia Ercolin de Moura** (cassiaercolin@gmail.com)
Universidade Metodista de Piracicaba (UNIMEP)
Sta Bárbara do Oeste - Brasil, CEP 13.400-911

in the Southern Hemisphere. Its importance is proved by the number of patents registered abroad, by the concentration of a number of institutions for research and development, universities and technology parks, as well as the responsibility for the generation of 5.9% of Gross Domestic Product (GDP) of the country. The metropolitan region of Campinas has approximately 15 000 industries, 50 thousand companies services and 60,000 commercial enterprises (UNICAMP, 2014). In view of the foregoing, the present article seeks to measure and describe the degree of innovation in five micro and small businesses in the Metropolitan Region of Campinas, in order to understand how the management of innovation is understood and carried out by them.

2 Methodology:

In order to evaluate the degree of innovation of the companies studied was employed the Model of Radar of Innovation, which in the present article, had a change promoted by the authors, to better meet the needs of research. This model was developed by Sawhney, Wolcott and Arroniz (2006), being used in academic studies, in addition to its use in a systematic way by Brazilian Service of Support to Micro and Small Businesses (SEBRAE, 2014). The diagnostic tool has twelve dimensions: (1) Offer (2) Platform (3) Brand (4) Customers (5) Solutions (6) Relationship (7) Aggregation of Value, (8) Processes, (9) Organization (10) Supply Chain (11) Presence and (12) Network. In addition to twelve dimensions former mentioned, earlier the authors included another one, that is Innovative Ambience (13), defined by Bachmann e Destafani (2008). The Radar dimensions are defined and explained in the Table I.

Table I
Innovation Radar Dimensions and their definitions.
Source: Elaborated by the authors.

Radar Dimensions	Definitions
Offer	Creation of new products and services valued by customers
Plataform	Use of common technologies for creating diversity of products and improvements in the manufacturing process
Brand	Use or brand extension for which customers can capture the values of the company
Customers	Ability and capacity to serve new markets and the unmet needs of customers of existing markets
Solutions	Personification and paying for products and services in order to solve customers' problems, as well as meet new needs or market niches
Relationship	Perception of the buying experience of their customers
Aggregation of Value	Mechanisms for the recovery of the value created and captured by the customer in order to obtain new sources of revenue unexplored by action
Processes	Processes redesign for increased efficiency
Organization	Improvements in the structure and scope of the company
Supply Chain	Agility in information flow, supply chain fast and flexible, change in its architecture logistics, whereas suppliers and partners
Presence	New forms of marketing at points of sale or the creation other concepts of distribution for the company
Network	Improvements in communication between the companies, their customers and partners
Innovative Ambience	Environment conducive to innovation and people based, third-party organizations, knowledge of suppliers and customers, deployment of processes of creation

The Model of Radar of Innovation is a data collection instrument, consisting of a questionnaire, available and authorized for use by the SEBRAE in this research, with structured questions adherents to the dimensions of the radar. This questionnaire has 42 questions, which sustain the 12 dimensions of innovation observed by Sawhney, Wolcott and Arroniz (2006) and a one more dimension, which was introduced by the authors and sustained by the approach used by Bachmann and Destefani (2008). Each one of the dimensions of radar was evaluated by means of a Likert scale, thus consisting of: (5) when the variable is systematic or common, (3) when the variable is present occasionally and (1) when the variable is not present or is non-existent. For the consolidation of the dimensions of radar were interviewed managers and workers at different levels of the companies as follows: Offer(5), Plataform, Brand, Customers, Solutions, Relationship and Aggregation of Value (2), Process (6), Organization (4), Supply Chain (1), Presence and Network (1or 2), Innovative Ambience (8). The data obtained by the answers of the respondents were consolidated for the descriptive statistical analysis, by the system Statistical Package for Social Sciences (SPSS) and Excel. That approach make it possible consolidated the information, enabling the comparison of the average of the different axes dimensions existing on the radar screen. In a second step was performed an inferential statistical analysis, and for this study, was used the non-parametric method by Kruskal-Wallis test with a significance level of 5 %. The justification for the use of the non-parametric test was because the sample was small and its distribution was not a normal curve.

2.1 Analyzed Companies:

The research project prioritized only five companies in this initial phase, and will be expanded to more companies in a next phase. The description of the companies analysed are listed below:

Company A: It operates in the education sector, a non-profit organization, founded in 1963, which aims to promote and encourage cultural relations between Brazil and the United States. In this way, it offers courses in English, American literature, didactic material and preparatory courses. Currently the organization is fit as small business and has around 50 employees.

Company B: It was founded in 2010 it is a microenterprise in the services sector, with approximately 20 employees and has as a main result a software developed for electronic invoices for all the national territory.

Company C: This company acts in the trade sector, it is a microenterprise, which yields furniture and decoration, where in addition to sell their items of decor and furnishings, it manufacture the own parts. Its was founded in the year 2007 and currently has 5 employees.

Company D: It was founded in 2007 it is specialized in auto parts for imported cars, working directly with workshops of luxury cars, and have a portal e-commerce, which fits the Brazil as a whole. The company currently has 4 employees.

Company E: The company E provides solutions to its customers in Web apps, Mobile apps and Games. Its main products are for companies that are looking for partnerships in the development of applications, both for the internet page as for the mobile phone and mobile platforms. The company currently has 12 employees and it fits a small business.

3 Obtained Results:

The Figure I bellow shows the distribution of the different dimensions of the Radar of Innovation for the five companies surveyed.

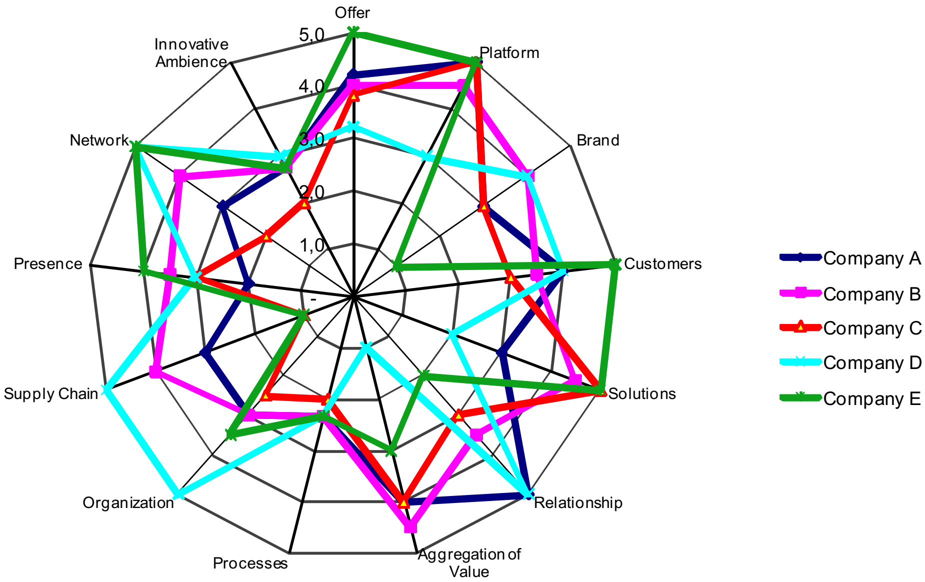

Fig.I
Measurement of the degree of innovation of enterprises at the Radar dimensions.
Source: Elaborated by the authors.

Based on the analysis of the Figure I was observed the marked variability of the geometry of the radar for the analyzed companies in relation to the dimensions on the radar screen, which shows special features and differences in the innovation process of each one of them. The ideal situation would be for all the dimensions of radar were at a same level simultaneously and, as can be seen, there is a broad range of actions, with possibilities of being improved and enacting, not only to bring about all the dimensions to the desired levels, but also actions to keep those dimensions that are with the score at the upper limit.

It is perceived that the dimension guidance to customers, the company E was the only one to obtain maximum score (5) and company B, which also operates in the same segment, had a score lower than (3.5). What usually occurs with technology companies is that they offer-shelf products already existing and in them, try to adapt the demands of our customers. That variation could be justified by the distinct business segments of activity of firms analyzed. The average of the degree of innovation of each dimensions of radar was calculated and then it could be possible to identify the dimensions, which have a greater and lesser degree, with the possibility to create a ranking between them, as indicated by Table II.

Table II
Value Average for each dimensions of the Innovation Radar.
Source: Elaborated by the authors.

Ranking of Radar Dimensions	Dimensions	Average of Innovation Degree
1° Position	Platform	4,5
2° Position	Offer	4,0
3° Position	Solutions	3,9
4° Position	Customers	3,9
5° Position	Relationship	3,7
6° Position	Network	3,6
7° Position	Organization	3,4
8° Position	Aggregation of Value	3,3
9° Position	Presence	3,1
10° Position	Brand	3,0
11° Position	Supply Chain	2,8
12° Position	Innovative Ambience	2,7
13° Position	Processes	2,3

The results showed in the Table II pointed out that the enterprises are concerned strongly to use technologies employed to disposal and creating products that add value and solutions associated with the products that are made available to customers. This fact is corroborated by the higher average dimensions of Platform (4.5) and Offer (4.0) which were obtained by the dimensions scores of the Radar of Innovation in the organizations surveyed. One of the possible analysis of these higher values can be explained when the enterprises use physical resources, technology and knowledge in order to produce a new product or to develop a new generation of them. It is important to highlight that all the enterprises added a kind of service to their products, which could aggregate value to the customers and serve not only to a product but also to a family of products. Besides that mentioned actions the same product was offered in most versions, to reach new markets or groups of consumers. It was observed still, that the examined companies had new products released in less than three years, or products that have been removed from the market by the failure that they had, which reflects the high degree of flexibility of these companies. In addition, a series of changes on the characteristics of products takes in consideration the environmental issues in their designs, by changes in aesthetics, in the drawing of the product, by the use of new materials or technologies radically new, contemplating these modifications in the period of the last three years. The higher degree obtained by the average of these dimensions in the studied companies, demonstrate that they have the understanding of the importance of generating something new, that they have an impact on better results for the organization, for the prosperity of the business and to increase their competitiveness. Attention should be given too, at the last three dimensions of Radar of Innovation of the ranking observed in the Table II, in particular for the supply chain, the innovative ambience and the management of processes present in organizations. Hypotheses must be raised about the low value of the average of these dimensions and in such a way, that there is not yet a concern of managers of such companies establish a tight partnership with their suppliers. The strategic partnership with the suppliers, Universities and other enterprises could improve the capacity of developing and strengthening a high aggregate value with these actors, and so, obtain a promise of contributions to be promoted by them, mainly in the process of innovation of these companies. The design of organizational processes and, in particular, the process of managing the innovation, is not yet understood as being a critical success factor, which makes it erratic, not systemized and contributes to the perception that the innovation is not due to a robust and continued process. This situation opens a huge arena to be exploited by the enterprises owners, in order to establish a competent management of the innovation's process of their companies. The fact that these enterprises belongs a family members, there are a strong influence promoted by them during the exercise of their leadership, which concentrate the decision-making power on them. Usually, this contributed to produce a strong influence on a negative way in the creation of a favourable environment for innovation, which must permeate all levels of the organization.

The Innovative Ambience (2.7) with the score obtained also spells out the gaps present in the use of external sources of knowledge, which could be obtained through partnerships with universities, customers and suppliers, support entities, attendance at conferences, seminars and customers. These actions promote the generation of knowledge and its exchange would allow the acquisition of rights for technical information, developing expertise and skills external and internal, which confirms the low score by degree of Supply Chain dimension (2.8). For this reason, it is possible to observe that these companies do not seek a managerial way in a holistic vision and synchronized actions in order to promote a favourable environment for innovation (TIDD et al. 2008). It is also perceived that these organizations tend to prioritize the vision inside the companies, as also do not tend to identify best practices in the market in order to exploit them, imitate them or even improve them as a form to obtain competitive advantage, as placed by Tidd et al. (2008). The visions of the authors listed above, underline the importance of both, internal and external environment to the generation of new ideas, and more, to help the organizations to break paradigms in order to create levels of innovations more effective and differentiated. In addition, to the data obtained by the dimensions analyzed, it was possible to accomplish also, a comparison of companies by their degree of general innovation, demonstrated by the Pareto's Diagram indicated by the Figure II.

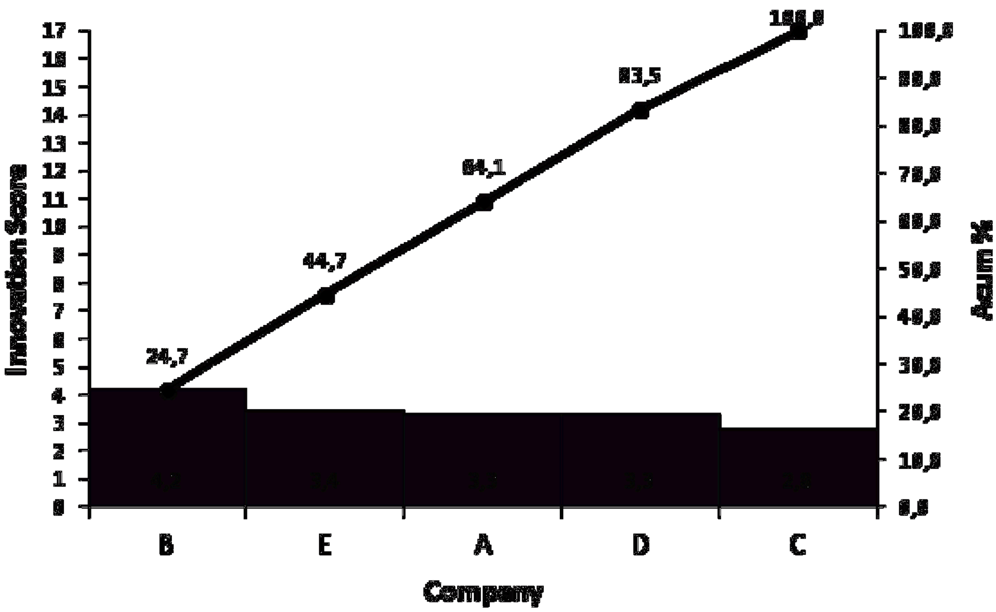

Fig.II
Innovation Score of the studied enterprises.
Source: Elaborated by the authors.

The interpretation of the Pareto's Diagram realizes that company B and E achieved a higher score on the degree of innovation and the company C, the lowest index. It should be noted that the companies B and E act on technology segment and company C in trade, which in principle could explain the score obtained by them. The interpretation of the dimensions of the radar must take into account that they are interdependent and any change in one of the dimensions resonates at different intensity in others. The inferential statistical analysis used in this article was the non-parametric method by Kruskal-Wallis test by means of an assessment performed with a significance level of 5 %. The choice of the non-parametric test was due to the fact that the sample is small and the distribution is not normal. After the test run, we obtained the following value for the p (value) = 0.021 and, therefore, lower than the value of 5% of significance. This result implies the existence of differences between the averages of the different dimensions of radar, rejecting the null hypothesis, that all the averages would be equal, as shown in Table III.

Table III
TesteKruskal – Wallis: p value.
Source: Elaborated by the authors.

Table III - TesteKruskal - Wallis: p value

Test Statistics[a, b]

	Value
Chi-Square	23, 948
df	12
Asymp. Sig.	0, 021

Source: Elaborated by the authors

The value of p (value) = 0.021 reinforces the existence of differences between the mean dimensions of the Radar of Innovation, which allow its used in future researches.

4 Conclusions

It was observed that the dimensions with a higher average of the Innovation Radar were the Platform (4.5) and Offer (4.0). In this way, it can be concluded that the companies studied have greater focus on the use of common technologies, which help them in launching products that add value to your customers. These companies in a certain way perceive the importance of innovation in aspect of competitiveness either to assure their maintenance or perpetuation in their actuation markets. In this way, the generation of something new, or actions to improve the products are effective at everyday actions in these companies. On the other hand, the dimensions of Supply Chain (2.8), Innovative Ambience (2.7) and Process (2.3) had lower degrees of score in the companies analyzed. It is clear that the management of the innovation process, it is not understood yet in a systematic way, not encouraging the environment for the generation of challenging ideas and not allowing the effective both participation of the employees and the supply chain on it. This lack of understanding and organizational synchronicity restricts the prospecting of new arenas to enlarge the competitive field of companies studied. Restricts the participation of persons within and at the same time reduces the participation and the exchange of knowledge with the external environment of these companies. One of the relevant aspects is the barrier built by the owners, inhibiting the effective participation of the people in the generation of new ideas. The model of the Radar Innovation proved to be important to measure the degree of innovation of the companies and the authors recommend that it is could more widely used and refined, so that it can be developed with the aim of better assess the degree of innovation of enterprises.

References

BACHMANN & ASSOCIADOS. Metodologia para estimar o grau de inovação nas MPE. Curitiba: 2008.

LA ROVERE, R. L. “Difusão de tecnologias da informação em pequenas e médias empresas: um estudo de caso”. Revista Brasileira de Economia, vol. 53, n. 1, 1999.

PRAHALAD, C.K; HAMEL, G. Competindo para o Futuro. Rio de Janeiro: Elsevier, 2005

SAWHNEY, M.; WOLCOTT, R. C.; ARRONIZ, I. The 12 Different Ways for Companies to Innovate. MIT Sloan Management Review, v.47, n.3, p.75-81, 2006.

SCHUMPETER, Joseph A. Teoria do desenvolvimento econômico; uma investigação sobre lucros, capital, credito, juro e o ciclo econômico. 3.ed. São Paulo: Nova Cultural, 1988.

SEBRAE. Serviço Brasileiro de Apoio às Micro e Pequenas Empresas. Disponível em: <www.sebrae.com.br>. Acesso em:10 de Setembro de 2014.

UNICAMP Universidade Estadual de Campinas. Disponível em: <http://www.unicamp.br/unicamp/content/regi%C3%A3o metropolitana-de-campinas>. Acesso em: 10 de Novembro de 2014.

Multicriteria Model for the Management and Maintenance of Critical Assets

Gómez A[1], Carnero M C[2]

Abstract: This paper describes an innovative multicriteria model built by integrating Markov chains and the multicriteria technique *Measuring Attractiveness by a Categorical Based Evaluation Technique* (MACBETH) for asset management in a health centre. In this case study, the model assesses decision making in the choice of optimal maintenance policies for critical care facilities such as those that treat contagious patients with hepatitis B and C. The model gives the most appropriate maintenance policies to apply and the possibility of taking further action such as including redundancy in equipment and facilities. The results are that corrective and preventive maintenance policies, together with two backup machines, is the ideal alternative in subsystems used for dialysis in contagious patients with hepatitis B and C.

Keywords: Maintenance; Healthcare Organization; MACBETH; Markov Chains.

1 Introduction

In healthcare organizations technologically complex equipment and facilities are found alongside conventional machines and apparatus; furthermore, the direct interaction between healthcare equipment and patients means that the technical services of healthcare organizations work with the goals of availability, safety and quality of the service provided, much more than other organizations.

The influence of medical technologies on diagnostic capacity and the treatment of patients is well known, as are the significant consequences for patient safety; nonetheless, the great importance of the maintenance of these technologies and apparatus is not generally recognised (Guelbenzu and Dueñas, 1990), as they are considered a support service rather than an integral part of medical treatments.

The choice of maintenance policy is a complex decision which should take into account strategic questions that tie in with strategic maintenance and so, through the business strategy, with technical matter related to, for example, the failure modes of machines. It is, therefore a decision that requires deep reflexion as it is necessary to consider a variety of quantitative and qualitative criteria, which justifies the use of multicriteria techniques.

This paper sets out an innovative multicriteria model built by integrating Markov chains for reparable systems and the technique Measuring Attractiveness by a Categorical Based Evaluation Technique (MACBETH) to perform optimal decision-making in the management of critical assets in the subsystem of dialysis for infectious patients with hepatitis B and C. The fact that the model provides the best combination of maintenance policies to apply, rather than a single option, and it also assesses the possibility of taking further action such as including redundancies in equipment and facilities, is especially relevant.

Section 2 gives an introduction to Markov chains for repairable systems as applied to the subsystems analysed. Section 3 describes the multicriteria model. Section 4 gives the results obtained. Section 5 sets out the conclusions, section 6 the acknowledgements and section 7 the references.

1 **Andrés Gómez Blanco** (andresg@sescam.org)
SESCAM. Hospital General Universitario de Ciudad Real.
C/ Obispo Rafael Torija s/n, 13005 Ciudad Real, Spain.

2 **María Carmen Carnero Moya** (carmen.carnero@uclm.es)
ETS Ingenieros Industriales. Universidad de Castilla-La Mancha.
Avda. Camilo José Cela s/n, 13071 Ciudad Real, Spain.

2 Markov Chains for Repairable Systems

Reliability $R(t)$, unreliability $F(t)$ and maintainability $M(t)$ are defined based on equation (2.1) (Creus, 2005), where λ is the failure rate and μ is the repair rate.

$$R(t) = \int_{t_1}^{\infty} \lambda e^{-\lambda t} dt = e^{-\lambda t} \Rightarrow F(t) = 1 - e^{-\lambda t} ; M(t) = 1 - e^{-\mu\, t} \qquad (2.1)$$

The equivalent of the unreliability or probability of change of state in *Δt* is defined as $P_{ij}(\Delta t)\ \forall j = (i+1....n)$. Each element of the matrix shows the repair starting from state k, determined by the equation (2.2) (Hillier et al., 2002).

$$p_{ii}(\Delta t) = 1 - \left\{ \sum_{j=i+1}^{m} p_{ij}(\Delta t) + \sum_{j=1}^{i-1} p_{ij}(\Delta t) \right\} \qquad (2.2)$$

Substituting equations (2.1) in (2.2) and rearranging is obtained the final non-homogeneous system of equations is shown in matrix form in equation (2.3) (Hillier et al., 2002).

$$\begin{pmatrix} P_0' \\ P_1' \\ . \\ . \\ P_{m-1}' \\ P_m' \end{pmatrix} = \begin{pmatrix} -\sum_{j=1}^{m} \lambda oj & \mu_{1,0} & . & . & \mu_{m-1,0} & \mu_{m,0} \\ \lambda_{0,1} & -(\sum_{j=2}^{m} \lambda 1j + \mu_{1,0}) & \mu_{2,1} & . & . & \mu_{m,1} \\ . & . & . & . & . & . \\ . & . & . & . & . & . \\ \lambda_{0,m-1} & \lambda_{1,m-1} & . & . & -(\lambda n-1, m + \sum_{j=0}^{m-2} \mu n-1, j) & \mu_{m,m-1} \\ \lambda_{0,m} & \lambda_{1,m} & . & . & \lambda_{m-1,m} & -\sum_{j=0}^{m-1} \mu n, j \end{pmatrix} \begin{pmatrix} P_0 \\ P_1 \\ . \\ . \\ P_{m-1} \\ P_m \end{pmatrix} \quad (2.3)$$

The subsystem for dialysis of infectious hepatitis B and C patients consists of a dialysis machine for each patient treatment area, with a total of three areas.

λ_1, λ_2, μ_1 and μ_2 are defined as the failure and repair rates of each monitor with the presence of a maintenance technician or by notification to the official repair service, respectively.

Two alternatives are considered for improving availability; adding one or two reserve dialysis machines to the set, with the workload proportionally distributed, and with the same operating conditions as the others. D_{0m}, D_{1m} and D_{2m} are defined as the availabilities in the case of there being no, one or two reserve machines, respectively. It is considered that, once repaired, they are in perfect working order with a useful working life that is the same for each of them. The resulting Markov graph is shown in Figure 1, where the 0 state is associated with the normal working of the system, with all the machines operating; state 1 with failure of the first machine; state 2 with failure of a second machine and state 3 with the failure of the third machine. The resulting transition matrix is shown in equation (2.4).

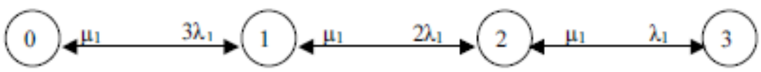

Fig.1
Markov graph for the subsystem of dialysis
for infectious hepatitis B patients.

$$\begin{pmatrix} -3\lambda_1 & \mu_1 & 0 & 0 \\ 3\lambda_1 & -2\lambda_1-\mu_1 & \mu_1 & 0 \\ 0 & 2\lambda_1 & -\lambda_1-\mu_1 & \mu_1 \\ 1 & 1 & 1 & 1 \end{pmatrix} \quad (2.4)$$

Mean availabilities are calculated from the Weibull distribution associated with the behaviour of the failures in mechanical and electromechanical components.

Mean availabilities for the original subsystem and for each of the proposed alternatives for improvement are: $D_{0m}=C_0$; $D_{1m}=C_0+C_1$ and $D_{2m}=C_0+C_1+C_2$; where C_i are the coefficients obtained by resolving this series of equations, for each alternative.

The subsystem for dialysis of infectious hepatitis C patients comprises five treatment areas, with one machine per area. λ_1, λ_2, μ_1 and μ_2 are defined as the failure and repair rates of each monitor where a technician is present, or by notification to the official repair service, respectively. Two possibilities for the improvement of availability are considered, which involve adding one or two reserve machines to those available, with the same working conditions as the others. D_{0m}, D_{1m} and D_{2m} are defined as the availabilities in the case of there being no, one or two reserve machines, respectively. It is assumed that, once repaired, they are in perfect working order with the same useful working life as the rest of the machines. The resulting Markov graph is shown in Figure 2, where the 0 state is associated with the normal working of the system, with all the machines operating; state 1 with failure of the first machine; state 2 with failure of a second machine and state 3 with the failure of the third machine and so on up to state 5. Now the transmission matrix corresponding to the Markov graph is obtained (see equation (2.5)).

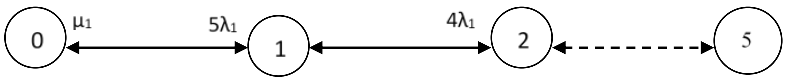

Fig.2
Markov graph for the subsystem of dialysis for infectious hepatitis C patients.

$$\begin{pmatrix} -5\lambda_1 & \mu_1 & . & 0 & 0 \\ 5\lambda_1 & -4\lambda_1-\mu_1 & . & 0 & 0 \\ . & . & . & . & . \\ 0 & 0 & . & -\lambda_1-\mu_1 & \mu_1 \\ 1 & 1 & . & 1 & 1 \end{pmatrix} \quad (2.5)$$

Mean availabilities for the original subsystem and for each of the proposed alternatives for improvement are: $D_{0m}=C_0$; $D_{1m}=C_0+C_1$ and $D_{2m}=C_0+C_1+C_2$; where C_i is the coefficient obtained by solving the above system of equations, for each action.

3 Multicriteria Model for Optimum Decision Making in Critical Asset Management

MACBETH (*Measuring Attractiveness by a Categorical Based Evaluation Technique*) (Bana e Costa and Vasnick, 1999) builds a cardinal scale of the alternatives, based on the information provided by the decision centre, for each pair of criteria submitted for judgement, so that this information is a group of attractiveness differences between the two stimuli. MACBETH has been applied in a number of real cases: Bana e Costa et al. (2008), Mateus et al. (2008), Bana e Costa et al. (2012) and Méndez (2014).

3.1 Criteria, Indicators and Weighting Process

The hierarchical structure of the decision model is shown in Figure 3. Each criterion uses an indicator with an associated scale, wherein the normal and good reference standards necessary for applying the model MACBETH have been identified (Bana e Costa et al., 2008).

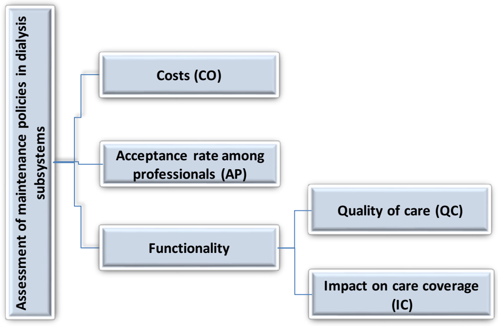

Fig.3
Hierarchical structure.

The following criteria were used:

- Costs (CO). This criterion considers the annual repayment costs of equipment purchase, infrastructure, introduction and setting up, including labour and materials, as well as maintenance. In this case, the annual costs of maintenance, including labour and materials, are considered. Corrective maintenance has a maximum response time of 24 hours from the official repair service, and is immediate if there is an in-house repair team. For the hepatitis B subsystem, €12,000 is considered a good level and €14,000 is the neutral value. For the hepatitis C subsystem, €18,000 is the good level while €20,000 is the neutral level.

- Acceptance rate among professionals (AP). This criterion considers the degree of satisfaction among those professionals responsible for maintenance. The scale levels of the associated indicator range from very good, where the professional feels confident of the diagnoses of the breakdowns analysed, and can programme the appropriate maintenance response jointly with the other subsystems involved, to very poor, where the professional does not feel any confidence in the diagnoses of the breakdowns analysed, and the corrective action in the subsystem must be carried out immediately.

- Quality of care (QC). This criterion takes into account the impact on the patient, bearing in mind the time that the subsystem is down, by considering mean availability. Impact levels range from good, where the mean availability of the subsystem is greater than 0.9990, to poor, which is held to be a mean availability for the subsystem of less than 0.9960, where a stoppage of the subsystem might occur.

- Impact on care coverage (IC). This indicator assesses the capacity of the subsystem to cover the various dialysis needs that patients may have. The scale levels used go from the highest level, in which the subsystem can carry out dialysis sessions on patients from other health areas, up to an increase of one hundred percent over the normal capacity during normal working hours, to the lowest level, where the subsystem has no capacity to carry out dialysis sessions on patients not included in the normal programme.

To obtain the weightings of the criteria in each area the following procedure is applied. Firstly, the possibility of an alternative that is at the neutral level in all the criteria and indicators is considered. The extent to which a change from the neutral level to the good level in each indicator would increase the preference for this alternative is assessed, using the semantic categories of MACBETH. This gives an ordering of the indicators as a decision matrix. Next a comparison is made between how preferable a change from the neutral level to the good level is in the first indicator with respect to the change from the neutral level to the good level in the second indicator. The comparison is repeated between the first indicator and the third, and so on. The process continues by rows, completing the decision matrix (Bana e Costa et al., 2012). Equation (3.1) shows the decision matrix using the pairwise comparison scales of the MACBETH method. The weightings W_i of the criteria obtained are: $W_{QC} = 44.44; W_{IC} = 33.33; W_{CO} = 16.67; W_{AP} = 5.56.$ A similar process has been used to obtain the matrix for the scale levels of each indicator.

$$\begin{array}{cc} & \begin{array}{cccc} \mathrm{QC} & \mathrm{IC} & \mathrm{CO} & \mathrm{AP} \end{array} \\ \begin{array}{c} \mathrm{QC} \\ \mathrm{IC} \\ \mathrm{CO} \\ AP \end{array} & \begin{pmatrix} 0 & \mathrm{weak} & \mathrm{moderate-strong} & \mathrm{strong} \\ & 0 & \mathrm{moderate-strong} & \mathrm{moderate-strong} \\ & & 0 & \mathrm{weak} \\ & & & 0 \end{pmatrix} \end{array} \quad (3.1)$$

3.2 Alternatives

The following alternatives for both dialysis subsystems are considered:

- Corrective and preventive maintenance with a technician present in every shift (Alt 1).
- Corrective and preventive maintenance plus a reserve machine (Alt 2). This alternative includes the first, but also gives the opportunity to substitute a monitor for the one which is not working, with a changeover time estimated as nil.
- Corrective and preventive maintenance with two backup machines (Alt 3). In this case, the maintenance is carried out by contract with the Authorized Repair Service, not present at the hospital, with full cover.

Mean availability obtained by each alternative under consideration is shown in Table 1. Similarly, it was necessary to assess the impact of each alternative on each criterion.

Table 1
Mean availability of each subsystem for each alternative.

Alternatives	Alt 1	Alt 2	Alt 3
Dialysis of infectious hepatitis C patients	0.9832	0.9998	1
Dialysis of infectious hepatitis B patients	0.9899	0.9999	1

4 Results

The results obtained are that having corrective and preventive maintenance policies with two backup machines is ideal (see Table 2) (Gómez, 2013).

In the case of the subsystem dialysis of infectious hepatitis B patients, currently corrective maintenance and preventive maintenance are being applied, with a technician present during each shift. This alternative gives an availability of 0.9899, while the multicriteria model selects an alternative which would allow an availability of 1 (Alt 3), although it would involve an increase in total annual cost of €3,000.

In the case of the subsystem dialysis of infectious hepatitis C patients, currently corrective maintenance and preventive maintenance are being applied, with a technician present during each shift. This alternative gives an availability of 0.9832, while the multicriteria model gives an alternative with an availability of 1 (Alt 3), at the same time reducing the costs by €1,950 a year.

In both subsystems, it should be borne in mind that the selected alternative (Alt 3) allows a number of patients to be attended who need urgent treatment at any time; this would mean that the care service could be offered entirely on the premises. If alternative Alt 3 is not chosen, part of the care service would have to be carried out off-site, with the consequent increase in costs.

Table 2
Preference level for each action in each subsystem.

Alternatives	Alt 1	Alt 2	Alt 3
Dialysis of infectious hepatitis B patients	57.86	84.97	96.19
Dialysis of infectious hepatitis C patients	26.42	49.73	80.00

5 Conclusions

The innovative multicriteria model described allows optimal decision-making in the management of critical assets by health care organizations. The model uses Markov chains for repairable systems, together with the MACBETH multicriteria technique, giving the best combination of maintenance policies. This model facilitates objective decision-making, based on mathematical methodologies in an environment where decisions have traditionally been based on experience. The results obtained in this case study, applied to subsystems of dialysis for infectious patients with hepatitis B and C, show how new alternatives in the management of critical assets have a decisive influence not only on maintenance costs, but also on availability, and so on the quality of healthcare.

6 Acknowledgements

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7 References

Almeida AT, Bohoris AT (1995) Decision theory in maintenance decision making, Journal of Quality in Maintenance Engineering 1(1):39-45

Bana e Costa CA, Vansnick JC (1999) The MACBETH approach: basic ideas, software and an application. In: Meskens, N., Roubens, M (eds.), Advances in Decision Analysis. Kluwer Academic Publishers, Dordrecht

Bana e Costa CA., Carnero MC, Duarte M (2012) A multi-criteria model for auditing a Predictive Maintenance Programme, Eur J Oper Res 217:381-393

Bana e Costa CA, Oliveira CS, Vieira V (2008) Priorization of bridges and tunnels in earthquake risk mitigation using multicriteria decision analysis: Application to Lisbon. Omega-Int J Manage S 36:442-450

Creus A (2005) Fiabilidad y Seguridad. Marcombo, Barcelona.

Gómez A (2013) Metodología para la optimización de la gestión y del mantenimiento de activos en un centro sanitario, Thesis, University of Castilla-La Mancha

Guelbenzu FJ, Dueñas PL (1990) Organización del mantenimiento en centro sanitarios, Instituto nacional de la Salud, Madrid

Hillier F, Lieberman G (2002) Investigación de operaciones, McGraw-Hill, México

Mateus R, Ferreira JA, Carreira J (2008) Multicriteria decision analysis (MCDA): Central Porto high-speed railway station. Eur J Oper Res 187:1-18

Méndez P, M'Zali B, Lang P, Pérez-Gladish B (2014) Measurement of U.S. Equity Mutual Funds' Environmental Responsibility Attractiveness for an Individual Investor, Open Journal of Business and Management, doi: 10.4236/ojbm.2014.22012

Inovation Management in a Public Service Company

Mena G[1], Gonzalez G[2], Olmo M[3], Maeso E[4]

Abstract: This paper focuses on the analysis of organizational factors and management practices that favor an efficient technological innovation in public sector companies of services. The aim is to show whether the factors determining of successful innovation identified in the literature are fulfilled in these businesses. We analyze how these factors are attended in a company chosen object of study justified by its excellence in its sector. This analysis allows us to advance in the design of management patterns of innovation applicable to this type of companies.

Keywords: Technological Innovation, Innovation Management, Transport, Case Study.

1 Introduction

The economic environment has changed drastically in the last years due mainly to the revolution brought about by information technology and communication and, in general, by the rise of knowledge-based economy or one that depends on knowledge, information and the high-level training.

The development in advanced economies has led to significant progress in the study of innovation; however it has focused primarily in the industrial sector. The growth of services in global economies cannot be ignored and simply assume that follows the same patterns and processes in the industrial sector (Miles, 2005). Moreover, innovation, itself, has been led by the private sector; in fact, most of the research on innovation refers to it. There is a significant knowledge gap regarding the public sector, where quality research is quite limited. A key question would be how transferable are the interpretations, perspectives and approaches (Mulgan and Albury, 2003). The innovation management includes management of R&D but also managing the launch of new products and the study of the success or failure (Escorsa and Valls, 2003). Since the mid-twentieth century, many authors have attempted to empirically identify key factors associated with successful management of innovation (Freeman 1982; Cooper, 1979; Quinn, 1986; Fernandez and Fernandez, 1988; Compain, 1990; Rothwell, 1992 Tidd *et al.*, 1997; Benavides, 1998; Gurteen, 1998; McAdam and McClelland, 2002; Barañano, 2005; Suarez *et al.*, 2007). All these authors agree that the success or failure is not determined by a single factor, since no tool or form of business management alone achieves the ideal environment to encourage and support innovation. Although the different factors that promote innovation in business, organizational type are the most influential (Naranjo *et al.*, 2012).

In this context, given the importance of innovation and management for companies and public sector services is considered interesting to deeply deal with the key factors for successful management of innovation in these businesses in particular. The case of a public service company with high innovative activity in which we study how attended factors are and management practices identified in the literature are analyzed.

1 **Gema Mena Tirado** (cgtransporte@uma.es)
2 **Guadalupe González Sánchez** (ggonzalez@uma.es)
3 **Ma Isabel Olmo Sánchez** (m.olmo@uma.es)
Cátedra de Gestión del Transporte. Universidad de Málaga.
Estación de Autobuses, Pso. de los Tilos s/n, 29006 Málaga
4 **Elvira Maeso González** (emaeso@uma.es)
Dpto. Economía y Administración de empresas. Escuela de Ingenierías.
Universidad de Málaga. C/ Dr. Ortiz Ramos s/n, 29071 Málaga

2 Literature Review

Innovation processes differ greatly by sector of activity concerned. In the services sector in which it innovates by introducing progressive continuum changes in products and processes, the distinction between the two types of innovation is not clear, since the production and consumption occur simultaneously. According Howells and Tether (2004) services can be classified in four groups: those relating primarily to property (such as transport and logistics), linked to information (such as customer service centers), based on knowledge and on persons (eg healthcare). Although it is necessary to consider this diversity you can, however, identify general characteristics applicable to majority of services. This is a sector that has traditionally been considered delayed in the the field of innovation, and a good example of this is that the first analysis of its role in innovation does not appear until the 80s (Camacho and Rodriguez, 2005). So Gershuny and Miles (1983) were pioneer in note the potential of ICTs to improve the cost and quality of services, to be based largely on the information. Although traditionally this sector has been dominated by technology suppliers. The growing recognition of the importance of innovation in the service sector and the contribution of this sector to economic growth has led to different studies have been made on this subject (Jong *et al.*, 2003; Hauknes, 1998; Howells and Tether, 2004; Miles, 2005; Lopez *et al.*, 2011). Although it was not until 1990 when the first attempts to establish some kind of pattern, giving as taxonomies result of innovation in the tertiary sector (Soete and Miozzo, 1990 arose; Evangelista and Savona, 1998; Evangelista, 2000; Gallouj and Weinstein, 1997; Gallouj and Gallouj, 2000; Gallouj, 2002 a, b). Also, the third edition of the Oslo Manual (2005) includes specific aspects of innovation in the services sector.

The benefits of innovation in the public services are many. Their successful innovation depends on developing better ways to meet needs, solve problems, increase responsiveness to local and individual needs, keep up with the needs and public expectations and efficiently use resources and technologies (Mulgan and Albury, 2003). Although innovation is often seen as a luxury option or an additional burden, it should be seen as an essential activity. However, there is a shortage of high quality research on innovation processes in non-market sectors. As shown in the Oslo Manual (2005), there is much work to be done in the study of innovation and the development of a framework for data collection innovation in the public sector. Therefore, as mentioned Salazar and Holbrook (2004), improvements in the public sector are expected to be greater in the near future.

3 Methodology

In methodology technique called “content analysis” is used, a systematic and reproducible literature review on a particular issue, to find out where and how research efforts are focused and to discover research gaps or opportunities. The words used for the search are: key factors in innovation, management innovation, innovation in business services and innovation in the public sector. Journals that represent the state of art of the selected topic, as well as books and other documents of interest were selected. Then the key factors of innovation management are identified. We choose to follow the taxonomy given by Hidalgo *et al*. (2008), to be one of the most accepted, which classifies the factors that characterize the innovation process into external and internal. External factors are associated with the sector to which the company belongs, the institutional context that surrounds it and the characteristics of the economic policy that affects it. While internal factors are the result of actions of the company and depend on the ability of management to consolidate the dimensions of quality and productivity (short term) and the ability to create, at lower cost and faster than competitors, technologies, skills and essential skills to generate innovative products or services (long term). These key factors identified will be examined in the company under study (Table 1).

Table 1
Internal Key Factors in innovation management.
Source: Author's own, from Hidalgo *et al.*, 2008

Human Factor	1. Develop creativity and curiosity about the unknown
	2. Enhance teamwork
	3. Develop a specific style of management based on leadership, motivation and commitment to the development of human capital of the company
Organizational Factor	4. Implement procedures to identify opportunities
	5. Being open to cooperation with other organizations/participation in networks
	6. Implement processes of planning and control and indicators to measure technological innovation
	7. Apply techniques of innovation management
	8. Integrate technological innovation at the functional level
Business – Market Factors	9. Accept risk
	10. Pay special emphasis on meeting customer needs and involve in the process of developing the product or service (market orientation)

For our study we have chosen Malaga Transport Company (EMT) for being a leading company in its sector for its innovation nationally and internationally. Data collection company has been conducted through interviews with the managers and analysis of internal company documentation. This allows to understand the manner and degree of implementation of the key factors identified allowing us to compare their level of kindness and efficiency.

4 Case of the Malaga Transport Company (EMT)

The Malaga Transport Company is a public company founded in 1984. Since 1991 major technological innovations are made with a clear commitment to customer orientation, as improved schedules and frequencies, modernization of the fleet and the incorporation of cleaner fuels, which has been granted a national and international recognition in its sector. In addition, EMT has been honored with numerous awards, highlighting the Gold Seal for Excellence in Public Administration, awarded by the State Agency for the Evaluation of Public Policies and Quality of Services AEVAL (2010).

5 Results

Now, we study whether the innovation management key factors are present in the company case study and in what form.

1. Develop creativity and curiosity about the unknown. To reach a creative idea generation atmosphere, the EMT process begins from above, ie from the direction that promotes the involvement and participation of staff in improvement activities of the company.

2. Enhance teamwork. The EMT consider that the main capital of the organization is the people who are as stated in its Strategic Plan. Its strategy is to improve the capacity for teamwork. So, working and improvement groups are created to operate with established objectives and are dissolved when they reach their achievement.

3. Develop a specific style of management based on leadership, motivation and commitment to the development of human capital of the company. The direction of EMT care specifically that there is an effective communication system. Communication needs are identified in the EMT through a policy of “open doors” which ensures that managers are accessible and facilitates communication “everybody”, maintaining a suggestion box, and by analyzing nonconformities cause of miscommunication.

Regard to internal communication, EMT has several means which serve as an information portal. Internal network or “Intranet” and the external network or “Employee Portal”. The continuing increase of the number of hits on both networks demonstrate that it is an element of consultation and disclosure of important knowledge. To strengthen external communication, has established an ongoing dialogue with shareholders of the company, primarily those with more influence as the city of Malaga (weekly meetings), users (regular satisfaction surveys and through web) and partners (according to the needs of the projects).

4. Implement procedures to identify opportunities. This is to give the company a technological surveillance system to pay attention to market trends and competitor behavior in order to identify opportunities. Currently, the monitoring process of EMT based on attendance at conferences and fairs, participation in technical seminars, reading technical magazines, etc. It is sufficient, however, the implementation of a technological surveillance system according to the UNE 166006 would be recommended in the event that a substantial increase in the information to be treated should occur.

5. Being open to cooperation with other organizations through participation in networks. The EMT develops and manages innovative projects establishing external partnerships through temporary agreements. Stand into partnerships with technology providers, with financial institutions and other agencies and administrations (University of Málaga, Malaga City Council and the Junta de Andalucía). Of all the associations of the transport sector which is linked to the EMT, it can highlight its relationship with ATUC and UITP. His performance is not limited to belong to them as members, but to be in the main organs of management and administration. Today, in addition to finding a strategic ally in these organisms have in mind the growing need to establish relationships between universities and companies. Since, universities serve society for the creation, development and transmission of science, technology and culture. And the companies realize the need to innovate and due to the lack of funds seeking new sources of research in universities. The EMT aware of this reality is linked to the University of Malaga in 2004 constituting the Department of Transport Management aimed analysis, research and teaching of reality, the problems and prospects of transport. In this respect, communication between the department and EMT contribute to the generation of ideas and proposals, and is flexible and informal, according to the needs of different projects.

6. Implement processes of planning and control and indicators to measure technological innovation. Regarding the existence of planning and project management innovation, although the EMT has not implemented a management system R&D&i constitution according to the UNE 166002 would be feasible because it meets most the requirements of the standard, failing to specify the control that the company has to perform the R&D&i that runs every foreign company with which signed cooperation agreements for most of the innovative activity.

7. Apply techniques of innovation management. The EMT adopts these techniques through a strategy of improvement based on continuous training and adapted to all levels of technical knowledge management, human resources, process improvement, etc.

8. Integrate technological innovation at the functional level. Although the EMT has a functionally departmentalized organizational model boasts a flexibility in its operations, a climate and coordination mechanisms that approaches a flattering administrative adhocracy innovation. The direction of the company encourages innovations arising from any department and according to the project is decided on which it falls leadership.

9. Accept risk. The assumption of risk and management support projects seen as they are driven from the address itself, with interdisciplinary teams, where risks are analyzed, evaluated and corresponding contingency plans are designed.

10. Pay special emphasis on meeting customer needs and involve in the process of developing the product or service (market orientation). The external orientation of the EMT is observed in their approach towards the user and citizen, explicit in their strategic values, and promoting the interaction of leaders EMT with customers, partners and other stakeholders in the innovation process (Table 2).

Table 2
Leader Relationship Matrix.
Fuente: EMTSAM, 2011

INTEREST GROUP	PERSONS / ORGANIZATIONS INVOLVED	LEADERS INVOLVED	ASSOCIATED ACTIVITIES
Customers	Citizens	Management	Surveys, interviews and client
	Users	Management Committee	Committee
Community	Neighborhood and	Management	Focus Group
	disabled associations	Management Committee	Interviews
	Consumer organizations		Delphi
	Schools	Management	views
		Management Committee	Open Days
Society		Department heads	EDUCATIONAL BUS
	University of Malaga	Department heads	University practices
	Business Schools	Managers and executives	Lectures and presentations
	Media	Management	Community Information, news,articles

6 Conclusions

The study of influential innovation in enterprises has been discussed by many authors and from different points of view but particularly has focused on the analysis of industrial companies variables. However, as has been verified during the review of the literature, is reaching more and more booming research on innovation given the growth of these and their contribution to the global economy services sector. The current economic situation is making special attention to the effectiveness of innovation in general in all sectors and particularly in the public sector as to increase its efficiency is provided.

The analysis of the degree of development of the key internal factors for the success in innovation management in the case of the Malaga Transport Company shows that most of them are clearly present. It would be advisable to sample a greater number of public companies engaged in the provision of different services, highlighted in each sector, on the degree of innovation and continue accumulating knowledge which would allow us to advance in the study of patterns of innovation to follow in public service companies.

7 References

Benavides CA (1998) Tecnología, innovación y empresa. 1ª edición, Pirámide, Madrid.

Camacho JA, Rodríguez M (2005) How Innovative are Services? An Empirical Analysis for Spain.The Services Industries Journal 25, 253-271.

Compain G (1990) Las reglas de la gestión de la innovación tecnológica. En: Escorsa, P. (Ed.), La Gestión de la empresa de alta tecnología. Ariel.Barcelona. pp. 105.

Cooper RG (1979) The dimensions of industrial new product success and failure. Journal of Marketing 43, 93-103.

EMTSAM (2011) Documentación interna de la EMT. Empresa Malagueña de Transportes, Sociedad Anónima Municipal. Inédita. Málaga.

Escorsa P, Valls J (2003) Tecnología e Innovación en la Empresa. Edicions UPC. Barcelona.

Evangelista R, Savona M (1998) .Patterns of innovation in services. The result of the Italian innovation survey. Paper in VIII Annual RESER Conference. Berlin, 9-10 October

Fernández E, Fernández Z (1998) Manual de dirección estratégica de la tecnología. La producción como ventaja competitiva. Ariel. Barcelona.

Freeman C (1982) The economics of industrial innovation. 2nd edition, Frances Pinter, London.

Gallouj F (2000) Beyond technological innovation: trajectories and varieties of services innovation. En: M. Boden e I. Miles (eds), Services, Innovation and the knowledge Economy. Continuum, London, pp. 129-145.

Gallouj F (2002a) Innovation in services and the attendant old and new myths. The Journal of Socio-Economics 31, 137–54.

Gallouj F (2002b) Innovation in the Service Economy. The New Wealth of the Nations.Edward Elgar, Cheltenham.

Gallouj C, Gallouj F (2000) Neo-Schumpeterian perspectives on innovation in services.En: M. Boden e I. Miles (eds), Services and the Knowledge-based Economy, Continuum, London, pp. 137–54.

Gallouj F, Weinstein O (1997) Innovation in services, Research Policy 26, 21–30.

Gershuny J, Miles I (1983) The new service economy: The transformation of employment in industrial societies. F. Pinter, London.

Gurteen D (1998) Knowledge, creativity and innovation. Journal of Knowledge Management 2, 5-13.

Hauknes J (1998) Services in Innovation, Innovation in Services. Synthesis report nr.1 of the SI4S programme. Brussels, European Commission, TSER.

Hidalgo A, Vizán A, Torres M (2008) Los factores clave de la innovación tecnológica: claves de la competitividad empresarial. Dirección y Organización 36, 5-22.

Howells JRL, Tether BS (2004) Innovation in Services: Issues at Stake and Trends – A report for the European Commission, INNO-Studies 2001: Lot 3 (ENTR-C/2001), Brussels.

Jong JPJ, Bruins A, Dolfsma W, Meijaard J (2003) Innovation in service firms explored: what, how and why? EIM Business and Policy Research, EIM Business & Policy Research, SMEs and Entrepreneurship, Netherlands Ministry of Economic.Affairs: 1-73.

López MC, Serrano AM, Gómez R (2011) Patrones de innovación en las empresas hosteleras: el caso español, Cuadernos de Gestión 11, 59-74.

McAdam R, McClelland J (2002) Sources of new product ideas and creativity practices in the UK textile industry,Technovation 22, 113-121.

Miles I (2005) Innovation in Services. En Fagerberg, J.; Mowery, D.C. y Nelson, R.R. (Eds.), The Oxford Handbook of Innovation. Oxford University Press. Oxford. UK.

Mulgan G, Albury D (2003) Innovation in the Public Sector, London: UK Government, the Strategy Unit in Cabinet Office. Draft discusión paper, ver 1.9.

Naranjo J, Jiménez D, Sanz R (2012) ¿Es la cultura organizativa un determinante de la innovación en la empresa?, Cuadernos de Economía y Dirección de la Empresa 15, 63-72.

OCDE y EUROSTAT (2005) Manual de Oslo: Guía para la recogida e interpretación de datos sobre innovación. 3ª edición, OCDE y EUROSTAT, Luxemburgo.

Quinn JB (1986) La gestión de la innovación, un caos controlado. Harvard Deusto Business Review 25, 43-56.

Rothwell R (1992) Successful industrial innovation: Critical factors for the 1990's. R&D Management 22, 221-240.

Salazar M, Holbrook A (2004) A Debate on Innovation Surveys. Science and Public Policy 31, 254-266.

Soete L, Miozzo M (1989) Trade and development in services: a technological perspective, MERIT 89-031, Maastricht.

Suárez J, Albisu LM, Sotolongo N, Blanco F (2007) Factores de éxito y fracaso en el comportamiento innovador de las empresas. Pastos y Forrajes 30, 381-394.

Tidd J, Bessant J, Pavitt K (1997) Managing innovation: Integrating technological, market and organizational change. 1st edition, John Wiley & sons, Chichester.

Multi-Objective Optimization for Mixed Model Automotive Production Lines

Currie K[1], Motlow E[2]

Abstract: This paper focuses on a multi-objective optimization methodology for mixed model production lines such as automotive assembly facilities. In General Assembly production lines the time taken to rebalance assembly tasks when models and production volumes change may take two weeks or longer. The proposed methodology optimizes cost, quality and safety of a mixed model automotive production line to meet changing customer demands. This is accomplished by using a Genetic Algorithm (GA) to manipulate assignment of tasks to specific work-stations to optimize resulting job loading, the probability of missed operations, minimizing ergonomic stresses of task assignments. Data indicates that a GA integrating assembly precedents and key indicators of quality and ergonomic stresses has the potential to be a powerful tool to identify optimum task to workstation assignments.

Keywords: Mixed Model Production; Multi-Objective Optimization; Genetic Algorithms.

1 Introduction

When designing an automotive production line, manufacturing engineers are challenged to maximize output, minimize quality issues and minimize ergonomic concerns for employees. Because of the criticality of optimum design to overall profitability, there is significant research and literature available on how to perform this optimization. These optimizations are generally based on forecasted overall demand and product mix. However, changes in consumer demand can dramatically alter actual demand and product mix. Production Managers indicate it can take up to two weeks to identify the need for and re-adjust task/workstation assignments to maintain optimum production environment with changes to product mix. The ability to quickly identify opportunities to adjust task/workstation assignments to maintain production efficiency, quality and safety is invaluable to an Operations Management Team.

2 Literature Review

Thomopoulos presented the first procedure to adapt single-model line balancing techniques to mixed-model schedule. In this paper, he also introduced a sequencing procedure for determining the order in which the models should be assembled on the line (Thomopoulos N. T., 1967). This procedure could not be used for solving large-scale problems. Thomopolous then extended his work by modifying the mixed model line balancing procedure to incorporate smoother workstation assignments on a model-by-model basis (Thomopoulos N. T., 1970). Thomopolous defined three main objectives of the smoothed station assignments. The three objectives included adherence to precedence restrictions, seeking station times that were approximately equal to the cycle time, and equalizing the total workload for each model over all the workstations.

Matanachai and Yano (Matanachai & Yano, 2001) developed a heuristic solution, considering the effect of within-station diversity as a component of its objective function. Their objective function considered total job balancing between workstations, job balancing between models within workstations, and job

1 **Kenneth Currie** (krcurrie@mail.wvu.edu)
Department of Industrial & Manufacturing Systems Engineering,
West Virginia University Morgantown, WV 26508, USA.
2 **Erika Motlow**
Canon County High School, Woodbury, TN 37190, USA.

balancing between models from workstation to workstation. In their study, they assumed both number of workstations and cycle time were provided.

Simaria and Vilarinho (Simaria & Vilarinho, 2004) presented a mathematical programming model and iterative genetic algorithm-based procedure for the mixed-model assembly line balancing problem with parallel workstations. Their goal was to minimize cycle time of the line and balance the workload between workstations for a pre-determined number of workstations.

Merengo, Nava, and Pozzettis (Merengo, Nava, & Pozzettis, 1999) developed a balancing algorithm to minimize workstations and minimize rate of incomplete jobs. Their approach was to minimize the rate of incomplete jobs by balancing the total workload across workstations and the workload of each model between workstations. They considered job sequencing separately from their balancing algorithm.

Bradley and Blossom (Bradley & Blossom, 2001) investigated increasing product mix flexibility in mixed model assembly lines. They recommended aggressively buffering a workstation for an assembly line to be flexible with regard to a fluctuating product mix. This minimized an adverse impact to overhead costs such as rework. The authors used a simulation experiment to investigate the effect of adding buffer capacity at strategic locations.

Because of the variety of research with mixed-model assembly line balancing, several researchers have focused on analyzing and classifying the available research. One document (Emde, Boysen, & Scholl, 2010) reviewed the different approaches to balance workstations. They took these different approaches and ran them through a simulation to see which approaches better reduced short-term work overloads. Another (Boysen, Fliedner, & Scholl, 2006) created a classification scheme for assembly line balancing and classified many works with this scheme. The scheme on three elements included the precedence graph characteristics, station and line characteristics, and objectives.

In going beyond cycle time optimization, (Choi, 2009) created a mathematical model to minimize processing time as well as physical workload. This recognized the need for optimization to consider factors beyond production efficiency. Choi utilized a goal programming approach, solving a problem to identify the minimum cycle time and physical workload, and then solving a third problem minimizing the deviation from the previous solutions.

The existing research lays the foundation and acceptance for mixed model production lines as a design to optimize production output and computer modeling as an effective tool in determining optimum workstation assignments. In considering overall profitability of a given production line, product quality is a significant driver. The opportunity to include quality indicators in the optimization of task assignment appears to be overlooked in existing research. This research further differs from those mentioned by driving changes in the workstation configuration from customer demand changes (whether that is a change in total demand or product mix).

3 Methodology

The goal for this research is to determine if a Mathematical Model can be developed to identify changes to a mixed model production line to improve efficiency and reduce missed operations and ergonomic concerns.

An ideal program allows the user to input changes to:

- Model Mix
- Product Cycle Time

And outputs recommended assignment of tasks to specific workstations to:

- Minimize Ergonomic Stressors
- Minimize the probability of Missed Operations
- Reduce Number of Workstations

As a foundation for these calculations a working knowledge of the following for the specific production line to be modeled is needed:

- Required Tasks
- Cycle Time per Task, per Model
- Task Precedents
- Ergonomic Indicators by Task
- Quality Indicators by Task

Underlying the entire model are the following assumptions:

- No limitations to workstation assignment due to tools
- No limitations to workstation assignments due to training
- Cycle time of no individual task would exceed overall cycle time

In a separate research partnership, The Center for Manufacturing Research at Tennessee Technological University collaborated with a major automotive manufacturer. As part of this previous research, task data was collected for a mixed model production line. Fortunately the data included all of the critical data points required to model the existing product line. For this research analysis, assembly operations of three production teams incorporating 11 workstations were selected. All workstations are included in single production line, supporting three production models including a two-door sedan, four-door sedan and wagon. The workstations included 53 specific tasks for assignment.

A Genetic Algorithm (GA) forms the basis for the programming logic. As would be expected, a GA utilizes the process of natural selection and survival of the fittest considered key processes in the continuation of the species. The goal of the GA is to assign tasks to work stations and optimize overall performance to target cycle time while minimizing ergonomic and missed operation index.

Initially, the GA creates 40 feasible strings then evaluates the fitness function for each solution. This function is the summation of three objective functions including:

- Job Loading
- Ergonomic Job Loading
- Missed Operations Index

3.1 Job Loading

The objective function in regards to job loading is to minimize workstation idle time by minimizing 1 - the maximum deviation of the sum of workstation task times as a percentage of cycle time.

$$\text{\% Job Loading} = \frac{(u - \sum_{j=1}^{N} x_{ij} y_j)}{u} \qquad (3.1)$$

By minimizing the amount of idle time, the function will effectively minimize the number of workstations.

3.2 Ergonomic Job Balancing

The existing data includes several ergonomic indicators. Each task is evaluated for key product and process factors on a scale of 0 – 3. Product factors include weight, size, torque, clearance among others. Process factors include access, back posture, neck posture, and wrist posture as examples. Since the goal is to minimize potential ergonomic stress, for each task the worse case (highest ranking) product and process score is selected. Summing the worse case product and process factors provides a 0 – 6 scale of the potential ergonomic impact of the tasks. Combining the scale factors and the percent static load per task, an ergonomic index Ergo Index_j was created for each task:

Ergo Index_j = (Worse Case Product Factor + Worse Case Process Factor) x Static Load Percentage

This Ergonomic Task Index is multiplied by the weighted processing time and divided by 60 to generate a Weighted Ergonomic Index per Task. The weighted indices are summed for each workstation to determine a Weighted Ergonomic Index per Workstation.

$$\text{Wtd Ergo Task Index}_{\text{j}} = \frac{Ergo\ Index_j \times y_j}{60} \qquad (3.2)$$

The objective function identifies the workstation with the maximum Ergo Index and minimizes the normalized value when divided by the Total Wtd Ergo Index.

$$\text{Min Max} - \frac{\text{Max} \sum \text{Wtd Ergo Index}_{\text{j}}}{\sum_{\text{i}=1}^{\text{n}} \text{Workstation Wtd Ergo Index}_{\text{i}}} \qquad (3.3)$$

3.3 Missed Operations Index

The previous research, (Williamson, et. al., 1999) identifies factors with significant impact on missed operations including:

- Frequency of Use (Options or not)
- Continuity of Task System
- Continuity of Task Location

With tasks assigned to workstations, the program calculates the missed operations index by using the available data and the following scoring

- Option Content; 1 - No Options; 4 - Options Available
- System Continuity; 1 - all tasks same system; 4 - change in system within workstation
- Location Continuity; Location Front to Rear; Location Right to Left; Front to Rear Index + Right to Left Index + 1

The overall workstation Missed Operations Index is the result of from multiplying the three factors together divided by the maximum potential score (64).

The objective function for missed operations works to minimize this index.

Min Max - Normalized Indicator of Missed Operations

3.4 Overall Fitness Function

As part of the initial data entry process, the user is provided the opportunity to weight the three objective functions. Over fitness function with weighting is as follows
Weighted Fitness Function =

$$\begin{aligned} & w_1 * \text{Max } \{1\text{-\% Job Loading}\} \quad + \\ \boldsymbol{f_i} = \ & w_2 * \text{Max } \{\text{Missed Operations Index}\} \quad + \qquad 3.4 \\ & w_3 * \text{Max } \{\text{Workstation Ergo Indicator}\} \end{aligned}$$

4 Results

Figure 1 below demonstrates how the fitness function is optimized over time. Note that with this model the idealized solution is achieved in the 153rd generation. Table 4 demonstrates the outcome from the program with a recommendation of tasks to specific workstations.

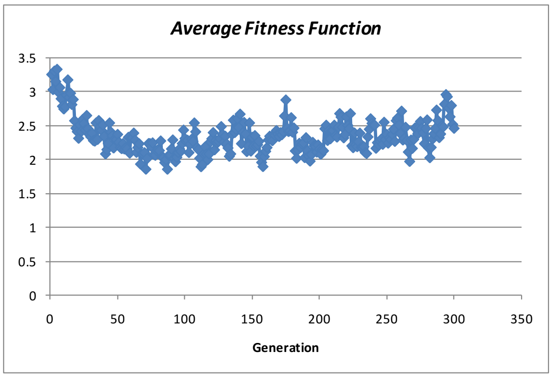

Fig.1
Generational Fitness Function.

Table 1
GA Results with Minimal Fitness Function.

Workstation	Optimum Task Assignments							
1	1	2	3	5	6			
2	7	8	9	12	15			
3	10	11	13	14				
4	16	17	18	19				
5	20	33	53					
6	21	22	23	24	25	26		
7	34	35	36	37				
8	38	39	40					
9	41	42	43	44				
10	45	46	47	48	49	50	51	
11	4	27	28	29	30	31	32	52

5 Conclusions

The research presents a model for using GA to optimize an existing automotive production line to: Minimize Ergonomic Stressors, Minimize Missed Operations, and Reduce the Number of Workstations

The results indicate the ability of a program to quickly evaluate multiple alternative workstation assignments and return improved overall results driven by a dynamic market with changing demand and model mix requirements. The research also demonstrates the ability the analysis to weight value of the optimization functions to best meet the needs of the operations manager.

6 References

Boysen, N., Fliedner, M., & Scholl, A. (2006). A classification of assembly line balancing problems.

Bradley, J. R., & Blossom, P. A. (2001). Using product-mix flexibility to implement a make-to-order assembly line.

Choi, G. (2009). A goal programming mixed-model line balancing for processing time. *Computers & Industrial Engineering* .

Williamson, K., Currie, K.R., and Agrawalla, A. J., (1999). A Statistical Study of the Factors that Affect Errors", 8th Industrial Engineering Research Conference Proceedings, Phoenix, AZ.

Emde, S., Boysen, N., & Scholl, A. (2010). Balancing mixed-model assembly lines: a computational evaluation of objectives to smoothen workload. *International Journal of Production Research* .

Fish, L. A. (2005). Teaching Assembly Line Balancing: A Mini-Demonstration with DUPLO Blocks or "The Running of the Dogs". *Decision Sciences Journal of Instructional Design* .

John D. Bransford, A. L. (1999). *How People Learn, Brain, Mind, Experience, and School.* Washington, D.C.: NATIONAL ACADEMY PRESS.

Matanachai, S., & Yano, C. A. (2001). Banlancing mixed model assembly lines to reduce work overload. *IIE Transactions* , 29-42.

McMullen, P. R., & Frazier, G. V. (1997). A heuristic for solving mixed-model balancing problems with stochastic task durations and parallel stations. *International Journal of Production Economics* , 177-190.

Merengo, C. F., Nava, F., & Pozzettis, A. (1999). Balancing and Sequencing manual mixed model assembly lines. *International Journal of Production Research* , 2835-2860.

Simaria, A. S., & Vilarinho, P. M. (2004). A genetic algorithm based approach to the mixed-model assembly. *Computers & Industrial Engineering* , 391-407.

Thomopoulos, N. T. (1967). Line Balancing-Sequencing for Mixed-Model Assembly. *Manaement Science , 14*, 59 -75.

Thomopoulos, N. T. (1970). Mixed Model Line Balancing with Smoothed Station Assignments. *Management Science , 16*, 593 - 603.

Proposal of a Management System for Preventing Intentional Food Contamination and the Improvement of the Supply Chain Security in the Food Sector of Guanajuato, Mexico

Navarrete R[1], **Lario FC**[2]

Abstract: In general terms, the research focuses on a proposal formulation that allows establishing a management system for preventing intentional food contamination and the improvement of the security of the supply chain. The aim is to manage the intentional contamination risks by means of a methodology that encompasses a risk analysis. The proposal establishes a system that is able to promote the security of each link, causing the whole supply chain to benefit from it, from the farm to the final consumers. The initial study covers only the theoretical methodological proposal and focusses only on the companies of the alimentary sector of Guanajuato State in Mexico. However, it may extend into a research plan security of food supply chain.

Keywords: risk management; food defense; supply chain management; supply chain security.

1 Introduction

Intentional food contamination represents a real and potentially catastrophic threat for the society, given that it can produce long reach disastrous effects, including direct morbidity and/or mortality, interruption of food distribution, loss of confidence from the consumers in the Government and the alimentary supply's responsible parties, company bankruptcies, trade restrictions and serious economic effects (Busta & Kennedy, 2011).

Alimentary terrorism has been defined by the World Health Organization as "an act or deliberately try of food contamination for human consumption with chemical, physical or microbiological agents, with the purpose of causing damage or death to civil populations or to interrupt the social, politic or economic stability" (WHO, 2008; Veiga, 2011).

Terrorism directed towards the alimentary sector could have extreme consequences in civil populations, affecting their physical and psychological health, causing distrust concerning the safety of the affected food group (Onyango et al., 2005). Deliberate contamination of alimentary supply could have a devastating impact in public health and the global economy (DHSS, 2005).

1 **Ramón Navarrete Reynoso** (ranarey@alumni.upv.es)
Dpto. de Estudios Empresariales. División de Ciencias Económico Administrativas. Universidad de Guanajuato. Fraccionamiento 1, Col. El Establo S/N, 36250 Guanajuato, México.

2 **Francisco Cruz Lario Esteban** (fclario@upv.es)
Centro de Investigación en Gestión e Ingeniería de la Producción (CIGIP), Universidad Politécnica de Valencia, Camino de Vera S/N. 46022 Valencia, España.

Brummer (2003) considers the following consequences: (i) physical consequences: an insufficient or non-edible alimentary supply. The direct results could be diseases and mortality, and indirectly hunger and malnutrition of the affected populations; (ii) psychological consequences: there may be problems in the consumers' behavior, which could include the perception of an unsafe and vulnerable alimentary supply; (iii) political consequences that could end up in civilian discord due to the alimentary shortage, decline in confidence in governments, outbreaks of destabilization and anarchy (iv) economic consequences of variable length with loss of consumer trust and deterioration of the image in the market of the companies involved.

The Food Defense refers to the analysis, control and improvement of prevention mechanisms of those attacks; that is, the Food Defense involves a Risks Management. This management is based on the premise that absolute safety does not exist and that the reliability in each of the components, even the highest, does not imply reliability equivalent to the whole system. Risk management consists of recognizing the risks, evaluating them and regulating some in relation to others, leaving aside the attempt to restore situations in which the risk would be completely excluded (Dourlens et al. 1991).

The oversight in this matter can lead to an increase in the failure probability in the security of the alimentary supply chain (Food Supply Chain: FSC); and therefore, generate potentially high costs for its constituents. The Security in the Supply Chain is defined as the enforcement of policies, procedures and technologies to protect goods of the supply chains from robbery, damage or terrorism and to prevent the introduction of smuggled goods, people or weapons of mass destruction along the supply chain (Closs et al. 2004). As a way to make reference to the multiplicity of players and spheres of action, the term Supply Chain Security Management (SCSM) (Bowersox et al. 2007) has been coined. Hintsa et al. (2009) later incorporated to this definition the dimension of the systemic solution pointing out that each SCSM measure should be oriented towards prevention, detection or recovery from a criminal act as quickly as possible.

Finally, this paper includes results of research in the doctoral thesis of Navarrete et al. (2012), and previous results published in Navarrete et al. (2009); Navarrete et al. (2010) and Navarrete et al. (2011), given the general importance of the topic within the trade relations between US-Mexico.

2 Objectives

To make a proposal of a management system for preventing intentional food contamination and the improvement of the security of the supply chain in the alimentary sector of Guanajuato.

3 Methods

The development of this proposal has been carried out under an approach that results from adaptation (and/or combination) of different management systems that cover a risk analysis, such as the Management System of Information Security (MSIS), based on the standard ISO/IEC 27001. The proposed procedure has been prepared in compliance with the Good Manufacturing Practices (GMPs) and the recommendations of the Food Defense proposed by experts in the government, academic and private fields of the alimentary sector. A risk analysis approach was taken into account during the evaluations of the intentional contamination dangers of the supply chain links.

To establish and manage the Management System for the Prevention of Intentional Contamination (MSPIC), and the security improvement to the Supply Chain, the continuous PDCA cycle is used (Plan, Do, Check, Act), which is traditional in quality management systems (see fig. 1).

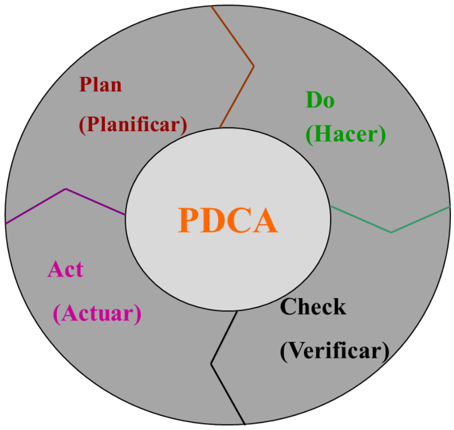

Fig.1
Continuous PDCA cycle.
Source: ISO/IEC 27001 (2005).

- Plan: establishes the MSPIC
- Do: implements and uses the MSPIC
- Check: monitors and reviews the MSPIC
- Act: maintains and improves the MSPIC

3.1 Plan

In this phase the MSPIC creation takes place, with the **scope** definition and the **Security Policy**. The range refers to the limits the MSPIC will have in terms of the characteristics of the FSC chain, its organizational structure, its location, its activities, its technology and the details of and justification for anything excluded from its range. The MSPIC policy as defined and approved by the management will in-clude: i) a key framework for objectives setting out a general sense of direction and principals for action relating to the prevention of intentional contamination; ii) the legal and commercial requirements; and iii) the definition of a criterion for evaluating risk that is in line with the organization's strategic risk management framework.

The fundamental core of this phase as well as of the MSPIC is the **risk analysis** performance that reflects the current situation of the entity. For the risks analysis it is necessary to define an adequate risk evaluation methodology, besides establishing the **risk acceptance criteria** and specifying the **acceptable risk levels**. It is of utmost importance to identify the dangers within the business processes and infrastructure of the analyzed supply chain link. Afterwards, the risks related to the identified dangers are being evaluated. Some of the methodologies, which could be adapted for this purpose, although currently used in the field of information security, are Magerit (Methodology of analysis and risk management information systems); the methodology detailed in the ISO/IEC 27005 standard, OCTAVE (Operationally Critical Threat, Asset and Vulnerability Evaluation), etc. In the field of food safety, methodologies that could be adapted are ORM (Operational Risk Management), CARVER + Shock , or the methodology suggested for business processes in Navarrete et al. (2011).

Finally, the different risk treatment options are identified and evaluated. In this methodology, control objectives and controls are selected to improve food defense performance.

3.2 Do

In this phase the **MSPIC' policy** and **controls** are implemented and operate with the **risks treatment plan** implantation and execution. The plan should identify the actions, resources, responsibilities and priorities in the risks management; with the purpose to achieve the identified control objectives. The possible actions for dealing with risk include: i) applying the controls; ii) consciously accepting the risk (doing nothing), as long as the criteria for risk acceptance are met; iii) avoiding risk (not carrying out the activity which entails risk); or iv) transferring the risk (for example by insuring or subcontracting). The **controls** have been prepared in compliance with the Good Manufacturing Practices (GMPs) and the Food Defense recommendations proposed by experts in the government, academic and private fields of the alimentary sector. The definition of metrics and indicators is important to evaluate the efficiency of the implanted controls.

Training programs must also be established to ensure that the personnel who have responsibilities defined in the MSPIC are competent to perform the relevant tasks.

3.3 Check

During this phase different types of revisions are performed to check the correct system implantation. Among those, an independent and objective **internal audit** takes place; as well as a **global review** of the MSPIC by the Board.

Internal audits should be carried out at planned intervals to determine whether the controls, control objectives and system procedures: i) comply with legislation or international standards; ii) comply with good manufacturing practices (GMPs) and Food Defense recommendations; iii) are implemented and maintained effectively; and iv) are performed as anticipated.

The management must check the MSPIC at planned intervals to ensure continuity, effectivity and suitability. The results of both checks must be clearly recorded and the records must be maintained.

Some of the general objectives of these checks are: to identify the security gaps, to guarantee the effectiveness of the controls, to update the risks analysis or review the compliance with the MSPIC's policy and objectives.

3.4 Act

The result of the reviews should be reflected in the definition and implantation of corrective, preventive and improved actions to advance in the achievement of an effective and efficient MSPIC. At this stage, the FSC chain must do the following: i) implement the identified improvements; ii) establish preventative and corrective actions; iii) communicate results and actions to those effected at an appropriate level of detail; and iv) en-sure that improvements achieve their stated objectives.

4 Results

The results from this research can be listed as follows:

1. A methodological option is provided: the improvement of the prevention of the intentional contamination based on a risks analysis.

2. The proposal establishes the use of metrics for the prevention of intentional food contamination and its possible impact on other metrics (cost and time) as a link of the supply chain.

3. According to the research reference frame, the proposal has the potential to improve the security of the supply chain in the alimentary sector of Guanajuato State, Mexico.

4. In accordance to the research scope, the proposal has the potential to improve the alimentary security (food safety and food defense) in the alimentary sector links in Guanajuato.

5 Conclusion

The PDCA is a continuous life cycle, which leads the 'Act' phase back to the 'Plan' phase to initiate a new cycle of the four phases. Therefore, the system allows continuous improvement in the prevention of intentional contamination risks and an increase in security of the alimentary supply chain, not only the food sector in the state of Guanajuato, but can be extended into a research plan security of food supply chain. It is important to note that in a second phase of the research is scheduled for implementation in any company in the food sector.

References

Ackoff R. (1967). The Design of Social Research. University of Chicago.

Boyle M. (2005). A Recipe for Disaster. Fortune International Journal; vol. 152, Issue 9.

Brakett R, Carson L. (2004) Food Safety and Security. U.S. Food and Drug Administration; Center for Food Safety and Applied Nutrition.

Bowersox D.J., Closs D.J. and Cooper M.B.(2007). Supply Chain Logistics Management. 2nd ed., McGraw-Hill, 2007.

Brummer, B. (2003). Food Biosecurity. Journal of the American Dietetic Association; vol. 103, no. 6, pp. 697-691.

Busta F.; Kennedy S. (2011). Defending the Safety of the Global Food System from Intentional Contamination in a Changing Market. NATO Science for Peace and Security Series A: Chemistry and Biology, Advances of Food Protection (Chapter 7), pp. 119-135.

Closs D. and Mcgarrell E. (2004). Enhancing Security Throughout the Supply Chain. Special Report Series, IBM Center for The Business of Government.

Department of Health and Human Services (DHHS), “Terrorrism and Food Suply. Terrorism and other Public Health Emergencies: a reference guide”, US Food and Drug Administration, Center for Food Safety and Applied Nutrition, United States, 2005.

Dourlens, C.; Galland, J. P.; Vidal-Naquet, P. A. (1991). Introduction. In: DOURLENS, C.; Galland, J. P.; Theys, J.; Vidal-Naquet, P. A. Conquête de la sécurité, gestion des risques. París: L’Harmattan.

Hartnett, E.; Paoli, G.M.; Schaffner, D.W. (2009). “Modeling the Public Health System Response to a Terrorist Event in the Food Supply”. Society for Risk Analysis, Journal of risk Analysis; vol. 29, no. 11.

Hintsa, J. Gutiérrez X., Hameri A.P. and Wieser P. (2009). “Supply Chain Security Management: an overview”, International Journal of Logistics Systems and Management, vol. 5, nums. 3/4.

Instituto Nacional de Estadística, Geografía e Informática, INEGI (2014), “Censo Económico 2014”. México.

ISO/IEC 27001 (2005) “Estándar Internacional: Tecnología de la Información-Técnicas de Seguridad- Sistemas de Gestión de la Seguridad de la Información”. 1ª Ed.

ISO/IEC 27001 (2013) “Estándar Internacional: Tecnología de la Información-Técnicas de Seguridad- Sistemas de Gestión de la Seguridad de la Información”.

Lyonga, A.N.; Sellnow T.L.; Nganje, W.E.; Venette S. (2006). “Insider AgroterrorismThreat and High Reliability in Turkey Processing.”. Journal of Food Protection Trend.

Miller D.C. (2002). “Handbook of Research Design and Social Measurement.”Thousand Oaks, Sage Publications.

Monke, J. (2004). “Agroterrorism: Threats and Preparedness”. Congressional Research Service; CRS Report for Congress.

Navarrete R., Lario F.C. (2009) “Modelo de gestión de la bioseguridad, basado en procesos de negocio de la cadena de suministro. Aplicación en la industria mexicana de los alimentos”. XIII Congreso de Ingeniería de Organización, 3rd International Conference on Industrial Engineering and Industrial Management, Barcelona España.

Navarrete R., Lario F.C. (2010)“Propuesta de una Metodología para el Modelado AS IS y TO BE de Procesos de Negocio de Bioseguridad (Terrorismo Alimentario), dentro del Contexto de la Cadena de Suministro. Aplicación en la Industria Mexicana Alimentaria”, XIV Congreso de Ingeniería de Organización, 4th International Conference on Industrial Engineering and Industrial Management, Donostia-San Sebastian, España.

Navarrete R., Lario F.C. (2011)“ Propuesta de un Procedimiento para la Elaboración de un KPI para la Medición de la Bioseguridad en Procesos de Negocio de la Cadena de Suministro Alimenticia. Aplicación en la Industria Mexicana Alimenticia”, 5th International Conference on Industrial Engineering and Industrial Management, XV Congreso de Ingeniería de Organización, Cartagena, España.

Navarrete R. (2012)“ Modelo de Bioseguridad en la Cadena de Suministros de Productos Alimenticios, teniendo en cuenta la Gestión de la Cadena de Suministros y la Visión de Procesos de Negocio. Aplicación a la Industria Alimenticia, de la Zona del Bajío (Méxict)”, Tesis doctoral, Universidad politécnica de Valencia, España.

Nganje, W.; B. Dahl; W. Wilson; S. Mounir; Lewis A. (2007). “Valuing Private Sector Incentives to Invest in Food Security Measures: Quantifying the Risk Premium for RFEM.” Journal of International Agricultural Trade and Development; vol. 3, no. 2, pp. 199–216.

Nganje, W.; Bier B.V.; Han H.; Zack L. (2008). “Models of Interdependent Security along the Milk Supply Chain” American Journal of Agricultural Economics; number 5, pp. 1265-1271.

Onyango, B.; Turvey C.; Hallman W. (2005). “Public Attitudes and Perceptions of the Vulnerability of the U.S. Food Chain to Agroterrorism” American Agricultural Economics Association annual meeting; Providence, RI, pp. 24-27.

Pérez Serrano, M. G. (1994). “Investigación cualitativa e interrogantes: técnicas y análisis de datos”. La Muralla, Madrid.

Peters, K. (2003). “Officials Fear Terrorist Attack on U.S. Food Supply.”. [en línea] http://www. govexec.com/ dailyfed/0603/061003kp1.htm. [consulta: 2/10/2008].

Pistole J. (2006). “Preparing for the Unthinkable: Agroterrorism”. Conference focuses on food defense. Food Business News; no. 1, pp 23-26.

Rasco, B.; Beldsoe, G. (2006). “Bioterrorism and Food Safety”. CRC Press; Boca Ratón, Fl., Estados Unidos.

Sampieri R.; Fernandez C.; Baptista P. “Metodología de la investigación” McGraw-Hill.

United States Department of Agriculture, USDA (2004). “A Biosecurity Checklist for School Foodservice Programs”. Biosecurity Guidelines.

United States Department of Agriculture, USDA (2005). “Pautas de seguridad para procesadores de alimentos. Biosecurity Guidelines, 2005.

United States Department of Agriculture, USDA (2008). “Developing a Food Defense Plan for Meat and Poultry Slaughter of Processing Plants”. Biosecurity Guidelines, 2008.

Wein, L.M.; Liu Y. (2005). “Analyzing a Bioterrorism Attack on the Food Supply: The Case of Botulinum Toxin in Milk.” Proceedings of the National Academy of Sciences; vol. 102, no. 99 pp. 84–89.

World Health Organization, WHO (2003). “Bioterrorismo: la amenaza en el continente americano”. Reunión Interamericana a Nivel Ministerial en Salud y Agricultura.

World Health Organization, WHO (2008). “Terrorist Threats to Food: Guidance for Establishing and Strengthening Prevention and Response Systems”. Department of Food Safety, Zoonoses and Foodborne Disease, Cluster on Health Security and Environment.

Veiga A. (2011). Food Defense and Security: A New Reality. NATO Science for Peace and Security Series C: Environmental Security, Environmental Security and Ecoterrorism (Chapter 4), pp. 39-54.

Zhuang, J.; V.M. Bier; Gupta A. (2007). “Subsidies in Interdependent Security with Heterogeneous Discount Rates.” The Engineering Economist; vol. 52, no.1, pp. 1–19.

Incursion of Knowledge Management in Management Excellence Models: An analysis in the Latin-American context

Resende Jr P C[1], Reis A L N[2]

Abstract: The aim of this article is to describe the relationship between theoretical knowledge management assumptions and knowledge management process involving Excellence Management Models in Latin America. Relevant literature was reviewed by carrying out a research based on document analysis involving requirement of excellence management models in the following countries: Argentina, Brazil, Chile, Colombia and Mexico. This research study used qualitative data-collecting methods by means of a content analysis technique, carried out between February 2013 and December 2014. The corpus was treated by using a content analysis technique, where categories of analysis were codified based on criteria, items and management process requirements of the models investigated. The findings show that the mains theoretical knowledge management assumptions are present, in some degree, in excellence management models in Latin America.

Keywords: knowledge management, management models, Latin America.

1 Introduction

This article aims to describe the presence of knowledge management theoretical assumptions and the process of knowledge management in Excellence Management Models in Latin America. This research makes it possible to produce consistent analyses based on pre-existing models that consider knowledge management as the basis of organization.

Six excellence management models where selected for this research study. The countries and their respective models are as follows: a) Argentina - Model for Management Excellence in Companies; b) Brazil - Management Excellence Model - FNQ; c) Brazil - Model for Management Excellence in Public Services - Gespública; d) Chile –Management Excellence Model; e) Colombia - Model for the Colombian Quality Management Award; and, f) México - Model for National Competitiveness, Medium-size and Large Companies. These models adhere to current New Public Management, and their keywords are: active professional management; performance standards and indicators; greater emphasis on results controls; the trend towards greater internal productivity and outside competition; imitating styles of management used in the private sector; greater emphasis on discipline and parsimony in resource use.

1 **Pedro Carlos Resende Junior** (pcrj73@gmail.com)
Researcher Professor. Professional Masters in Administration.
University of Brasília. Campus Darcy Ribeiro. Brasília. Brazil.

2 **André Luiz Nascimento Reis** (uai@hotmail.com)
Master Degree Student. Master Program in Knowledge Management and Information Technology.
Catholic University of Brasília. Brasília. Brazil.

2 Theoretical References

According to Barclay and Murray (1997), information and knowledge are recognized as corporative assets and, as such, their management requires policies, strategies and tools. Furthermore, according to those authors, since those assets produce competitive advantages, they require systemized search and transfer mechanisms for the stakeholders. As stated by Nonaka (2008), those organizations that are able to continually create and spread knowledge are those that have the greatest strategic success. Sveiby (2001) also views knowledge management as the art of creating value based on intangible assets, where knowledge is like a human feature. In the same vein, Dalkir (2005) also shares this interdisciplinary viewpoint that knowledge management involves strategies, tools and skills.

On the other hand, Davenport (1998) establishes a direct relationship between information and knowledge when he defines knowledge as information combined with context, experience, interpretation and reflections. In the same vein, most of the models selected for the purpose of this research, adopt criteria of excellence aimed at knowledge management involving integrated, though distinct information management and knowledge management practices.

Contradictory to the previous definitions, Earl and Scott (1999) state that there is no widely accepted definition about the construct of knowledge management. Even so, these authors mention three points of convergence: a) that knowledge is a sustainable source of competitive advantage; b) that, in general, organizations acknowledge that they do not administer knowledge well; e) that organizations recognize the potential of knowledge value creation, but that this is something they do not adequately explore. Even though they do not acknowledge that there is a widely accepted definition of knowledge management, the points hereby illustrated refer to common elements highlighted by the afore-mentioned authors. In a study involving 160 models of knowledge management frameworks from around the world, Heisig (2009) noted that, in general, these models show that the following activities are an inherent part of knowledge management: to identify, create, store, share and apply. For the purpose of this research, knowledge management is considered as a structured process to manage intangible assets that involve such activities as sharing, creating, applying, storing and identification, so as to generate new assets and wealth for organizations.

3 Methodology

The present research study was undertaken using a qualitative approach for data collection and analysis. The document analysis and content analysis were undertaken between February 2013 and December 2014, which consisted of a survey based on data that involved excellence management models in the following countries: Argentina, Brazil, Chile, Colombia and Mexico. The corpus was treated by means of a content analysis method, according to Bardin (2002), where two analysis categories were codified: a) Category 1, called Information, deals with management process requirements, management practices and standards of work and measurement mechanisms related to the need for information, information systems management and the integration of information between organizations and stakeholders, with their respective information security management; and b) Category 2, called Knowledge, presents extracts related to the development, retention, protection, dissemination and use of knowledge that an organization needs to carry out its operations and strategies.

4. Data Analysis

4.1 Model for Management Excellence in Companies - Argentina

According to MECA (2013), the knowledge management model from Argentina can be summarized by the following practices: obtain collective experience from internal sources; acquire information and knowledge from external sources; apply these to procedures; develop future learning innovations; and protect the organization's knowledge assets. The Table 1 shows the requirements related to this item.

Table 1
Management process requirements related to knowledge management based on the model from Argentina.

a) Identify present and future information and knowledge needs in order to develop a business strategy.
b) Guarantee access to information based on external as well as internal sources.
c) Management of the organization, retention, protection and confidentially of information and knowledge.
d) Ensure that information and knowledge are promptly available for those who are responsible for their use.
e) Promote organizational knowledge, independently of those who are responsible for their production and administration.
f) Management of networks relationships with external interested parties (such as suppliers, universities) who provide access to knowledge.
g) Evaluate and improve information and knowledge management.

4.2 Management Excellence Model – Chile

According to MEMC (2012), the Chilean model is similar to the model from Argentina, in that it provides no specific or fundamental principle related to knowledge management. The Chilean model describes the requirements which enable a company to administer information, guaranteeing authenticity and availability, as well as how to manage organizational knowledge. Table 2 shows the requirements related to information management.

Table 2
Management process requirements related to information management outlined in the model from Chile.
Adapted by the authors.

a) Identify information needs to structure daily operations and decision-making.
b) Ensure that the demands of employees, suppliers / partners and clients in identifying information needs are respected.
c) Ensure that information is available to users.
d) Ensure that the technology methods used are secure and easy to use by those who use them.
e) Up-date mechanisms to make available information in accordance with the needs of the business and changes in technology.
f) Guarantee the precision, integrity, reliability, promptness, safety and confidentiality of information.

Table 3
Management process requirements outlined in the Chilean model.

a) Identification, evaluation and management of organizational knowledge to increase the aggregate value of products and services.
b) Maintain organizational knowledge.
c) Collect and transfer knowledge between employees, different areas and teams, clients, suppliers and partners.
d) Manage the exchange and implementation of good practices.

4.3 Model for the Colombian Quality Management Award – Colombia.

In the case of this model, the management processes relating to knowledge management appears to be linked to an innovation construct, meaning that the organization structures a system of management based on knowledge and organizational learning that directs efforts towards developing new products, services, skills and processes that generate a differential value. The following issues are included in the criteria for the Colombian model: Knowledge Management and Innovation and Methodologies and Innovation Practices, shown in Tables 4 and 5, respectively.

Table 4
Requirements outlined in the model from Colombia for management processes related to knowledge management and innovation.

a) Establish knowledge management as a learning and development factor.
b) Identify, protect and use knowledge as an innovative element for organizational development and to attain a better performance and to create value for the different interested parties.
c) Create knowledge to develop new products, services, processes and skills.
d) Provide incentives to share knowledge, as well as to encourage creative and innovative thinking within the organization.
e) Incorporate experiences and lessons that have been learned as elements that will generate knowledge within the organization
f) Develop areas involving intellectual property rights and copyright.
g) Evaluate and improve knowledge management procedures.

Table 5
Requirements outlined in the model from Colombia referring to methodologies and innovation practices. Requirements outlined in the model from Colombia.

a) Present organizational approach for innovation by means of objectives, goals and actions to develop innovation skills.
b) Destination of resources allocated for innovation within an organization.
c) Development of capacities required to create a culture of innovation within an organization.
d) Develop innovative procedures, products and services.
e) Sharing innovative achievements.
f) Evaluate and improve innovation procedures.

By adopting an integrated view of knowledge management and innovation, the Colombian model understands that the flow of innovation goes through three stages: a) knowledge administration; b) creating and transferring knowledge; and c) organizational learning.

4.4 Model for Management Excellence in Public Services – Gespúplica - Brazil

In the case of the Mexican model, the management processes are focused on analyzing how an organization collects, selects, manages and uses data in decision making and to promote innovation at all levels of the organization, with the following elements: Strategy Alignment, Information Management and Knowledge Management, as shown in Tables 6, 7 and 8, respectively.

Table 6
Management process requirements related to strategy alignment included in the Mexican model.

a) Management of information and knowledge systems to support the implementation of an organization's strategic objectives.
b) Identify information and knowledge required to support the implementation of an organization's strategic plan.

Table 7
Management process requirements related to information management included in the Mexican model.

a) Obtain the necessary information to develop an organization's strategic planning.
b) Manage information to support the implementation of strategic objectives.
c) Manage information to provide guidance for the continual improvement of organizational and process innovation.
d) Information integration for decision making processes at different levels within an organization.
e) Evaluation and improvement of information management processes.

Table 8
Management process requirements related to knowledge management in the Mexican model.

a) Identify an organization's knowledge assets.
b) Structure knowledge to create improvement and innovation projects value.
c) Identify knowledge management improvement projects.
d) Protect organizational knowledge.
e) Evaluate and improve information and knowledge systems.

4.5 Model for Management Excellence in Public Services- Gespública - Brazil

Gespública (2014) is the only model included in the selected sampling that specializes in public sector organizations. The elements of Information Management and Knowledge Management may be found under this criterion, as shown in Tables 9 and 10, respectively,

Table 9
Management process requirements related to information management contained in the Brazilian model and applied in the public sector.

a) Identify information needs to support day-to-day operations, accompany progress in the strategic plan and support decision making at all levels.
b) Identify principle information systems and their aims, including the systems of administrative information in public administration.
c) Produce management information, providing the degree of interoperationability between the different information systems and indicators used in information management.
d) Develop and implement improvements in the main information systems.
e) Guarantee the interoperationability between the internal systems of information and public administration administrative systems.
f) Update technology in already developed systems, providing principle technological skills used and policies related to this area.
g) Make available all necessary information to its internal and external public, including users, suppliers and partners.
h) Use information technology to support an organization to fulfill its goals and promote integration between other government organs and with society.
i) Use information management to comply with the Law on Access to Information.
j) Information security management.
k) Guarantee the updating, confidentiality, integrity and availability of information.

Table 10
Management process requirements related to knowledge management in the Brazilian model applied to the public sector.

a) Develop and share knowledge within the organization
b) Guarantee that knowledge effectively contributes towards improving procedures, products and services.
c) Protect knowledge and historical information and institutional archives.
d) Identify, develop and measure the organization's intangible assets.

4.6 Model of Excellence in Management - FNQ - Brazil

According to FNQ (2014), the criterion Information and Knowledge aims to identify information needs and relative treatment so as to define, develop, establish and improve information systems, to integrate organization information with external interested parties and to make this information available while keeping it secure. Thus, the criterion is structured in Organization Information and Organization Knowledge, as shown in Tables 11 and 12, respectively.

Table 11
Management process requirements related to the FNQ model.

a) Identify information needs and their respective treatment, so as to operate and manage an organization.
b) Identify new demands for strategic and operational information.
c) Develop, establish and improve main information systems, taking into consideration the needs that have been identified.
d) Guarantee that up-to-date technology is used in information systems.
e) Ensure there is integration between the organization and its clients, suppliers and other external interested parties, by means of information systems.
f) Create an infrastructure that is compatible with the growth of the business so as to make information available to users.
g) Guarantee users rapid and easy access to information.
h) Guarantee infrastructure continuity, so as to make information available in emergency situations.
i) Evaluate user satisfaction with regards to information and communications systems.
j) Guarantee information security.
k) Ensure that information is updated, and that its confidentiality and integrity is maintained.

Table 12
Management process requirements related to the FNQ model.

a) Identify the most important knowledge needed to fulfill an organization's mission and to implement its strategies.
b) Classify types of knowledge and criteria to define those of greater importance.
c) Provide principal internal and external sources of knowledge that have been used.
d) Develop the most important knowledge.
e) Establish a favorable environment for the search and creation of knowledge.
f) Use personal and organizational networks to help to search for and develop knowledge.
g) Storage knowledge.
h) Adopt methods to attract and retain those persons and partners who hold an organization's most important knowledge.
i) Disseminate and use an organization's knowledge.
j) Provide access to and use knowledge that is held.
k) Share knowledge, both internally and externally.
l) Use personal or organizational networks to help spread knowledge.

4.7 Comparative analysis

The comparative analysis of models (Table 13) shows that there is a majority group presenting a balanced relationship between categories 1 e 2. That group is compounded by Argentina, Chile, Mexico and Brazil (Gespública). The balanced relationship suggests that organization efforts must be distributed in an equal way, according these models.

In the other hand, the models from Colombia e Brazil (FNQ) presents completely contrary positions. While the Colombia's model is focused in category 2, Brazil's model is focused in category 1.

Table 13
Classification of requirements in each Model.

Country	Requeriments Category 1 Information	Requeriments Category 2 Knowledge	Total
Argentina	50%	50%	100%
Chile	44%	56%	100%
Colombia	0%	100%	100%
Mexico	48%	52%	100%
Brazil (Gespública)	73%	27%	100%
Brazil (FNQ)	51%	49%	100%

In a second analysis was identified the presence of the activities of knowledge management as such the definition used on this paper. Each process requirement was classified according the activity most closely with. The result is presented on Table 14. The models from Argentina, Chile e Brazil are focused on sharing activity while the models from Colombia and Mexico are focused on creating and applying activities respectively.

Table 14
Presence of elements of Knowledge Management in each Model.

Country	Activities					
	Sharing	Creating	Applying	Storing	Identification	Total
Argentina	43%	14%	14%	14%	14%	100%
Chile	30%	0%	20%	30%	20%	100%
Colombia	12%	35%	29%	18%	6%	100%
Mexico	0%	0%	58%	8%	33%	100%
Brazil (Gespública)	31%	6%	25%	19%	19%	100%
Brazil (FNQ)	35%	13%	13%	22%	17%	100%

5 Conclusions

The Latin American models present different levels of structure and maturity. According to specialists interviewed in this research, the colombian model shows the highest maturity level because treats the knowledge management construct as being part of strategic perspectives, information management and innovation management. A gap found in some of the Latin American models of excellence, was the absence of knowledge management as a fundamental organizational structure. Despite the models from Argentina, Chile, Mexico and Brazil (Gespública) presented a balanced relationship between categories 1 e 2. It is suggested that a future research agenda should consider the need to extend this study to include other Latin American countries.

References

Bardin, L. (2002). *Análise de Conteúdo*. Lisboa: Edições 70.

Barclay, R. O., & Murray, P. C. (1997). What is knowledge management. *A Knowledge praxis*.

Dalkir, K. (2005). *Knowledge Management in Theory and Practice*. New York: Butterworth-Heinemann.

Davenport, T. H., De Long, D. W., & Beers, M. C. (1998). Successful knowledge management projects. *Sloan management review*, 39(2), 43-57.

Earl, M. J., & Scott, J. A. (1999). Opinion: what is a chief knowledge officer? *Sloan management review*, 40, 29-38.

FNQ (2014). Fundação Nacional da Qualidade. *Critérios de Avaliação 2014,* São Paulo.

Gespública (2014). Brasil. Ministério do Planejamento, Orçamento e Gestão. *Instrumento para a Avaliação da Gestão Pública - Ciclo 2014*. Brasília: Seges.

Heisig, P. (2009). Harmonisation of knowledge management-comparing 160 KM frameworks around the globe. *Journal of Knowledge Management*, 13(4), 4-31.

MECA (2013). Model for Management Excellence in Companies - Argentina. Critérios de Avaliação 2014, Buenos Aires.

MEMC (2012). Management Excellence Model – Chile. Critérios de Avaliação 2012, Santiago.

Nonaka, I. (2008). A empresa criadora do conhecimento. In, Nonaka, I. & Hirotaka, T. 2008. *Gestão do conhecimento*. Porto Alegre, RS: Bookman.

Sveiby, K. E. (2014). What is knowledge management? Disponível em http://www.sveiby.com/articles/KnowledgeManagement.html. Acessado em 15 de dezembro de 2014.

A Proposal of a Model for Decision Making and Process Improvement: An Knowledge Based Analysis

Machado C[1], Scavarda A[2], Kipper L[3], Frozza R[4]

Abstract: The main objective of this research is to develop a model that explores the relationships between lean practices, knowledge management and information management as supports management decision making. The research reviews the relevant literature to build the computational tool, lean methodology, knowledge management and knowledge-based systems. The methodology used is exploratory and descriptive approach. The proposed tool is able to inform improvements in the production process through the value stream map and knowledge management which is the basis of the tool. The information extracted from the stream map value identifying and suggests improvements over the process of managerial decision, in order to reduce the intermediate stocks through the manipulation of knowledge. The model helps to management decision making, provided reorganization of the processes generating profits by minimizing the waste identified by the value stream map.

Keywords: Lean, Decision Making, Knowledge management, Knowledge Based Systems.

1 Introduction

The tool to support better decision-making is increasingly a priority for managers in terms of competitive advantage creation and achieves superior performance. Organizations need to develop skills related to learning, allowing the understanding of the process of creation of information and engagement of those involved. Create knowledge and apply it to develop better processes of management decision (Demirkan *et al.,* 2013). Enrichment processes is by transforming data into information and knowledge, thus adding value to it. Therefore, it is necessary to achieve provide quick responses according to the needs, so the lean assume the role of leverage and effectively improve the productive capacity of any company.

Currently much used in manufacturing processes, lean aims to improve the value stream and therefore improves the process as a whole. For the improvement of processes using the knowledge management can generate greater fluidity in operations, providing agility and competitive advantage (Dal Forno *et al.,* 2014; Al-Najem *et al.,* 2012).

Manage knowledge in organizations requires conditions so that people can make available their knowledge, and develop it, protect it and use it. Thus the viability and competitiveness of organizations depend on their capacity to spread and use of knowledge across the organization in order to create innovation and sustainable competitive, is arguably central factor for the active involvement in development initiatives of knowledge-based systems (Ho *et al.,* 2014). These systems are created in order to reach the best possible outcome in a situation, that is, efficient responses in problem solving and sustainable decision-making for the organization.

To this end, this research aims to develop a model that explores the relationships between lean practices, knowledge management and information management as supports management decision making, which

1 **Cátia Milena Lopes Machado** (catia.machado7@gmail.com)
Dpto. de Administração. Faculdade Dom Alberto, Brasil.
2 **Annibal Scavarda** (annibal.scavarda@unirio.br)
Departamento de Engenharia de Produção.
Universidade Federal do Estado do Rio de Janeiro.Brasil.
3 **Liane M Kipper** (liane@unisc.br)
4 **Rejane Frozza** (frozza@unisc.br)
Programa de Pós-Graduação em Sistemas e Processos Industriais Mestrado,
Universidade de Santa Cruz do Sul, Brasil.

can contribute to the organizational development of a medium-sized industry using the Value Stream Map (VSM) to identify the causes and waste, enabling the decision-making assertive thus making the production process more suited to the current competitive environment.

This research is divided into five sections, including this introduction, literature review, methodology, model to support the dissemination of knowledge and decision-making and conclusion.

2 Literature Review

2.1 Knowledge Based lean Technique

The biggest challenge for organizations today is the involvement and identification of delivering value every customer and stakeholders to meet this challenge requires ability to be lean in entrepreneurial level (Marodin *et al.,* 2014).

It is not today the concern of organizations with the efficiency and effectiveness of its processes, in this sense, to Womack and Jones (2000), Lean is a way to do more with less, while offering customers exactly they desire. The key to the successful implementation of Lean Thinking system is transparency. This system will only bring benefits to the company through a dedicated team to understand this new culture, so that everyone can use this philosophy in the most optimized way possible.

To achieve the goal proposed by the thin, one needs to apply some tools such as value stream map, Total Productive Maintenance (TPM): Takt Time (TT): Just in Time: 5S: Kaizen: Kanban and others, which will help in getting the results. In organizations management methodologies by more modern they are, always need real knowledge so that it becomes in value. Therefore companies should take care that the knowledge generated in the organization is not dispersed. These tools are instruments used for the implementation of lean philosophy, which dictate "how to" follow their principles (Badurdeen *et al.,* 2011).

As the authors Womack and Jones (2000), since for a given product value has been specified precisely, the mapped value stream, the steps that do not add value are eliminated, it is essential that the value in the process flow, smooth and continuously, within the three critical management tasks: problem solving, information management and physical transformation, making the lean process (Al-Najem *et al.,* 2012).

The value stream mapping (VSM) is one of the essential tools of lean, which is the process of identifying all activities that occur in the processing of the product. Value stream is understood as a set of all activities that occur from the request from order to delivery of the product to the consumer. It is a model of observation and understanding of the current state and the design of a map of the processes is the visual representation of every process in the material flow and information revising a set of key points and draw a future state map of how production should flow. Another benefit that provides the VSM is the mapping of knowledge within organizations.

2.2 Information and Knowledge Management

Information management comprises up in organizational environments as a set of activities aimed at: getting a diagnosis of information needs; map the formal information flows in the various sectors of the organization; prospect, collect, filter, monitor, disseminate information of different nature; and develop services and information products, aiming to support the development of activities / daily tasks and decision making in these environments (Isik *et al.,* 2012).

Knowledge management (KM) is a set of activities aimed at working the organizational / informational culture and organizational / informational communication in organizational environments, in order to encourage a positive environment in relation to the creation / generation, acquisition / seizure, sharing / socialization and use / use of organizational knowledge (Smith *et al.,* 2004).

The KM has established itself as a valuable alternative management for organizations looking for a way to effectively leverage the knowledge available in environment. The intention of maximizing knowledge within the group of employees can promote both individual training as well as enhance the community (Wu *et al.,* 2014; Isik *et al.,* 2012).

The KM term implies the use of mechanisms that help organizations manage knowledge as an asset that promotes organizational development. Knowledge Management seeks to approximate the man of information technology, enhancing human cognitive ability within an organizational context.

As Massingham (2014) the integration of KM to business processes covers not only protect the intangible assets of an organization, as also develop them and lever-age them, stimulating the creation of more adapted products and services customer needs and increasing the competitiveness of the organization. Thus, business processes are seen as the main liaison between the work and skills of members of an organization and the wishes of their customers (Smith *et al.,* 2004). Become also instruments for the implementation and formalization of the GC in the company and for the realization of their potential benefits. According to Lin *et al.,* (2014), KM is increasingly recognized as a key success factor for organizations

2.3 Systems Based on Knowledge Support for Decision Making

The decision-making process is the main function of managers, because there is no perfect decision, always have to think about the advantages and disadvantages of each alternative to choose the best, always seeking the best economic performance, noting that there are also non-economic results such as the satisfaction of members of the business and employees (Demirkan *et al.,* 2013). Decision making is a process that consists in identifying the problem, criteria, how to pre-pare, analyze and choose alternatives, checking the effectiveness of the decision. The decision-making act can be an act of suffering, the great difficulty to make decisions often happens when have not the knowledge of a particular subject or process.

Within the KM, decision Support Systems (DSS's) are compounds for knowledge based systems (KBS) and knowledge support systems. The KBS can be best de-scribed as software developed to meet the needs of specific user, usually as an application specialist in a particular area, to assist in decision making (*Demirkan et al.*, 2013). It should represent all the descriptions of the system, necessary for the process to be performed properly and if necessary, solving problems encountered efficiently. To initiate studies on knowledge-based systems is to differentiate what is data, in-formation and knowledge. Information and knowledge explicitly depend on a factor called, data or data to be built structure. In this case, the capture process is necessary, and therefore, analysis of these data so can be the process of transforming data into information, following the implementation of the knowledge to finally to take the appropriate decision problem.

As a result, important decisions are made without the necessary information, that is, without a correct analysis of the data (Oliva 2014; Massingham *et al.,* 2014). In this sense, the need for adequate storage of knowledge, that is, the need for processing of all data that travels the organization in information capable of forming a knowledge base to support decision-making.

3 Methodology

Compared to the main goal, this research is exploratory and descriptive. It is exploratory why aims to provide greater familiarity with the subject performing data collection, reporting its true importance, the stage where are and reveal new sources of information, involving literature. It is descriptive, because from the exploratory research will be conducted the survey of the features that are part of the problem.

This research will use as a data collection procedure case study methodology, as select an object. In this case, seeks to discover the connection of lean, knowledge and information management, so that can develop in knowledge-based tool and practices of lean for achieving a proper management decision making to minimize waste.The diagnosis of the main sources of waste was identified through the VSM Map helps identify the sources of waste in the value stream. After identified and prioritized the sources and types of waste, by analyzing the VSM, proposals were developed for improvement using lean manufacturing to the knowledge-based tools, such as tool example kaizen.

4 The Case Study

The present study was conducted in a medium-sized toy company in Brazil.

The mapping begins with the expected demand for sales made from client requests, extends to the production and logistics. The product manufacturing process consists of 24 activities. The mapping shows a high rate of inventory, from raw material to finished stock in shipping product, as well as the stocks of intermediate items in all activities. When the VSM is designed / created, problem areas have become apparent. Bottlenecks, the accumulation of stock, with low quality processes and operations that require excessive coordination should all be marked as kaizen explosion, indicating areas the focus.

It was noted that the company's information system generates a lot of paperwork, has little flexibility and efficiency and intermediate stocks are relatively high.

Most of the information system areas, online management system, online program and online monitoring of production are related to information systems, this is due to poor or lack of information, especially of a system that manages the information at the time of occurrence. Check out what's happening during production is crucial to minimize the problems and helps in better decision making. The intermediate stocks demonstrate a lack of control in intermediate stocks. It identified many products waiting to be processed due to lack of organization or absence of a sequential program.

5 Model to support the dissemination of knowledge and decision-making

It presents the application of the proposed methodologies (Lean, information through the knowledge based systems (KBS), Knowledge Management), as well as suggestions for improvements proposed for the case study in building a system that helps to minimize the main waste identified the stock, and proposal a model for a decision making.

The main reason for adopting a program of process improvement is to achieve a significant improvement in quality, productivity, costs and get control of the process used by the organization. If the organization has no control of the process, this is reflected in numerous losses. So, no need to obtain a standardized process that allows the tracking and control of the production stages.

With this in mind, this system is designed to assist the control of production, identify improvements / waste, providing information for the growth of operational knowledge.

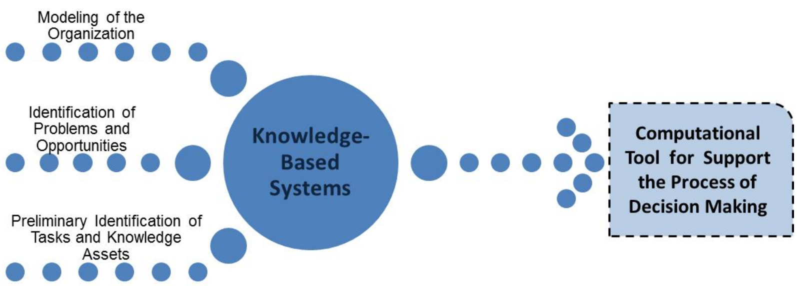

Fig.1
Structure of the tool.

Figure 1 is the overall structure of the proposed developed according to the following steps:

- Model of Organization, and the analysis of the main characteristics of the organization, with the aim of discovering problems and opportunities for knowledge systems, establish its feasibility and measure the impact on the organization of actions required knowledge.
- Tasks modeling are relevant parts of a business process. The task model analyzes the global task layout, its inputs, outputs, conditions and performance criteria, as well as resources and skills.
- Modeling agents are the executors of a task. An agent may be human, an information system or any other entity capable of performing a task. In addition, lists the communication links between needed to perform a task agent.
- Modeling of communication and knowledge, it is important to model the communication transactions between them, because many agents may be involved in a task. This is done by the communication model, independently of implementation or concept, as the knowledge model, with the purpose of the knowledge model is to explain, in detail, the types and structures of knowledge used to perform a task. This makes the model of knowledge an important means of communication with experts and users on aspects of solving the problem of a system of knowledge, in both the development and implementation.

- Knowledge-Based System, gathers, organizes and retrieves information. The main components of a KBS include a database of knowledge, knowledge representation, search engines and inference engines. Inference refers to the ability of the system to create new knowledge and continuously expand the system, assisting in decision making.

6 Conclusion

This research proposed the model explores the relationships between lean practices, knowledge management and information management supports the management decision making.

The value of a strategic decision for the business depends on information available to the manager of an organization, the training that has to interpret them and experience to associate them in a convenient way. The only sustainable advantage of a company is what known collectively as efficiently it uses the knowledge or organizational-and the readiness with which it acquires and manages the plan.

In this sense, knowledge management helps the process of collecting and structuring of knowledge within a company. The model was developed to provide learning, transfer and application of knowledge. The main tools of dissemination of knowledge can be considered the reports, which focus on purpose of providing accurate and timely information, there is no help to better decision-making, as the goals and strategies of the organization and knowledge bases.

Through the tool presented is necessary to highlight the issue of developed knowledge base. Its purpose is to manage, collect, store, combine and disseminate data, information and knowledge. Knowledge discovery in databases process can support decision making in order to maintain the competitive organizations in relation to competition and stay mainly in the market.

According to the theoretical model, the main KBS are associated with the existence of a knowledge base and reasoning engine able to draw conclusions on this basis to generate conclusions.

The Daily Board, and generate, collect, combine and disseminate data, information and knowledge, generates a base of various data reports for food, for example, stocks, volume, productivity, and others report. The knowledge base contains all the information necessary for the particular problem domain, resulting in an intelligent and specialized program for troubleshooting.

For validation / assessment tool, queries, allowing experts to ascertain the results were performed. For example, all part of registration, planning, production and verification of the results in reports of a given product was performed.

References

Al-Najem, M.; Dhakal, H.N.; Bennett, N., 2012. The role of culture and leadership in lean transformation: a review and assessment model. International Journal of Lean Thinking, v.3, n.1.

Badurdeen, F. Wijekoon, K.; Marksberry, P., 2011. An analytical hierarchy process-based tool to evaluate value systems for lean transformations. Journal of Manufacturing Technology Management, vol. 22 n. 1.

Dal Forno, A.J. Pereira, F. A. Forcellini, F. A. Kipper, L.M., 2014. Value Stream Mapping: a study about the problems and challenges found in the literature from the past 15 years about application of Lean tools. Int J Adv Manuf Technol. Vol. 72, pp 779-790.

Demirkan, Haluk, Delen, Dursun. 2013. Leveraging the capabilities of service-oriented decision support systems: Putting analytics and big data in cloud. Decision Support Systems. Vol 55, n. 1, pp. 412-421.

Ho, Chin-Fu; Hsieh, Pei-Hsuan; Hung, Wei-His. 2014. Enablers and processes for effective knowledge management, Industrial Management & Data Systems, Vol. 114 n. 5, pp.734 – 754.

Isik, O.; Mertens, W.; Bergh, J.V., 2012. Practices of knowledge intensive process management: quantitative insights. Business Process Management Journal, Vol. 19, n. 3, pp. 515-534

Lin, Hsiu-Fen, 2014.Contextual factors affecting knowledge management diffusion in SMEs. Industrial Management & Data Systems, Vol. 114, n. 9, pp.1415 - 1437

Marodin, Giuliano Almeida; Saurim, Tarcisio Abreu, 2013. Implementing lean production systems: research areas and opportunities for future studies. International Journal of Production Research, Vol. 51, n. 22, pp.6663-6680.

Massingham, Peter. 2014. An evaluation of knowledge management tools: Part 1 – managing knowledge resources, Journal of Knowledge Management, Vol. 18 n. 6, pp.1075 – 1100.

Oliva, Fabio Lotti. 2014. Knowledge management barriers, practices and maturity model, Journal of Knowledge Management, Vol. 18 n. 6, pp.1053 – 1074.

Smith,H.A.; Mckeen,J.D., 2004. Development sin practice: Knowledge- enabling business process. Communications of the Association for information Systems, Vol.13.

Womack,J.P.; Jones,D.T.; Roos,D., 2000. A Máquina que mudou o Mundo. RiodeJaneiroEd.Campus,ed.10.

Wu, Ing-Long; Chen, Jian-Liang . 2014. Knowledge management driven firm performance: the roles of business process capabilities and organizational learning. Journal of Knowledge Management, Vol. 18 n. 6, pp.1141 – 1164.

Business Process Management as an Alternative for Promotion of Knowledge Management

Matos M[1], Sá E[2], Silva R[3]

Abstract: This paper presents how Knowledge Management can be supported by Business Process Management. As results, this research proposes a KM lifecycle supported by BPM and describe each correlation between phases of KM and BPM.

Keywords: Knowledge Management, Business Process Management.

1 Introduction

Companies need to keep yourself updated regarding best management practices to become competitive and to survive on globalization and extensive competition.

Knowledge Management (KM) is a business strategy that seeks to increase the competitiveness and ensure the sustainability of enterprises by encouraging the creation and use of organizational knowledge. According Tarapanoff (2006), the focus of knowledge management is the effective application of what is known in the organization to ensure their development and survival.

Business Process Management (BPM) is another business strategy that uses the management of work processes to promote organizational efficiency and increase competitiveness.

There is a degree of approximation between BPM and KM in many ways. The benefits offered by BPM, for example, are potential actions of knowledge generating and application in organizations. The objective of this work is to show that BPM is an enabler of KM.

Two important definitions should be considered for the entire context of this work. First, BPMS (Business Process Management System) is considered as part of BPM. Second, knowledge is considered as an intangible asset that exists only in people's minds, which can't be stored in the form of physical or electronic media. It can't be distributed or shared. According Tarapanoff (2006), knowledge is not a thing, but a complex and dynamic process.

2 Problem and Motivation

A major problem in the management of knowledge is the tendency for people to retain their knowledge. Even those that don't do this intentionally simply may not be motivated to show what they know (DOS SANTOS, 2001).

There are major efforts of companies to develop institutional policies that stimulate KM. Propositions of organizational structures oriented for KM, learning process focused on the individual, socialization and interactions between people and groups, activities oriented by work processes, Information Systems implementation and top management commitment are examples of such efforts.

1 **Marcos Matos** (marcosmatos30@yahoo.com.br)
Depto. Engenharia da Computação.
Univ. Estadual do Maranhão. Tirirical, São Luís, MA, BR.
2 **Eveline Sá** (eveline@ifma.edu.br)
Depto. Informática, Inst. Federal de Educação.
Campus Monte Castelo, São Luis, MA, BR.
3 **Reinaldo Silva** (reinaldo.silvarrb@gmail.com)
Depto. Engenharia da Computação.
Univ. Estadual do Maranhão. Tirirical, São Luís, MA, BR.

The hypothesis in this study is that BPM is an alternative to obtaining the KM. This suspicion is justified by the BPM cover the efforts mentioned above to support KM. BPM: proposes a virtual organizational structure focused on business processes; encourages learning of the individual; in its essence is a systematization of work routines based processes; has as a critical success factor the top management commitment; promotes collaboration among employees; and has the support of specific IT tools, called BPMS.

3 Justification

In literature there are many works linking BPM and KM, but there are few that explain how this approach is. This work aims to cover the theoretical gap between KM and BPM relations.

Many studies expose a correlation between the lifecycle of BPM and KM, however, merely indicate a positional correspondence between the steps. This paper presents how each BPM step contributes to the creation, storage, share and application steps of the KM lifecycle. It presents also a proposal for KM lifecycle supported by BPM.

Therefore it is understood that this study contributes to researchers and practitioners in the areas of Management, Information Systems and Production Engineering by BPM proposition as an enabler of KM and the proposition of a new KM lifecycle supported by BPM.

4 Methodology Approach

An exploratory research was conducted with the objective of discovering relevant variables on the relationship between KM and BPM. For this, bibliographic queries and content analyzes were performed in Information Science, Production Engineering, Computer Science and also in Administration.

5 Theoretical Referential

Never produced so many data nowadays. The fact is that the data, in most cases, are used only as a means of proof of an action rather than as raw material for creating information.

Dalkir (2005) defines data as content that is directly observable and verifiable and information as a content that represents analyzed data.

According Tarapanoff (2006), organization should use the information for create meaning, build knowledge and make decisions. This author defines knowledge as it is what we know and it involves the mental processes of understanding, comprehension and learning that take place in the mind and only in the mind, regardless of interaction with the world outside the mind and the interaction with other.

Knowledge Management represents a deliberate and systematic approach to ensure the full utilization of the organization's knowledge base, coupled with the potential of individual skills, competencies, thoughts, innovations, and ideas to create a more efficient and effective organization (DALKIR, 2005).

Knowledge Management is a discipline that works systematically to information and knowledge in order to increase the response capacity of the company to the environment with innovation and expertise, developing the effectiveness and corporate knowledge (TREHAN, 2005).

BPM implies a permanent and continuous commitment of the organization to manage its processes. This includes a number of activities, such as modeling, analysis, design, performance measurement and processes transformation (ABPMP, 2013).

Weske (2007) says that the objective of BPM, reporting that the most important goal of business process management is a better understanding of the operations a company performs and their relationships. The explicit representation of business processes is the core concept to achieving this better understanding.

It is much easier to implement a BPM initiative when this is supported by a computer system of business process management, which is the BPMS. Association of Business Process Management Professionals (ABPMP, 2013) reports that a BPMS provides a new level of automation by creating and implementing applications that combine logic shown in business models with rules and data connected to the activities.

The phases of BPM lifecycle defined by the Association of Business Process Management Professionals (ABPMP, 2013) were adopted in this research. The phases are *Planning*, *Analysis*, *Design*, *Implementation*, *Monitoring & Control* and *Improvement*. BPM lifecycle is cyclical and continuous.

6 Proposal KM Lifecycle Supported by BPM

There are several definitions about KM lifecycle, some of them are defined by the following authors. Becerra-Fernandez, Gonzalez and Sabherwal (2003) define it with four phases: discovery, capture, share and application. Nair and Prakash (2009) define it with 5 phases: identification, creating, storage, share and application. Alavi and Leidner (2001) define it with 4 phases: creation, storage, transfer and application.

In this paper it will assumed the proposal of Alavi and Leidner, but it is considered some modification. This author considers that knowledge can be storage, which is divergent of the definitions of knowledge adopted in this work. Here, it is considered that knowledge can't be saved in any structured information stored in electronic databases. Data and information can be stored and shared.

A proposal of lifecycle of KM supported by BPM is described in the figure 1.

7 BPM as Enabler of KM

According to Pimentel and Fuks (2011), the collaboration has a decisive impact on the construction of knowledge. They also report that the exercise of collaboration requires appropriate systems for the registration of individual productions, for socialization of production, for coordination of actions, for intelligent retrieval of information produced and its reflection on the final product.

Many technological solutions to support KM are summarized in the automation of data generation routines and information provision, through developing a database, accessed by software. This type of initiative has major contribution in Store and Share steps of KM lifecycle. It is very common to hear that organizations do KM when in fact what they do is Information Management.

BPM is a business strategy that includes support of top management, employee commitment, collaborative activities, election of processes that represent core activities of the company, the planned versus realized analysis, incorporating improvements every cycle, governance and IT. For all these features, the BPM is elected as an enabler of KM methodology.

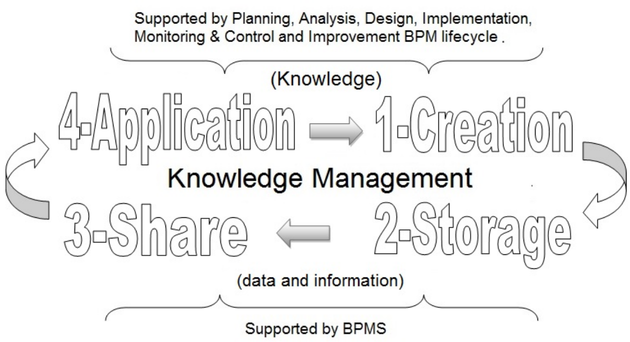

Fig.1
Proposal KM lifecycle supported by BPM.

7.1 Creation and Application Phases of the KM Lifecycle

The first phase of a BPM, *Planning*, consists in a stage of socialization among employees who meet to identify organizational priorities, business processes and also the definition of actions for the implementation of BPM. To achieve this goal, knowledge workers, top management, managers and technical experts meet to share experiences, conduct brainstorm, validate ideas, apply problem-solving techniques etc. Finally, it creates an environment conducive to intensive production of knowledge, necessary to define the goals and business strategies.

The *Analysis* is the stage complementary to the *Planning*. While in the first stage the business processes were defined, in the Analysis, these processes need to be detailed. There is a stimulus to the creation of knowledge to define each component activity of the processes.

The *Design* is the phase of BPM lifecycle that produces as result the business processes modeling. This is an electronic artifact with great potential to become the principal generator source of knowledge for the organization.

In the *Implementation* phase, the next one after *Design*, where instances of processes are executed, a large volume of data is generated. It is impossible to direct transformation of data into knowledge, however, is relatively simple to transform data into information. Since there is the availability of information, it creates the possibility of generating knowledge.

Also regarding *Implementation*, there are situations that activities do not follow the expected procedure and exception situations happen. This requires changing the process design and results in a potential activity of knowledge creation. As Sordi (2006), the exception indication is not just for the process instance does not stand still and someone to give the necessary routing, but also for knowledge management of business rules, often providing the inclusion of a new rule or change existing ones.

In the *Monitoring & Control* phase, raw data are transformed in information through management reports and become potential generators of knowledge.

The *Improvement* is the last stage of the BPM lifecycle and consists in a moment of reflection of all the steps taken previously. In this stage, employees and employers can evaluate the business processes and improve the efficiency of the organization with the knowledge produced during the whole lifecycle of BPM. For this, the stakeholders can get together to exchange experiences, report the difficulties, describe the best practices, share the problem solving, among other actions.

Now referring to the Application phase of the KM, apply knowledge means reuse existing knowledge in familiar or unfamiliar situations instead of create new knowledge for these situations, however, this is not a simple task, it is necessary to identify the types of work performed by employees.

Employees known as knowledge workers, responsible for the creation of new products and services, as well as the creation of marketing programs and business strategies, have great tendency to create new knowledge rather than reuse existing knowledge. According Brocke e Rosemann (2013), knowledge workers often have the power to resist being told what to do, and process analysis is usually a sophisticated approach to having someone else tell you how to do your job.

The adoption of BPM to stimulate reuse of knowledge by knowledge workers is limited to submit them to follow support processes, related with routines and internal rules.

In the case of the employees whose processes of job are well defined, dependent on formal rules and procedures for implementation, BPM is a working methodology that provides all the conditions for the knowledge be reused and improve the organization. The cyclical and continuous nature of the stages of BPM stimulates the application of prior knowledge.

In the *Planning* phase of the BPM happens the revision of some business processes or inclusion of new business processes. These actions will use the experiences obtained in previous cycles.

In the *Analysis* phase of the BPM, the business processes defined in the planning stage, are detailed. In this stage are needed the use of tacit and explicit knowledge existing in the organization to identify how the activities are carried out and how they can be optimized.

The *Design* phase of the BPM includes the modeling of business processes. When there is no process designed, it's used the detailed business process from *Analysis* stage for the production of the first model. When there are modeled processes, creating new process becomes easier with the use of existing processes models.

The *Implementation* phase consists of electronic forms that indicate the ways of running instances of processes. In practice, employees have to apply the knowledge created by mentors and modelers processes.

In the *Monitoring & Control* step, real and expected results are compared and these information reveal errors, successes, deviations, areas with great performance and areas inefficient. So, in the last BPM stage, the *Improvement*, real data are analyzed and become source of information to identify and solve the problems and improve the organization.

7.2 Storage and Share Phases of the KM Lifecycle

It's considered that these two phases of the KM are related only with storage and sharing of data and information. It's also considered that knowledge can't be stored and shared. BPMS is the main actor that supports these phases.

To support Storage KM phase, the *Design* and *Implementation* phases of a BPM lifecycle are the protagonists.

As the process is designed in a specific BPMS module, occurs automatically its storage in a database. In the *Implementation* phase of BPM, instances of process are executed through a software interface and a large number of data are stored in a structured database. Objectively, BPMS natively support the storage and sharing of data and information.

Related with Share KM phase, it's important to say that some organizational data and information, stored in libraries, electronic database or other means, should have their controlled access. Strategic information, for example, should be preserved and restricted to certain members only. On the other hand, many organizational information of great value, without restricted access, are stored and inaccessible to employees. The Share stage of KM manages these situations.

The functionality of access control through user profile and data security, inherent in a BPMS, allows data and information to be easily and securely shared in an organization.

BPMS have the exportation functionality of processes models to many standards, highlighting the XPDL format that allows exchange of models between BPMS of distinct developers. It's also possible export the modeled processes to HTML format and easily promote the information sharing through the intranet.

8 Related Works

Sena, Dandolini and Schneider (2013) present a proposal for integration between BPM and KM and identify desirable features in a BPMS that support this integration. The authors propose an interesting correlation between the lifecycle of BPM and KM, but the features presented only describe common features of any BPMS. The authors also consider that knowledge can be stored in electronic media through storing business processes models.

9 Conclusion

This work presented empirical data indicating the validation of the hypothesis that BPM is an enabler of KM by describing correlations between the lifecycles of them. However, it's necessary more practical experimentation and theoretical investigation to clearly validate the hypothesis.

Another aspect is that the hypothesis relates the BPM only as an enabler of KM. This implies that a successful implementation of BPM produces a breeding and suitable ground for KM, with potential to happen a continuous flow of generation of knowledge and spontaneous use of it. But, it is important to mention that a successful KM depends of the humans contributions. Terra e Gordon (2002) report that the KM does not happen without the active participation of employees and the company itself. Contributing with the thought, Dos Santos (2001) describes that there are some challenges to overcome in Knowledge Management: worker behavior, considered the greatest of them; and make the organization's leaders buy the idea.

10 References

ABPMP (2013). Guia para o Gerenciamento de Processos de Negócio Corpo Comum de Conhecimento (BPM CBOK V 3.0). Association of Business Process Management Professionals, 1st ed.

Alavi, M; Leidner, D. (2001) Knowledge management and knowledge management systems: conceptual foundations and research issues, MIS Quarterly, 25(1): 107-136.

Becerra-Fernandes, I; Gonzalez, A; Sabherwal, R. (2003) Knowledge Management: Challenges, Solutions and Technologies. Prentice Hall.

Dalkir, K. (2005). Knowledge Management in Theory and Practice. Burlington: Elsevier Butterworth-Heinemann.

Dos Santos, A. R. et al. (Org.) (2001) Gestão do Conhecimento: uma Experiência para o Sucesso Empresarial. [Online] Available from http://www1.serpro.gov.br/publicacoes/gco_site/. [Acessed: 10th February 2015].

Nair, P.; Prakash, K. (2009) Knowledge Management: Facilitator's Guide. Tokyo: Asian Productivity Organization.

Pimentel, M; Fuks H. (Org.) (2011) Sistemas Colaborativos. Rio de Janeiro: Elsevier.

Sena, M. A. C.; Dandolini, G. A.; Schneider, V. (2013). Funcionalidades Desejáveis em um BPMS para Suportar os Processos de Gestão do Conhecimento. [Online] Available from http://www.aedb.br/seget/arquivos/artigos13/40618636.pdf. [Acessed: 15th January 2015].

Tarapanoff, K. (Org.). (2006) Inteligência, Informação e Conhecimento. Brasília: IBICT, UNESCO.

Terra, J. C. C.; Gordon, C. (2002) Portais corporativos: a revolução na gestão do conhecimento. São Paulo: Negócio Editora.

Trehan, R. (2005). Knowledge Management, a business perspective. [Online] Available from http://www.hospitalitynet.org/news/4024789.print [Acessed: 24th February 2015].

Weske, M. (2007) Business Process Management: Conecpts, Languages and Architectures. Heidelberg: Springer.

The overcoming challenges of technology for ceramic industry with a partnership university-company: a brazilian experience in innovation search

Tamanine A[1], Lourenço G[2], Pasini E[3]

Abstract: The partnership between universities and companies allied to intrapreneurship, planning, technical field of industrial processes, technological foresight and creativity were factors which led the company Casagrande Ceramic Coatings SA develop an efficient solution to a problem detected by the client in a the product market leader in tiles. The aim of this paper is to report, broadly, this experience occurred in southern Brazil, involving business and universities in the pursuit of innovation was chosen competitive strategy. Research and technological forecasting as impact factors in the development of an improved product and the importance of industrial management - operations management in organizations and their systematic approaches - were treated as reasons for the effective arrival of the new product to the market and its characterization as innovation. The main result, occurs highlight the value of university-industry partnerships and business to business as essential to the functioning of the national innovation system.

Keywords: Ceramic industry; partnership university-company; product innovation.

1 Introduction

For almost 40 years working expressively in the Brazilian construction market, Casagrande Ceramic Coatings SA continually develops new concepts and solutions for your business. Along that time, the production of ceramic glazed *semi-gres* tiles produced in the process via single firing drought earlier study also originated the partnership between university and company - provided an opportunity to a significant share of total sales in the domestic tiles market. Parts sales until the end of 2014 totaled more than two million five hundred thousand monthly items, a result that works with the company's goal to be a leader in this segment in the country.

It was in 2008 that the *semi-gres* tile, target product of this study, was launched in the domestic market and has revolutionized the ceramic production sector. The company Casagrande Ceramic was the second brand in Brazil to adopt this new tiles manufacturing method. The new tile was highlighted by having the same quality guarantees a tiled piece of *semi-gres* flooring, ie have high quality in mechanical strength properties to freezing, salinity and low water absorption. In addition, it presents minimal dimensional variation and high aesthetic beauty, factors that have made it the reference product in tiles. This new type of manufacturing caused impact on companies producing conventional tiles as it generated great market prospects gain and sparked immediate interest among producers of the floor segment and coatings. In this regard, since its launch, there were more than a dozen manufacturers in Brazil, bringing the volume of domestic production for close to 16 million pieces month.

1 **Andréa M. B. Tamanine** (atamanine@yahoo.com.br)
2 **Gilberto Lourenço** (gilberto.lourenco@rcasagrande.com.br)
3 **Evandro T. Pasini** (etpasini@uol.com.br)
Dept . Mechanical Production Engineering.
University of Joinville Region - Univille.
Rua Norberto Eduardo Weihermann,
230 Colonial , Sao Bento do Sul , SC , Brazil.

Named *PClassic* Tiles, ceramic tiles Casagrande was the first to bring to market a line of various accessories in porcelain for tiling. As the company invests in innovation, it was also the first to bring to market the tiles with glaze application on bells. Also between the years 2013 and 2014, the Casagrande launched several new products on the market for line tiles and, with continued increased competition in the new segment, has launched a brand new tiles, the *Pgres* exclusively for combat. All these initiatives have led to the Casagrande Ceramic to become a reference for new manufacturers. Your monthly billing on the 1st. *PClassic* sales year exceeded 1.2 million pieces sold, the product for which the company provides full warranty for 50 years. In less than four years after the product launch, the company had an average turnover of more than two million six hundred thousand monthly parts, ie, an increase in line with the quality given to processes dedicated to the product and its derivatives.

But despite the use of simulations, the new product had not yet sufficient history in the market to certify the performance under special conditions and eventually present a problem. Initially, the client's account of drip under the roof was interpreted as infiltration between the parts, so the negotiations for solution adopted by the company, the recommendation of the blanket placed under the roof, had no effect. The problem remained and customers continued to complain about the product.

Thus, from a stronger manifestation of the problem of a distributor and his client, located in the state of Espirito Santo, southeastern Brazil, a survey on the ground and the technical team Casagrande company it was made after analysis of the environment, the team identified that the problem was not caused by water infiltration, but by condensation. From this evidence, a new technological challenge is put before the company and the partnership with the university was again the path chosen for their solution. The main objective of this report, therefore, is to present part of the research work carried out for reaching a solution to the condensation problem presented in the use of *PClassic* tiles. The work was conducted in partnership between university and companies, making real the process of interaction so that innovations come to more quickly and efficiently market, as advocated in the current Brazilian innovation policies.

2 The university-industry partnership

In the place visited by the technicians of Ceramic Coatings company to check the problem in the state of Espirito Santo, a nearby residence to the sea, the high moisture was not absorbed by the tiles, because they had a total waterproofing the surface under and over the product. Also, for their dimensional quality in the construction of the roof did not occur any space for ventilation, getting the internal and external environments fully packed. Thus they were formed droplets in a row tile drip after receiving the warmth of the sun. Understood the reason of the problem, it was given the difficulty of solution, mainly because the cause is linked to a major product quality characteristics: a low water absorption.

Given this fact, the need for technological research to resolve the issue in an innovative way, adding more value and quality to the product before the customer and surpassing the competition has become essential concern of the company. Another very important factor is that Silva (2012) gives much emphasis to the act of creation. For the author, the development of new products, and consider the functional, technological and economic factors, there must be clear predominance of style over durability and image of efficiency. Products under no circumstances may fail to comply with human needs and the preservation of natural ecosystems. In addition, innovative organizations depend on their ability to meet not only the technical requirements of the product but also meet the needs and desires of its customers, key players in innovative processes such as creation and diffusion. It is important to consider that culture and innovation "interact and influence each other, and are reflected in the results of innovative development" (DAVILA, EPSTEIN, SHELTON, 2008, p. 244). So it is clear to innovate and effectively for a competitive front differential to its competitors, it is also necessary for the company to be well structured for the management of its human and physical resources, as well as relative to its historical and dynamic knowledge, calculate risks and it is pre-disposed to partnerships. Thus, companies must seek innovation strategies, active or reactive, and its success will depend on different factors such as "os recursos à sua disposição, sua história, a atitude de seus diri-gentes ou a sua boa ou má estrela"[4] (REIS, 2008, p.82).

Faced with the technological need mentioned, the partnership between company and university was the strategy used for the research and development process was conducted. Then originated the now reported academic work, the company's partnership between Casagrande Ceramic Coatings with the University of Joinville Region - Univille, located in São Bento do Sul - SC. The formalization was made through the Internship Required in the course of Production Engineering and had the guidance of teachers researchers, supervision and technical support Professional Development area of Company products Casagrande Ceramic and implementation by the academic those who finished. The main strategy initially set the group was the maximum use of available resources in the company, conducting prospecting of products with similar functionality and application technology research for a new solution. The possibility of forming partnerships business to business was still not a considered factor, however has become fundamental in the solution, as explained below.

2.1 Methodological aspects

In order to guarantee greater assertiveness in all the actions taken, the work was developed based on literature review, experimental and descriptive research. Part of the activities was reported here with applying the following methodological resources:

a) preliminary analysis of the situation-problem to define its size and its relevance to the organization through the *control charts* and *Pareto chart*. Knowing yourself is essential for the management function can establish the correct setting parameters between "fontes selecionadas e o contexto da empresa em termos de seus próprios recursos e capacidade de absorção"[5] (TIDD, BESSANT, PAVITT, 2008, p.395).

b) application of decision matrix was carried out quantitative analysis to view the most appropriate way device manufacturing and restrictions in relation to internal manufacturing, which confirmed the unfeasibility. Which also served to confer the necessary characteristics to the product without causing bottlenecks to tile manufacturing process;

c) defined the project scope, benchmarking was applied because the ability of businesses to take ownership of relevant knowledge from external sources becomes a competitive advantage (REIS, 2008). They were carried out technical visits to companies selected to present the project and survey of the manufacturing costs, and the study of adjustments necessary to device characteristics;

d) to obtain knowledge of the products on the market, technological prospecting was carried out on banks of patents and other sources of technological information;

e) with all mapped conditions, device models have been developed in CAD 3D computer graphics software. The ability to analyze the characteristics of the physical performance of a project before creating the prototype and / or product can significantly increase productivity through predictive data, because the simulation capabilities can solve complex analysis problems;

f) finally, there is that were used project management tools such as EAP, EAR financial and physical schedule, and the decision matrix through the PMBOK methodology (2004) in order to perform and evaluate effectively design.

2.2 The identification of the problem and the solution search

To set the project, a decision matrix having three alternative reference was elaborated: 1) designing a device for mounting on tile (pump); 2) design a tile air circulation system; 3) acquire an existing device on the market. Among the possibilities, selecting the first alternative option as the work took place from

[5] [..] "selected sources and the company context in terms of their own resources and absorption capacity" (TIDD, BESSANT, PAVITT, 2008, p.395). *(Our translation)*

the identification of the lack of solutions on the market and the financial and structural impossibility of making and integration into the manufacturing of a specific die shop process to produce a piece with double functionality. Then, the project focus was directed to the development of a complementary device to the tile that can be coupled to *PClassic*, but offer visual identification of a single piece.

Also to ensure the successful development of the pump design air, the Risk Breakdown Structure, which were selected potential risks to the progress of the air circulator design for installation in *PClassic* tile was developed. You might view the potential risks identified in pump design air from the quantitative analysis and qualitative analysis of risk by assessing and combining their probability of occurrence and impact.

After he left to technological prospecting similar products for identification and study of applied technologies that would boost the generation of new ideas and/or whose adaptation possible and legally permissible for solution of the problem under study. So, with no solutions in the domestic market researched in foreign markets, with particular attention to Europe, more precisely to the Spanish and Italian markets because they are great references and global influences on ceramic concept. With the prospect been found that in European output tiles are occurring ever developed for roof ventilation, and the manufacturing process of the product quite different from that used in Ceramic Coatings Casagrande, some steps of the craft virtually processing. Therefore, no products formed a single piece, differentiating the sought solution, a separate piece that can be coupled to *PClassic* tile. Still, they identified as products of two European companies manufacturers of conventional ceramic tiles that inspired the development of drafts of air circulator device for installation in semi-stoneware tile.

Another determining factor in the development of the pump model was technological research conducted in parallel to another project developed in Univille by engineering students, this related to a vehicle on ethanol for participation in national competition called Energy Efficiency Marathon. The vehicle had a ventilation problem for the propulsion system and the pilot's cockpit, therefore a group of academics developed the structure of the vehicle an air circulation system that had excellent performance, then the solution was adapted and used as a reference in development of the air pump in the model 3D modeling.

After different projects of the devices to the pump not approved because of the high degree of complexity of manufacturing, was prepared and submitted a proposal for a device on the tile last, after joint analysis among the sectors of production, RD, quality and commercial, was approved by company management, as can be seen in Figure 1.

Fig.1
Approved pump image.
Source: Primary (2014)

In the design shown in Figure 01 fins were developed inside the product in order to avoid possible rainwater flow returns, which you can view in the project outline. Also shape has been carefully studied so that, beyond aesthetics and functionality, facilitate its production. During project design, it was taken into consideration the hole size required in tile to install the pump so that remained discreet, did not affect the quality characteristics of the product in question and was in default of diamond glass saws available on the market.

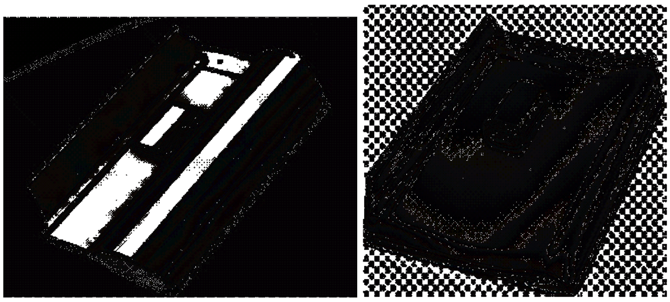

Fig.2
Image Air Circulator mounting Classic and Plan Tile
Source: Primary (2014)

With the approval of the project by the company, the presentation of all simulated product testing and further development of the prototype, went to benchmarking step, given the aforementioned impossibility changes in the production system of own Casagrande. Benchmarking, according Ballestero-Alvarez (2010), is presented as a valuable tool to initiate, guide and depersonalize the way for continuous improvement. When establishing a new set of measures is achieved unfreeze the mindset to compliance standards. Therefore, it is said that benchmarking lays the foundation for overcoming the past, creating a new culture with the best of the past, but without the unproductive approach.

Technical visits were scheduled at three factories of São Bento do Sul (A, B, C), manufacturers in porcelain, and in Criciuma - SC (D) in order to meet the manufacturing process and make a conversation starter for the manufacture of the air circulator. The company chosen from the technical visits was to the ceramics industry in São Bento do Sul. As a partner of choice, factors such as geographical proximity and possibilities of new interactions knowledge were considered by Casagrande. To Kupfer (2002, p.431), the company is conceived as a living organism constantly changing influences that receives from its environment (market), but at the same time is able to transform it or create new markets or industries from the introduction of technological innovations. In this sense, the ceramic industry portfolio, which only included plates, cups and many utensils in porcelain dishes, now also produce the air flow throughout the Casagrande Ceramic gaining a new niche market, establishing a win-win. (FONTENOT *et alli*, 1998).

The assembly process of the ventilated tile was prepared simply and easy to drive, with a production capacity of 600 pieces daily. Today that par would be enough to supply the market demand, which is around 0.25% of the total production of tiles Casagrande Ceramic Coatings currently revolves around 2.400.000.00 monthly parts, which will surely be increased.

2.3 Conclusions about the experience

In this study, we wanted to highlight the importance of the partnership between the university and the company as a key element for the success of the innovation system, and in particular sought to strongly encourage the vision of this partnership as a competitive advantage on the companies involved. Is important evidence the role of the university in the formation of intrapreneurs, as the executor academic fit the transformation of ideas into results, developing a feasible and appropriate solution for the organization and the market. For Reis (2008, p.173), an employee can be an entrepreneur within the organization; no need to leave the company where he works to experience emotions, the risks and rewards an idea transformed into reality can offer.

It was also objective of this study report the value of being open to the interventions of the customer as fundamental inputs to innovate. And, to highlight the value of traditional management tools as indispensable in the management of innovative processes within enterprises. Finally, there is the consensus that there is no single model that guarantees success for innovative organizations, but partnerships and meet and constantly evaluate their own internal technological capabilities, as well as monitor the competitors, is notorious requirement for the technological innovation process occurs and is continuously enhanced.

3 References

Ballestero-Alvarez E M (2010) Gestão de Qualidade, produção e operações. São Paulo: Atlas.

Davila, T.; Epstein, M.; Shelton, R.(2008) As regras da inovação: como gerenciar, medir e lucrar. Porto Alegre: Bookman.

Fontenot, R.; Vlosky, R.; Wilson, E. & Wilson, D. (1998) Effect of Buyer-Seller Relationship Structure on Firm Performance. American Marketing Association - Winter Conference, Feb.

Kupfer, David. (2002) Economia Industrial: Fundamentos teóricos e práticos no Brasil. Rio de Janeiro: Elsevier.

Pmbok (2004) Project Management Institute, Inc, Conjunto de Conhecimentos em Gerenciamento de Projetos. 2. ed. Pennsylvania- EUA, Four Campus Boulevard. p. 5-112-161-249.

Reis, D R (2008) Gestão da Inovação Tecnológica. Barueri-SP: Manole.

Silva, Christian Luiz da. (2012) Inovação e Sustentabilidade. Curitiba, Aymará educação. p.13. Tidd, J; Bessant, J; Pavitt, K.(2008) Gestão da Inovação. 3 ed., Porto Alegre: Bookman.

Contribution of Design Thinking to Jet Engines Manufacturing

Pereira J[1], Quelhas O[2], Lima G[3]

Abstract: The objective of this paper is to examine the contribution of design thinking to quantitative risk analysis in the manufacturing of jet engines focused on software, human and calibration reliability. Interview with experienced technicians raised the risk factors in the different processes in the engine manufacturing. Affinity diagram classified the risk factors into three categories: human, software and calibration reliability. Within each category, Bayesian network represented the risk factors taking into account their interdependency. Final prototyping validated the networks. Results indicate that the design thinking is an adequate technique for qualitative risk analysis in preparation for quantitative risk analysis. The benefits of the technique are evident and have practical implications for specialists dealing with the identification of risk factors in the quantitative risk analysis in the manufacturing of jet engines and other industries

Keywords: Design Thinking; Quantitative Risk Analysis; Jet engine manufacturing.

1 Introduction

The jet engines manufacturing industry faces a variety of risks, many capable of compromising the viability of an organization. In order to ensure decision makers consider the probability and severity of adverse consequences on product reliability, risks need to be addressed through probabilistic risk analysis in a systemic way (Leveson, 2011), (Boring et al., 2010), (Beugin et al., 2007), (Droguett et al., 2014), (Esteves et al., 2005). Bayesian Networks is very useful (Groth and Swiler, 2013), (Podofillini and Dang, 2013) and (Pasman and Wiliam, 2013) for this purpose. Omnipresent in the manufacturing industry, poor decision making are usually detrimental to the whole system. The manufacturing of jet engines is very complex and depends on the performance of software, equipment and humans (Pereira, 2012). Knowledge of causal sequences of engine failure in operation situation is crucial (Pereira and Lima, 2015a) and (Pereira, Quelhas and Lima, 2015b). The novelty of this paper is the use of design thinking approach to aid in the construction of a transparent causal structure in a risk model that explicitly relates the overall level of safety to individual processes safety.

2 Objective

The main objective of the paper is to examine the contribution of Design Thinking (DT) approach to Quantitative Risk Analysis (QRA) in the manufacturing of jet engines. This paper complements a previous paper published by the authors and addresses the following hypothesis: H1: Design thinking as resource has positive effect on the determination of risk factors for quantitative risk analysis.

1 **José C. Pereira** (pereirajosecristiano084@gmail.com)
2 **Osvaldo Quelhas** (quelhas@latec.uff.br)
3 **Gilson Brito Alves Lima** (glima@id.uff.br)
Industrial Engineering Department,
Universidade Federal Fluminense (UFF),
Rua Passos da Patria, 156, Bloco D, Niteroi, RJ, Brasil, 24210-240.

3 Method

Design Thinking process (Behm et al., 2014), (Brown, 2008), (Brown, 2009), (Dunne and Roger, 2006), (Goh et al., 2010), (Hall et al., 2013), (Ilipinar et al. (2011), (Johnston, 2010), (kimbell, 2009) and (Martin, 2009) was employed. Technicians recorded the risk factors on several insight cards. By using affinity diagram, the insight cards were grouped by similarity. A conceptual map was built for each category by representing the risk factors in specific tables to represent their interdependency. Specialists reviewed the risk factors to verify their compatibility with the established objectives and criteria. The last step was the construction of Bayesian Network prototypes based on the conceptual map and have them validated by specialists.

4 Results

Figures 01, 02 and 03 show the prototypes of Bayesian Networks built with the aid of design thinking process. The networks show the risk factors and their interdependency. As proposed in the objective session, the risk factors for quantitative risk analysis were determined effectively with the aid of design thinking.

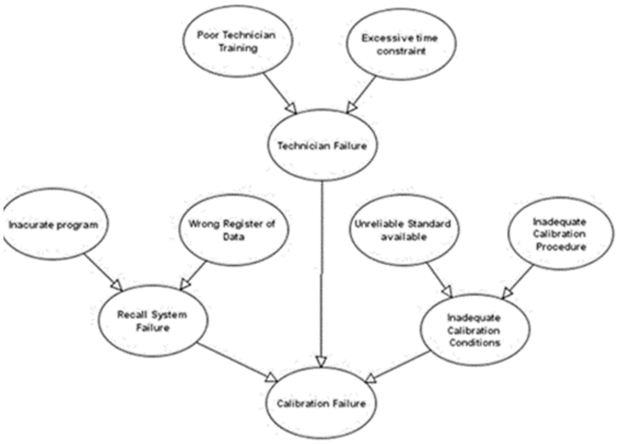

Figure 01 – Bayesian Network
Calibration reliability

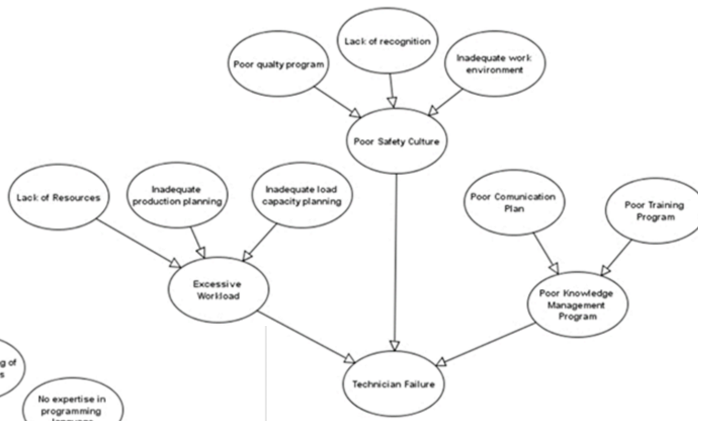

Figure 03 – Bayesian Network
Technician reliability

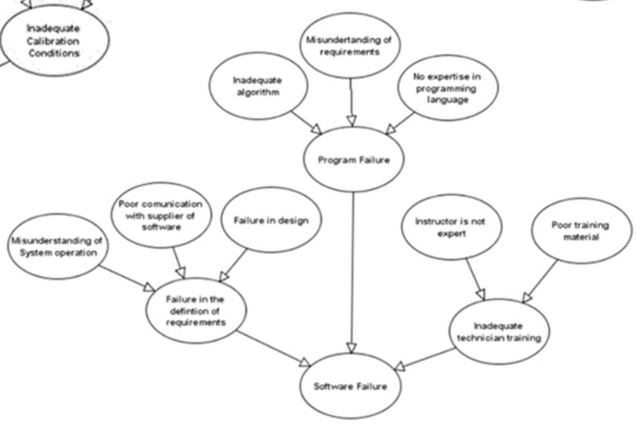

Figure 03 – Bayesian Network
Software reliability

5 Conclusion

The paper's contribution and novelty is the proposal of a methodology to perform a qualitative risk analysis to identify the main risk factors in preparation for quantitative risk analysis. Based on the results, the conclusion is that this methodology is effective to build the Bayesian networks, so the hypothesis is validated, confirming that design thinking, as a resource, has positive effect on the determination of risk factors for quantitative risk analysis.

6 References

Behm, M; Culvenor, J; Dixon, G., 2014. Development of design thinking among engineering student. Safety Science 63, 1-7.

Beugin J, Renaux D, Cauffriez L., 2007. A SIL quantification approach based on an operating situation model for safety evaluation in complex guided transportation systems. Reliability Engineering and System Safety, 92: 1686-1700.

Boring R L, Hendrickson S M L, Forester, J A., 2010. Issues in benchmarking human reliability analysis methods: A literature review. Reliability Engineering and System Safety, 95: 591-605.

Brown, T., 2008 'Design thinking.' Harvard Business Review, June 2008, 84-92.

Brown, T., 2009. Change by design: How design thinking transforms organizations and inspires innovation. New York: Harper Business.

Droguett E.L, Groen F, Mosleh A., 2004. The combined use of data and expert estimates in population variability analysis. Reliability Engineering and System Safety, 83:311-21.

Dunne, D.; Roger M., 2006. 'Design thinking and how it will change management education: An interview and discussion.' Academy of Management Learning & Education, 5/4: 512–523.

Esteves, A S; Lima, G.B.A; Quelhas, O. L. G., 2005. Process Risk Assessment and Management in a Petroleum Production Nucleus. Petroleum Science and Technology; 23: 5-6.

Goh, Y.; Brown, H.; Spickett, J., 2010. Applying systems thinking concepts in the analysis of major incidents and safety culture. Safety Science 48 (3), 302–309.

Groth K, Swiler L P., 2013. Bridging the gap between HRA research and HRA practice: A Bayesian network version of SPAR-H. Reliability Engineering and System Safety, 115: 33-42.

Hall et al., 2013. Future aircraft cabins and design thinking: optimization vs. win-win scenarios. Propulsion and Power Research; 2(2):85–95.

Ilipinar, G., Johnston, W. J., Montaña, J., Spender, JC, Truex, D., 2011. Design Thinking in the Postmodern Organization. China-USA Business Review, ISSN 1537-1514. (10-11), 1203-1212.

Johnston, I., 2010. Beyond "best practice" road safety thinking and systems management – A case for culture change research. Safety Science 48 (9), 1175–118.

Kimbell, L., 2009. 'The turn to service design' in Guy Julier and Liz Moor (eds.), Design and creativity: Policy, management and practice, 157-173. Oxford: Berg.

Leveson, N. G., 2011. Applying systems thinking to analyze and learn from events. Safety Science 49 (1) 55–64. 4

Martin, R., 2009. The design of business. Why design thinking is the next competitive ad-vantage. Cambridge: Harvard Business Press.

Pasman; R., William, 2013. Bayesian networks make LOPA more effective, QRA more trans-parent and flexible, and thus safety more definable! Journal of Loss Prevention in the Process Industries; 26: 434-442.

Pereira, J.C., 2012; Lima, G.B.A., Critical operational risk factors in the aeronautical maintenance industry. In: Brazilian Association of Production Engineering (ENEGEP), TN-STO-158-925-19430.

Pereira, J.C.; Lima, G.B.A., 2015(a). Probabilistic risk analysis in manufacturing situational operation: application of modelling techniques and causal structure to improve. International Journal of Production Management and Engineering, 10.4995/2015.3287, 3(1), 49-58.

Pereira, J.C.; Lima, G.B.A., 2015(b). Probabilistic risk analysis in manufacturing situational operation: application of modelling techniques and causal structure to improve. Int. J. Decision Sciences, Risk and Management, 5 (3), 293-309, 2014.

Podofillini L, Dang V.N., 2013. A Bayesian approach to treat expert-elicited probabilities in human reliability analysis model construction. Reliability Engineering and System Safety; 117: 52-64.

Innovation management in Brazilian retailer

Catelan VD[1], Marques KFS[2], Naimer SC[3], Siluk JCM[4], Werner L[5]

Abstract: Innovation is now recognized as an essential factor for the competitiveness of organizations. In this context, the study aimed to identify aspects that contribute to the management of innovation. The survey was applied in one of the largest electronics networks in Brazil, in sixteen states dealing with the four operating regions. After applying the diagnosis, it was possible to verify the management of innovation and the innovator potential of the retailer system; identify the main challenges and benefits that contribute to the perception of the factors that actually have an influence in management of innovation in nation retailing.

Keywords: Retail Management; Business Competitiveness; Performance Evaluation.

1 Introduction

The last decades show a period of profound changes in the world scenario, both social and economical as behavior and consumption of the population.

Research says that there is a high level of insecurity on the part of managers in diagnosing the management of innovation in their companies. For this are necessary tools, in order to provide means to achieve a better understanding of the practice of innovation management.

Therefore, it was constituted the research problem, represented by the following question: "The Diagnosis of Innovation Management can assist in fostering innovation aimed at improving the performance and competitiveness in an organization of the retail sector?" Where it is intended to diagnose the management of innovation in retail.

2 Objectives

This research aimed to identify aspects that contribute to the management of innovation, by applying the diagnosis of innovation management.

3 Methods

The research includes the company being study and its branch offices, sixteen states located in four Brazilian regions of network performance, where the application of the diagnosis of innovation management was made.

To verify the diagnosis, it was first necessary the realization of tests and statistical analysis, for safety and accuracy of the method.

To check the reliability of the scales it was chosen the *Alpha de Crombach*, by measuring the internal consistency between the items that compose each dimension, presenting a variation of 0 to 1, whereas values lower than 0,6 indicate an unsatisfactory consistency (Malhotra, 2006; Crespo, 2009).

For the eight dimensions it used the correlation test in order to verify that the independent variables are significantly correlated with the overall result.

1 **Kelen Franciane Scherolt Marques** (UFRGS)
2 **Julio Cezar Mairesse Siluk** (UFSM)
3 **Liane Werner** (UFRGS)
4 **Verônica Dallmolin Catelan** (UFSM)
5 **Simone Caberte Naimer** (UFSM)

Completed the analysis of the reliability and correlation of the factors in relation to the general, began the analysis of eight independent dimensions (Strategy, Culture, Relationships, Financial, Structure, Process, People and Leadership) in the network and the results by acting regions.

4 Results

At the end of this research, as table 1 shows the results of the eight dimensions analyzed in the branches of the four regions that the network operates:

Table 1
The results of the eight dimensions analyzed.

Region.	**CO**	**S**	**SE**	**NE**	**Total**	**p-value***
Strategy	4,13	4,16	4,14	4,19	4,16	0,9603
Culture	4,03	4,21	4,17	4,16	4,18	0,6063
Relationship	3,90	4,03	4,18	4,09	4,11	0,0090
Financial	3,68	3,89	4,06	3,92	3,97	0,0031
Structure	3,70	4,06	4,06	4,12	4,06	0,1936
Process	3,96	4,09	4,14	4,02	4,10	0,1336
People	3,92	4,10	4,13	4,07	4,10	0,2401
Leadership	4,20	4,12	4,20	4,21	4,18	0,2812
Total	3,92	4,07	4,13	4,08	4,09	0,0108

* Kruskal-Wallis test - the same letters did not differ statistically (Dunn test)

It can be observed that the diagnosis in relation to the strategy dimension the highest rate (4.19) was obtained in the Northeast region. In relation to the dimension the highest rate obtained Culture (4.21) was in the South region. For the other regions it is noted that the Southeast region presented in its total the best rate (4.13) compared to the others. The region also had the highest rates of diagnosis on the dimension relation-ship (4.18), Financial (4.06), Process (4.14) and People (4.13). It can be said that the region is directly related to the network process, whereas out of the eight dimensions evaluated four of them showed high rates.

5 Conclusion

So as, to answer the research problem it was observed the great importance of the diagnosis of innovation management, to promote innovation, improvements in performance and competitiveness in retail companies.

References

Crespo AA (2009) Estatística, 19 ed. São Paulo. Saraiva.

Malhotra N (2006) Pesquisa de marketing: uma orientação aplicada. Porto Alegre: Bookman.

PMO standardization through Hoshin Kanri

Improving the Management of Projects by Process Management

Villalba Díez J[1], Ordieres Meré J[2], Alba Elías F[3], González Marcoa A[4]

Abstract: Project management has become more than just a supporting role for businesses. For many organizations, it is a relevant part of getting things done, and the many tasks associated with managing projects require more attention than just the scope of work of individual project management professionals (PMPs). This paper will contribute by showing how through taking standardization as the goal as well as using it internally, the Project management Offices (PMO) will contribute to the maturity level of the organization in terms of project management and increase the sustainability of their business. The core concept of this contribution is the use of Hoshin Kanri (HK) ideas to standardize communication among the process-responsible members at the PMO. Finally, application from a practical point of view is presented and its meaning discussed.

Keywords: Project Management; PMO; Communication Standardization; Maturity Models.

1 Introduction

Projects have become important instruments for change and development in organizations. There are many approaches to studying project performance but one of the most common is investigation of critical success factors (CSFs) as predictors of performance. For example, Pinto (Pinto, Slevin 1988) identified 10 CSFs, ranging from project mission, top management support, project schedule/plan, client consultation, technical tasks and communication, to personnel recruitment/selection and training. These CSF are quite project-centric but other proposals (Seddon, Calvert & Yang 2010) have promoted other factors that consider not only intra-project aspects but organizational ones. Some authors suggest that the broader utilization of projects requires a new orientation in project management (PM) and a new model for more effective operations in project-driven organizations as presented in reference (Dai, Wells 2004). In spite of the advantages of using the project approach, however, Jessen (Jessen 1993) suggests that because of the one-time nature of projects, an organization may often derive little benefit from previous successes and failures due to a lack of effective knowledge transfer. Improvements are required in order to foster process management to help the project development style; those improvements need to address the lack of knowledge transfer. As previously mentioned, this can be done by means of increasing trust as well as standardization of activities.

Management of project knowledge is a critical factor for project success. In this sense PMO can be seen as a unit within organizations to centrally facilitate, manage and control organizational projects to improve the rate of success. The role of the PMO varies between organizations: it can play a major strategic role while in other organizations it can play a more limited supportive role. Desouza & Evaristo (2006) identify different roles for the PMO, ranging between strategic, tactical and operational. In that

1 **Javier Villalba Díez** (jvdiez@gmail.com)
CEO of Center for Leadership Mannheim UG,
Waldseerstrasse 102, 88400 Biberach, Germany. PMQ research group.

2 **Joaquín Ordieres Meré** (j.ordieres@upm.es)
PMQ research group. Depto IOAEyE, ETSII.
Universidad Politécnica de Madrid. c/ José Gutiérrez Abascal 2, Madrid, Spain.

3 **Fernando Alba Elías** (fernando.alba@unirioja.es)

4 **Ana González Marcos** (ana.gonzalez@unirioja.es)
Mechanical Engieering Department. Universidad de la Rioja.
Luis de Ulloa 20, 26004 Logroño. La Rioja. Spain.

sense the research in this paper is focused on the PMO playing the operational role, and in some cases the tactical role, when its focus is on fostering consistent quality of products and services generated by projects.

The latest research studies illustrate that there was an increment estimated at 39% of organizations having PMOs between the years 2000 and 2014 (Research 2015). This jump can be seen as indicating that the importance of the PMO is growing over time. Due to increased interest of developing PMOs, the Project Management Maturity Model (PMM) has been proposed to help develop PMOs gradually (Spalek 2012). The PMM contributes to evolvement of PMO from immature to mature levels through addressing appropriate PM practices. Despite the importance of project knowledge, it has not been extensively investigated in project environments.

The potential is recognized for the PMO to introduce order and systematic view in the front end of innovation projects, which were understood in the past to be the most troublesome and chaotic phase of the innovation process. At the same time, the front end provides the greatest opportunities to improve the overall innovative capability of a company (Artto et al. 2011).

It is also relevant to highlight that the human resource management practices in the project context are still underdeveloped. They have been recognized as a basis for achieving competitive advantage (Yang et al. 2014).

The following areas for improvement are combined in this paper:

- Trust based on standardization of procedures.
- PMO as leader for process standardization both internally and across projects.
- Communication in the project as a key area for improvement.

A strategy for standardizing the inter-process communication at the PMO will extend the maturity of PM across the organization, as well as foster knowledge management in projects. The way of getting this standardization is not just a set of rules but it will be based on a kind of continuous improvement mechanism (Villalba Díez, Ordieres-Mere 2015).

In an organizational business context as those where the projects grow, with numerous interdependent process owners (POs) acting simultaneously at different levels (tasks, work packages, monitoring, configuration, reporting and so on), a model of the system helps to understand the interactions. In this paper, the organization will be depicted as an oriented network of nodes (POs) connected through arcs which represent structured exchanges of information. This view is compatible with the existing theories of organizational design (Cross et al. 2010). As these environments used to be different and dynamic, such POs need to be aligned towards a common direction (HOSHIN), adding value to the sequence itself.

Furthermore, researchers have argued that not only support of empowerment management systems are necessary, but also alignment with strategic purposes, understood as "compliance with strategic plans and targets" (Cäker, Siverbo 2014). Certain studies (Frow, Marginson & Ogden 2010) show that multiple controls are needed to balance both empowerment of PO and the alignment towards strategic goals. HOSHIN KANRI (HK) (management by giving direction) (Jolayemi 2008) is a comprehensive management system that enables such alignment of complex systems.

Section 2 of this paper will deal with process standardization, knowledge management impact in PM and PMO impact in the PMM in more depth, as well as looking at the relevance of the communication in the PM. In section 3, the proposal of the PMO inter-process standardization of communications mechanism will be presented and discussed against the common way of looking for maturity through a PMO. Section 4 will present a case study, and finally in section 5 a discussion of the main findings as well as the conclusions will be presented.

2 Literature Review

In the organizational environment, barriers to communication are easily detected and difficult to overcome (Sengupta 2011). The complex nature of communication arises from many factors, such as semantics, power politics, and organizational and technological issues (Easton, Gilchrist & Lenney 2012).

Project communication has been of interest to a number of scholars and practitioners and the bodies of knowledge (BoKs) establish guidelines for communication in projects. The use of BoKs, such as those from PMI and the capability maturity model from (CMM/CMMI) has increased in different projects.

Furthermore, efficient performance requires intense and media-rich communication among project stakeholders.

From an organizational perspective, the PMO plays a significant role because its primary function is to develop and monitor compliance with organizational PM methodology (policies, processes, procedures and best practices). The PMO represents a bridge between the organization's strategy and projects. It also coordinates communication across projects and collects data from projects, consolidating them and reporting to internal and external stakeholders (Nahod, Radujković 2013). Desouza & Evaristo (2006) argue that tacit knowledge obtained through projects is difficult to capture. Therefore, it is important to build a bridge between PM and knowledge management, creating collaborative communities for project managers that are centralized through the PMOs.

The success of the formal communication strategy strongly depends on trust (Maurer 2010). Koskinen & Pihlanto (2007) introduce four types of trust for a project setting: deterrence-based trust, role-based trust, knowledge-based trust, and identification-based trust. When properly managed, the PMO approach will foster at least the role-based and the knowledge-based trust. Standardization of formal communication processes will help to increase the identification-based trust and this is one of the more significant aspects of using HK approach. HK as described in HOSHIN KANRI TREE (Villalba Díez, Ordieres-Mere 2015) can be understood as a KPI-driven, behavioral process management method. HK is implemented by standardizing the communication between process owners (POs) through *(CPD)nA*, thus creating an organizational structural network of autonomous agents whose actions are guided by certain strategic goals.

3 PMO inter-process standardization of communications

Standardization practices are not new in project management. They have been reported as relevant to a project's success (Fernandes, Ward & Araújo 2014). This paper will attempt to exploit an opportunity to extend the standardization of processes related to the management of the project (at least those being part of the common knowledge that the company should develop) into the project management daily activities. The goal is to gain an insight into the performance of the projects and also increase the corporate knowledge of the company.

In the rest of this paper, when referring to inter-process standardization the authors shall refer to both PMO internal processes as well as cross-functional processes such as Yokotenkai 横展開, (Hino 2007) in its PM related version.

The authors consider the *(CPD)nA* as inter-process communication standard between PMO agents. The *(CPD)nA* application in the PMO context follows the phases as defined in Villalba Díez & Ordieres-Mere (2015).

The implementation phases of HKT as described in Villalba-Diez & Ordieres-Meré & Nuber (2015) are:

1. *Awareness.* 3G Gemba-Genjitsu-Gembutsu. The purpose of this phase is to raise aware-ness regarding HKT in both PMO and PM.

2. *Nemawashi*. The purpose of this phase is to prepare the foundations by understanding the PMO and PM KPI structure.

3. *Ueru Management*. Planting the HKT. The purpose of this phase is to install Shopfloor Management in both PMO and PM based upon *(CPD)nA*.

4. *Ueki-Ya Leadership Phase*. Taking care of the HKT. The purpose of this phase is for the PMO to acquire the role of Lean Leader as gardener and trust fosterer.

5. *Alignment and Executive Review*. The purpose of this phase is aligning and reviewing PMO efforts with senior management.

The *(CPD)nA* is a cyclical management process of continuous improvement behavioral patterns, which acquires in this PMO context a novel dimension as standard communication pattern between PMO members within the PMO, and between the PMO and their customers.

4 Case Study

The research site for this study is Global Equipment Manufacturer (GEM), which produces a variety of machines. In 2013, GEM reported around $3 billion in revenue, with around 10,000 employees and 11 factories in 4 continents. The data for this study comes from GEM's headquarters' PMO regarding its structure and perceived changes in PMO performance. In this case study we present the change process from the traditional GEM's headquarters' PMO structure towards a Hoshin Kanri based PMO, and present the perceived changes in PMO performance.

We aim to study the effect of the implementation of HKT upon the temporal variation of performance at GEM's PMO in terms of several KPIs.

The PMO's performance is measured on a weekly basis, based upon following KPIs:

- KPI1. Number of PM Members in HKT/Number of Total PM Members. Measured in [%].
- KPI2. PMO Average Project Schedule Delays. Measured in [%]
- KPI3. NHPM/NH Total. Measured in [%].
- KPI4. Project Cost Overrun. Measured in [%].

All data was gathered in an ongoing research effort which spanned 12 months from January to December 2014. The observations of the implementation degree of HKT technology were measured on a weekly basis given by the % of PMO POs and PMO clients involved in the HKT as depicted in Figure 1, where the phase durations have been highlighted.

5 Discussion & Conclusion

By standardizing the PMO inter-process communication through *(CPD)nA,* the PMO adopts the shape of an organizational structural network in which the nodes are the PMO agents and the edges are the KPIs as described in the *(CPD)nA*.

This approach presents several advantages:

1. The PMO benefits from this standardization because it can foster a common language between all PMO activities.

2. The PMO is likely to increase its performance because each PMO agent is responsible for a certain KPI and reports this KPI within the PMO organization, as well as optimizing its value.

3. By standardizing inter-process communication through *(CPD)nA,* organizations will bridge the gap between PMO and knowledge management because all PMO related activities will be recorded throughout the Phase Act. These jointly developed standards serve as common ground by helping identify common platforms for future development.

4. Identification based trust within the PMO and between PMO and the organization is likely to increase because of inter-process communication standardization due to the increased transparency upon expectations.

5. An example of this system is provided by HKT. If HKT technology is implemented, the PMO management can run PMO wide shop floor management, thus deploying strategic and operational goals throughout PMO organization.

6. The PMO benefits from the *(CPD)nA* standard also in the role of PM due to the evolutional nature of the *(CPD)nA* process management approach. In fact, because the standard in the Phase Act has evolved in closed relationship with the operational process owner, the project can benefits from the standardization.

7. To conclude, we can establish that by creating a structural organizational network within the PMO and by linking this network with the rest of the organization through the PM, the PMO will be empowered towards new levels of influence in the organization. The PMO becomes an even more important player in the strategic task of process standardization because each of its activities (internal and PM-related) happen via an inter-process communication standard such as *(CPD)nA*.

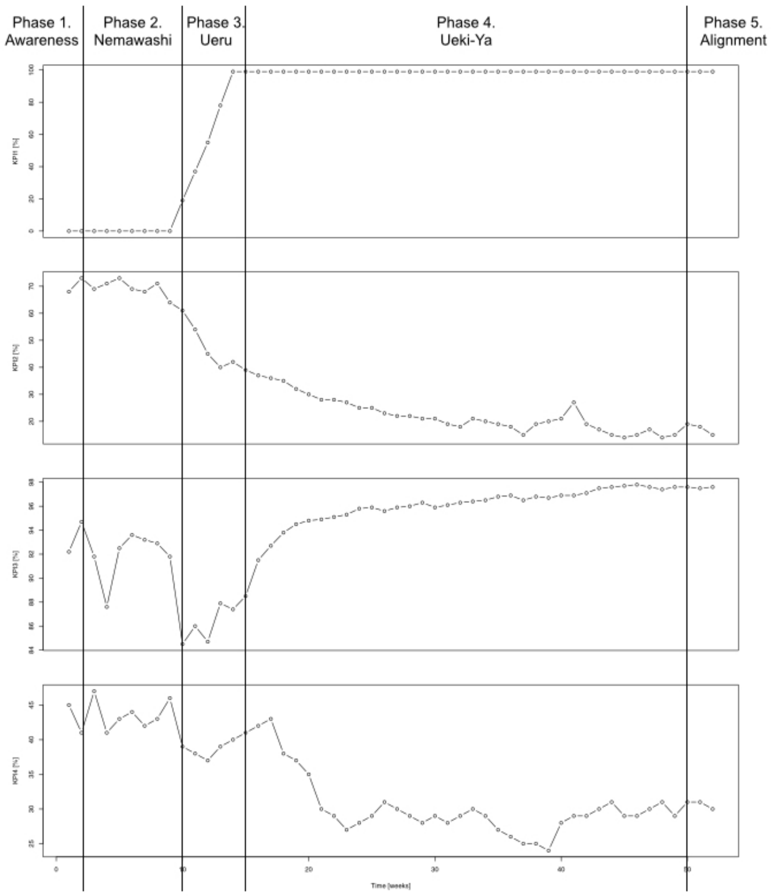

Fig.1
Time evolution of the four defined KPIs where the impact of the implementation of the Communication Standardization is clearly identified.

6 References

Artto, K., Kulvik, I., Poskela, J. and Turkulainen, V. (2011), "The integrative role of the project management office in the front end of innovation", *International Journal of Project Management,* Vol. 29, No. 4, pp. 408.

Cäker, M. and Siverbo, S. (2014), "Strategic alignment in decentralized organizations – The case of Svenska Handelsbanken", *Scandinavian Journal of Management,* Vol. 30, No. 2, pp. 149.

Cross, R.L., Singer, J., Colella, S., Thomas, R.J. and Silverstone, Y. (2010), *The organizational network fieldbook: Best practices, techniques and exercises to drive organizational innovation and performance* translated by Anonymous John Wiley \& Sons.

Dai, C.X. and Wells, W.G. (2004), "An exploration of project management office features and their relationship to project performance", *International Journal of Project Management,* Vol. 22, No. 7, pp. 523.

Desouza, K.C. and Evaristo, J.R. (2006), "Project Management Offices: A Case of Knowledge-based Archetypes", *Int.J.Inf.Manag.,* Vol. 26, No. 5, pp. 414-423.

Easton, G., Gilchrist, A. and Lenney, P. (2012), "The Co-constitutiveness Nature of Organizations and Industrial Networks: A Critical Realist Approach", "The Co-constitutiveness Nature of Organizations and Industrial Networks: A Critical Realist Approach", *28th IMP Conference*.

Fernandes, G., Ward, S. and Araújo, M. (2014), "Developing a Framework for Embedding Useful Project Management Improvement Initiatives in Organizations", *Project Management Journal,* Vol. 45, No. 4, pp. 81-108.

Frow, N., Marginson, D. and Ogden, S. (2010), "“Continuous” budgeting: Reconciling budget flexibility with budgetary control", *Accounting, Organizations and Society,* Vol. 35, No. 4, pp. 444.

Hino (2007), "トヨタ経営システムの真髄 (The essence of the Toyota management system)", "トヨタ経営システムの真髄 (The essence of the Toyota management system)", , University of Hiroshima, pp. 35.

Jessen, S.A. (1993), *The nature of project leadership* translated by Anonymous Oxford University Press.

Jolayemi, J.K. (2008), "Hoshin kanri and hoshin process: A review and literature survey", *Total Quality Management \ & Business Excellence,* Vol. 19, No. 3, pp. 295-320.

Koskinen, K.U. and Pihlanto, P. (2007), "Trust in a knowledge related project work environment", *International Journal of Management and Decision Making,* Vol. 8, No. 1, pp. 75-88.

Maurer, I. (2010), "How to build trust in inter-organizational projects: The impact of project staffing and project rewards on the formation of trust, knowledge acquisition and product innovation", *International Journal of Project Management,* Vol. 28, No. 7, pp. 629.

Nahod, M. and Radujković, M.V.M. (2013), "The Impact of \ICB\ 3.0 Competences on Project Management Success", *Procedia - Social and Behavioral Sciences,* Vol. 74, No. 0, pp. 244.

Pinto, J.K. and Slevin, D.P. (1988), "Project success: definitions and measurement techniques", *Project Management Journal,* Vol. 1988/2, No. 19, pp. 67-72.

Research, P.S. (2015), "The State of the Project Management Office (PMO) 2014"Vol. 1, pp. 1-12.

Seddon, P.B., Calvert, C. and Yang, S. (2010), "A Multi-project Model of Key Factors Affecting Organizational Benefits from Enterprise Systems", *MIS Q.,* Vol. 34, No. 2, pp. 305-328.

Sengupta, S. (2011), *Business and Managerial Communication* translated by Anonymous PHI Learning Pvt. Ltd.

Spalek, S. (2012), "The role of project management office in the multi-project environment", *International Journal of Management and Enterprise Development,* Vol. 12, No. 2, pp. 172-188.

Villalba Díez, J. and Ordieres-Mere, J. (2015), "Improving manufacturing operational performance by standardizing process management.", *Transactions on Engineering Management,* Vol. submitted.

Villalba-Diez, J., Ordieres-Meré, J. and Nuber, G. (2015), "The HOSHIN KANRI TREE. Cross-Plant Lean Shopfloor Management", "The HOSHIN KANRI TREE. Cross-Plant Lean Shopfloor Management", *The 5th Conference on Learning Factories 2015*, Elsevier, Bochum.

Yang, L., Chen, J., Wu, K., Huang, D. and Cheng, C. (2014), "A framework for evaluating relationship among HRM practices, project success and organizational benefit", *Quality & Quantity,* , pp. 1-23.

Measuring Open Innovation Projects

Kissimoto K O[1], Mattos C A[2], Laurindo FJB[1]

Abstract: Measuring open innovation results configures a big challenge for many companies. Previous studies addressing the need to measure the open innovation results mentioned the use of patent data, the success of new product development, percentage of sales in products and services from external technologies, among others. By applying a multiple case study, this research proposes to measure open innovation projects using operational metrics, like the ones that are used to measure a project success. In the studied cases, organizations that adopted a typology where the participants were selected and there was a specific topic of discussion achieved better results.

Keywords: Open Innovation; Performance; Measurement.

1 Introduction

Measuring the open innovation initiatives configures a big challenge for companies. Open innovation might impact different areas within the company – business processes, organizational structure, communication, rewarding system and organizational culture (Remneland-Wikhamn and Wikhamn, 2011), demanding for a more reliable metrics and systems to measure open innovation results (Chesbrough et al.,2006, West et al., 2014).

Previous works presented some dimensions to measure open innovation. Cheng and Huizingh (2014) based their model in three aspects – strategic orientation, innovation performance and control variables. Song *et al*. (2014) analysed the influence of social media in the product innovation results; Gassmann *et al.* (2010) and Laursen, Salter (2006) and Fabrizio (2009) related the search for outside knowledge and the absorptive capacity with a better innovation performance. Based in the open innovation typology literature, this paper aims to understand how the way organizations choose to implement open innovation initiative affects its performance.

2 Methods

Through a multiple case study this research investigated how companies are implementing and measuring the open innovation projects. The selection criteria was companies that fit to one of the open innovation typology cited by Phillips (2011). Six companies were selected, all the interviews were recorded, and a transcription were provided. A coding process were applied and the main findings were grouped around the research constructs. To measure open innovation results, operational metrics from Shenhar and Dvir (2013) were applied to the cases.

3 Results

Phillips (2011) presents four different typology for open innovation, but the one that presented the best results were those when participants were selected and invited to discuss specific topics.

1 **Kumiko Oshio Kissimoto** (kkissimoto@usp.br)
Fernando José Barbin Laurindo (fjblau@usp.br)
University of São Paulo, Production Engineering Dept. São Paulo, Brazil.
2 **Cláudia Aparecida Mattos** (cmattos@fei.edu.br)
Centro Universitário da FEI. São Paulo, Brazil.

4 Conclusion

The way open innovation is implemented affects its results. Applying operational metrics to the open innovation typology is possible to understand if it presents a more immediate results or if its results prepare them for the future.

References

Cheng CCJ; Huizingh EKRE (2014). When Is Open Innovation Beneficial? The Role of Strategic Orientation. *Journal of Product Innovation Management,* 31**,** 1235-1253.

Chesbrough H; Vanhaverbeke W; West J (2006 0. *Open Innovation: Researching a new paradigm,* New York, Oxford University Press Inc.

Fabrizio KR (2009). Absorptive capacity and the search for innovation. *Research Policy,* 38**,** 255-267.

Gassmann O, Enkel E, Chesbrough H (2010). The future of open innovation. *R & D Management,* 40**,** 213-221.

Laursen K; Salter A (2006). Open for innovation: the role of openness in explaining innovation performance among U.K. manufacturing firms. *Strategic Management Journal,* 27**,** 131-150.

Phillips J (2011). Open innovation typology. *In:* Sloane P (ed.) *A guide to open innovation and crowdsourcing.* Great Britain: KoganPage.

Remneland-Wikhamn B; Wikhamn W (2011). Open Innovation Climate Measure: The Introduction of a Validated Scale. *Creativity and Innovation Management,* 20**,** 284-295.

Shenhar AJ; Dvir D (2013). *Reinventing Project Management: The Diamond Approach To Successful Growth And Innovation*, Harvard Business Review Press.

Song GY, Cheon Y, Lee K, Lim H, Chung KY, Rim HC (2014). Multiple categorizations of products: cognitive modeling of customers through social media data mining. *Personal and Ubiquitous Computing,* 18**,** 1387-1403.

West J, Salter A, Vanhaverbeke W, Chesbrough H (2014). Open innovation: The next decade Introduction. *Research Policy,* 43**,** 805-811.

Roadmap for the Implementation of a Project Management Model in a SME of Engineering and Turn-key Supply of Industrial Equipment

Hermida D[1], De la Fuente D[2], García F[3]

Abstract: Project management is focused on planning, executing, monitoring and controlling of all aspects of a project, defined as a temporary effort to carry out a unique result, in order to achieve the targets set under the criteria of time, quality and cost restrictions. In a small or medium-sized organization focused on this type of activity, the integration of the various factors involved in the project life cycle is needed. A roadmap developed as a set of guidelines for effective project management, tailored to this type of organizations but based on the existing sets of best practices and methodological standards (traditionally oriented to huge corporations), is pursued in this work.

Keywords: project management, roadmap, SME.

1 Introduction

Within an organization whose activity is focused on providing "turnkey" industrial equipment and facilities of a generalist character, which can cover many technical areas and adopt very different characteristics, often unique for each type of facility or equipment depending on the different conditions or on the needs of each client, the execution of the productive work must necessarily be oriented to projects.

This research starts with the assumption that the incorporation of management standards in project management can provide solutions to the problems of quality, time and cost due to the lack of integration of the management system, which can cause numerous problems in projects along its entire value chain. The control of information flows and relationships between the various participants (including their cooperation grade and the ability to forecast the impact of their decisions) directly affect the level of quality, time and cost of the project from the initial time.

2 Objectives

The main objective of this work is to establish an optimized set of guidelines which integrates a subsequent flowchart (roadmap) as a model adapted to the initiation, planning, execution, monitoring and closing of projects in SMEs, optimized by applying the best practices contained in the most-globally used methodological standard (PMBOK), and tailored to the particular organization type.

1 **David Hermida Martínez** (hermida@live.co.uk)
Dpto. de Administración de Empresas.
Universidad de Oviedo. Gijón, 33204, Spain.
2 **David De la Fuente García** (david@uniovi.es)
Catedrático de Universidad. Dpto. de Administración de Empresas.
Universidad de Oviedo.
3 **Fernando García De la Vega** (fernando.garcia@tsk.es)
Dpto. de Compras. Grupo TSK.
Parque Tecnológico de Gijón, Gijón, 33204, Spain.

3 Methods

After conduct a comprehensive review of the framework for managing projects, an analysis of the different approaches and its degrees of tailoring to SMEs, and of the relationship of these approaches with the different cultures of the organization, is performed. An analysis of the relationship of that framework to the process-based approaches (EFQM), and to the innovation management, is also performed, as well as the relevance in that framework of existing tools and IT technologies is also considered under the cross objective of obtaining patterns adapted to the objectives of the organization, enabling continuous improvement.

4 Results

Through this way, an initial approach to the operational definition of the roadmap is developed, establishing a flow-structured program for implementation and monitoring processes, analyzing their strengths and weaknesses. Currently a second round of feedback is being prepared throughout an interview to experts.

5 Conclusion

Although there are existing process models and guidelines covering various aspects of project management, they are usually focused on large companies, making necessary to adapt them to the particular conditions of SMEs. In addition, the particularities of the industrial sector and of the organizations dedicated to engineering (regarding management), further accentuate this adaptation needs, which can be achieved through easy-to-install roadmaps for management as proposed.

References

Baum, Michael J.; Kaufman, Chris; Sarkar, Baisali. (2012) Ramp-up PMBOK Adoption in your organization. In: PMI Global Congress Proceedings. Vancouver, Canada

Turner, Rodney; Ledwith, Ann; Kelly, John (2010) Project management in small to medium-sized enterprises. In: International Journal of Project Management. Vol. 28 No. 8

Scientific and Technological Mapping of Magnesium Batteries

Munhoz I[1], Akkari A, Santos N, Santos R, Knupp J, Santos F

Abstract: This study performs a scientific and technological mapping of magnesium batteries through the number of patents. The indicators have shown that patents granted in electrical equipment is growing, as well as the patents related to magnesium batteries. The main holders of this technology are Japanese companies, as Toyota, and main applications are in engineering.

Keywords: magnesium batteries; patents; R&D.

1 Introduction

There is a great interest in evaluating the impacts of Research and Development (R&D), motivated by the need to understand their effects (Dilling-Hansen *et. al*, 2003). In the energy sector, global warming and rising energy crisis raised concerns and research in energy accumulators to achieve improvements in overall environmental and energy scenario.

Coupled to these factors, the battery Magnesium – Air has been considered a promising source of electricity (Huang *et. al*, 2013), mainly by not polluting the environment, it is cheap, has high specific energy and it is the seventh chemical element abundance on the planet. These characteristics have transformed this battery in a potential substitute for other conventional technologies.

However, the magnesium battery has disadvantages that need to be overcome through research to leverage its massive commercial use.

2 Objectives

The objective of this paper is to conduct a scientific and technological mapping of magnesium batteries through an output indicator of R&D (number of patents) in Brazil, Japan and in the world, as well as identify key features of the technology, its key holders and applications.

3 Methods

This is an exploratory study involving a literature survey and the collect and analysis of secondary data obtained from two patent databases, the Intellectual Property Statistics, developed by World Intellectual Property Organization – WIPO, and the Derwent Innovations Index, a patent search tool produced by Thomson Reuters, and a Scientific data bank of companies investing in R&D, the E U Industrial R&D Investment Scoreboard.

Data analysis involved the application of the method of least squares in MATLAB®, to predict future scenarios of the technology and the last step was to draw up a case study, based on the information previously collected, to greater understanding of magnesium batteries in Toyota Motor Corporation.

1 **Igor Polezi Munhoz** (igor.munhoz@ufabc.edu.br)
Centro de Engenharia, Modelagem e Ciências Sociais Aplicadas,
Universidade Federal do ABC, Av. dos Estados, 5001,
CEP: 09210-580, Santo André, SP, Brasil.

4 Results

Indicators of the WIPO have shown that in Brazil, Japan and worldwide, patents granted in electrical equipment and energy are growing, but in Brazil the share of this sector in patent applications is in 8th place, while in Japan is first. Brazil is a country with a recent innovation process, compared to the leading countries, however, Japan has experienced recent crises in growth and economy (1990s onwards) and only in recent years is giving signs of recovery. Even with these problems, Japan invests almost 3.4% of GDP in R&D, while Brazil is close to 1%.

Indicators of Derwent also show that the number of specific patents related to magnesium batteries is growing, but the forecast is slowing. The main holders of this technology are Japanese companies, as Sanyo Electric Co Ltd. The main applications are in engineering, chemistry and energy and fuels, however, is growing in transport, as is the case study with Toyota, to apply in hybrid vehicles.

5 Conclusion

In this study it was possible to analyze the differences in R&D in Brazil and Japan, as well as to identify the trend in the number of patents related to magnesium batteries, identifying the main holders of technology and its uses.

Another contribution is the research methodology developed, which can be applied in other cases for technological exploration and evaluation of the process of research and development of new products.

References

Dilling-Hansen M, Madsen ES, Smith V (2003) Efficiency, R&D and ownership: some empirical evidence. International Journal of Production Economics, doi:10.1016/S0925-5273(02)00302-X.

Huang G, Zhao Y, Wang Y, Zhang H, Pan F (2013) Performance of Mg–air battery based on AZ31 alloy sheet with twins. Materials Letters, doi:10.1016/j.matlet.2013.09.041.

Public Policy Focus on R+D+i for the Demand and Opportunities of Industrial Innovation

Piñero A[1], Rodríguez Monroy C[2], Peláez M A[3]

Abstract: The present work aims to develop a proposal for public policy focus on R+D+i for demand and opportunities for Industrial Innovation, specifically in the area of Small and Medium Industries (SMIs) since they represent a priority for development in the international context. This study summarizes documentary and applied research. The work starts from the discussions and recommendations made by different researchers and international cooperation agencies relating to public policy design for R+D+i to promote demand for product innovation in the market through purchases by State companies or the establishment of partnerships with private business for purchases, in order to encourage and stimulate the interest of SMIs in participating in the R+D+i projects. These recommendations become the basic guidelines for the design of various models of public policy approach to R+D+i.

Keywords: Public Policy for R+D+i; Demand for Innovation; Innovation System.

1 Introduction

The development of the R+D+i has become a priority for government administration designing public policy on R+D+i, to understand that innovation is the alternative to boost economic, social and sustainable development of a country. Benavente et al., (2012) consider that government policies have an important role in establishing a suitable environment for companies to improve their level and willingness to innovate. These initiatives have led to other studies such as Ben (2012), in the evolution of public policy, aimed at cooperation in the interactive R+D+i process with a focus on the Innovation System (IS).

2 Objectives

This paper aims to develop a proposal for R+D+i Public Policy focus for Demand and Opportunities for Industrial Innovation, specifically in the field of SMIs, since this represents a priority area for development in the international context.

3 Methods

The study presents a documentary and applied research type. The research work starts from the discussions and recommendations made by different researchers and international cooperation agencies concerning the design of R+D+i public policy to promote demand for innovation in the market. Subsequently these recommendations, theories of innovation and process innovation system become the basic guidelines for the design of various types of R+D+i public policy approaches for demand and opportunities for industrial innovation.

1 **Alexander Piñero** (alexanderpinero12@gmail.com)
Universidad Nacional Experimental de Guayana (UNEG).
Puerto Ordaz, Venezuela

2 **Carlos Rodríguez Monroy** (crmonroy@etsii.upm.es)

3 **Miguel Ángel Peláez** (mapelaez@etsii.upm.es)
Universidad Politécnica de Madrid.
c/ José Gutiérrez Abascal, 2, 28006 Madrid

4 Results

As results of this study different models are proposed for R+D+i public policy approaches for demand and opportunities for industrial innovation, specifically in SMIs. Each model is described and the role of the government institution in implementing the R+D+i public policy approach is analyzed.

5 Conclusions

The model approach to R+D+i public policy for the demand and opportunities for industrial innovation must have internal assessment stages in the innovation processes of SMIs and the external evaluation concerning the placement of products on the market, in order to detect possible obstacles in the implementation of SMIs' plans to achieve a better capacity in their innovation goals. Without the stages of internal and external evaluation there is the risk of not being able to correct those actions which ensure the compliance with the public policy for R+D+i.

References

Ben M (2012) The evolution of science policy and innovation studies. Research Policy. Volume 41, Issue 7, Pages 1219-1239.

Benavente D, Dutta S, and Wunsch-Vincent S (2012) The Global Innovation Index 2012: Stronger Innovation Linkages for Global Growth. Chapter 1. INSEAD and WIPO 2012. ISBN: 978-2-9522210-2-3. France.

University Technology Enterprise Network in Portugal: A bottom-up approach to Improve Regional Innovation Ecosystems

Resende, D.[1], **Bravo, M.**[2]

Abstract: The objective of this article is to present a successful program that built a National Innovation Network based in the University Technology Transfer Offices (TTOs), incubators and science parks. The University Technology Enterprise Network (UTEN), which was launched in March 2007, includes 15 Portuguese Universities and select international partners in a 5-Year program funded by the Portuguese government. The main objective has been to accelerate the development of a sustainable, globally competitive, professional technology transfer and commercialization network within Portugal to increase Portugal's international competitiveness in university–based science, and technology transfer and commercialization. We argue that all initiatives taken place in the project have gotten UTEN network presently run in the Open Innovation paradigm fostered mostly by the TTOs and their own networks and officers.Science and technology based entrepreneurship was increasingly seen as a key element of Portugal's ability to grow and prosper (UTEN, 2012). Research universities had worked to foster a range of technology transfer and commercialization activities and offices, together with industrial liaison programs, mostly devoted to fostering entrepreneurial environments, launching technology based start-ups, and bringing ideas from the laboratory to the market. UTEN was created to synergize this growth and stimulate new competencies in international technology transfer and commercialization to facilitate industry access to leading markets worldwide. In other words, UTEN is the living example of an Innovation network - an Open Innovation Network launched to contribute to build the necessary relationships between all actors, giving them the necessary knowledge to play their roles. This working paper shows the actions taken to construct UTEN and improve the Portuguese Innovation Ecosystem. These actions follows the patterns observed in other studies – essentially those ones from Resende et al, 2013; McAdam et al., 2012; Philpott et al., 2011; Todorovic et al., 2011; Rogers, 2002; Rogers et al., 2001; Rogers et al., 2000 and Gibson and Rogers, 1994.We have collected data that shows the success of the program based on the results of the first five years of the project.

Keywords: Technology Commercialization; University Industry Relationship; Technology Valorisation; Open Innovation; Innovation Ecosystems.

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1 Environment and Scenario

The Portuguese Science and Technology Foundation (FCT) working with The University of Texas at Austin's IC2 Institute has, launched The University Technology Enterprise Network (UTEN) in March 2007 with the vision of building, within five years, a globally competitive and sustainable science and technology (S&T) transfer and commercialization network, managed by highly trained Portuguese professionals, in close international collaboration, achieving a co-creative environment through the empowered links of the network. In fulfilling this vision, UTEN is working to accelerate the international commercialization of Portuguese science and technology through the development of skills and

1 **David Resende** (david@ua.pt)
Universidade de Aveiro
Escola Superior de Tecnologia e Gestão de Águeda, Portugal.
2 **Marco Bravo** (bravo@ic2.utexas.edu)
IC2 Institute, The University of Texas at Austin.
2815 San Gabriel, Austin, Texas 78705, USA.

professional competence at home and the leveraging of UTEN partnerships to foster international technology-based entrepreneurship and business development throughout Portugal.

We will show, in the next sections, how UTEN have applied a well-planned set of procedures to build, within its first five years of implementation, a globally competitive and sustainable science and technology (S&T) transfer and commercialization network, ready to the co-creative OI Ecosystem. UTEN has focused in the TTOs (a bottom-up approach) to build and spread the Portuguese regional innovation ecosystem. Initial clear challenges involved strengthening existing Portuguese regional and national technology transfer (TT) academic-science-business cooperative networks and abilities in order to achieve needed critical competencies of required expertise to successfully take the best Portuguese S&T and entrepreneurial capabilities to commercial applications and international markets.

This is a working paper based in collected data and will demonstrate the success of the UTEN program (the methodology to collect data consisted of documental analysis, surveys, and interviews).

This working paper is organized as follows: 1. Environment and Scenario; 2. Problem characterization; 3. Research Methodology; 4. Research Data and Discussion; 5. Final Notes and Conclusions; Acknowledges and References.

2 Problem Characterization

The significant challenges Portugal currently faces center on 1) retaining the country's educated talent by developing high value jobs and careers, by 2) commercializing Portuguese S&T in global markets to create these new jobs and regional wealth across Portugal (UTEN 2012). UTEN's initial goal since inception has been the enhanced training and network building, on an international scale, of Portugal's TT managers and staff, and technology entrepreneurs —an effort initiated under the leadership of the FCT, INPI – Instituto Nacional da Propriedade Industrial, and the IC² Institute at The University of Texas at Austin.

2.1 Capacity Building

UTEN's network includes 14 Portuguese universities and select technology parks and research centres. It focuses on capacity building for the accelerated commercialization of Portuguese S&T.

Portugal stands unique in conceiving, launching, and continually assessing UTEN as an international program for capacity building focused on commercialization of academia S&T to business development and venture creation. These challenging tasks are key to wealth and job creation—in emerging, developing, and developed economies—especially during the current global financial challenges. If it were easy to launch and build globally competitive national and international technology-based companies then all nations would be doing it. It is not easy. And while Portugal has select examples of such successes, more needs to be done. The following pages demonstrate UTEN's proposal to address these challenges and to produce significant results.

UTEN has been continually enhanced from 2007 through 2012, to provide much-needed training in technology transfer and commercialization, together with increased access to international networks, in order to increase capacity building that would:

- Strengthen Portuguese academic-industry linkages
- Increase technology-based entrepreneurship
- Accelerate firm growth nationally and globally.

2.2 Taking the Last Mile

In networked systems that support many of today's critical services – roads, energy grids, telecommunication infrastructures, etc. – there is a well-known difficulty referred to as "the last mile problem." The (common) difficulty is bridging the gap from a local high-throughput distribution centre to every single consumer home, equipment or individual, so that the service delivery point can actually (physically) meet the consumers, satisfying their needs and thereby producing value. The challenge is to feed the network with valuable content while providing it with the required capillarity to bridge the gap and avoid connectivity problems.

UTEN was born as a concept or a vision of a cooperative network aggregating entities and individuals in Portugal concerned with technology transfer, with a single major goal: Improving and accelerating the transformation of science and knowledge into economically valuable innovative solutions as well as addressing societal problems in a global context. Such a network is being built, with UTEN support, on increasingly larger and more effective knowledge-producing nodes (laboratories, university research groups, tech-based companies) and on the new delivery links created through the technology transfer offices and professionals associated with those labs and universities – the boundary-spanners.

In the OI environment, a boundary-spanner links the desired actors of an innovative project. The links (inbound or outbound links) with partners, brokers or any kind of organization or company participating in a project need to be managed.

Because these links have been initially created to interconnect the knowledge-producing nodes, they have trouble in effectively connecting with the knowledge-consuming nodes (the end-user companies and other licensees aiming at transforming and/or selling technology and technology-based products and services). This difficulty in effectively connecting to potential clients is the "last mile problem" of the technology transfer network.

With the application of all the capacity-building programs and activities over five years the "last mile problems" of UTEN Portugal have already shown relevant results as can be seen in the next sections.

We intend to show that the practices taken place in the UTEN program to improve and accelerate the transformation of science and knowledge of a region/country ecosystem into economically valuable innovative solutions as well as address their societal problems are adequate.

The questions driving this analysis are concerned with UTEN project and are:

- Granted, there is a huge collection of variables conditioning the TT relationships, can we confirm that all processes, procedures and structures in UTEN network improved and accelerated, with relevant results, the transformation of science and knowledge of UTEN partners into economically valuable innovative solutions?

- Is it possible to characterize processes, procedures, and structures in the network, and to identify their weight in the results?

- Is it possible to point out processes and critical procedures that are still weakly implemented?

- If we find and improve weakly implemented processes and mechanisms, what performance increases (both efficiency and effectiveness) can we expect to achieve from intervening and rectifying existing problems?

3 Research Methodology

The research approach of this study is action research. Action research uses a scientific approach to study important social or organizational issues together with those who experience these issues directly. It has always two goals: making the action happen and reflecting what happens in order to contribute to the theory. This process involves collaboration between researchers and members of the organizational system. Action researchers are not just observing change; they are actively working to make it happen (Coughlan and Coghlan 2002).

Tharenou et al. (2007) argue that action research studies iteratively cycle through diagnosis and intervention until there is an understanding of the situation investigated. In this study, the action research is used to develop practice-based innovation processes in cooperation with the employees of case organizations.

The empirical research is based on various case studies. In fact, these case studies are all related to each other since the intention is to create a powerful network in the Portuguese innovation ecosystem. "Case study is a comprehensive inquiry, conduced in the field, into a single instance, event or setting" (Tharenou & al. 2007). Case studies allow concentrating on specific instances aiming to provide a multidimensional view of the situation (Remenyi & al. 1998). Although the results of a case study are difficult to generalize to other cases, the generalizability can be improved by using more than one case (Tharenou & al. 2007).

Action research always requires pre-understanding of the organization's environment, conditions of the business as well as structure and dynamics of the operating systems (Coughlan and Coghlan, 2002). Therefore, a baseline data collection was gathered in the first research phase.

4 Research Data and Discussion

According to Coughlan and Coghlan (2002), the general phases of an action research process are: planning, taking action, evaluating the action and further planning. This section describes the evaluating phase (s) with UTEN Program where twenty offices were contacted, and responses were received from 18 TTOs as of late October 2012.

The next discussion is a transcription of selected parts of our empirical research from UTEN report (UTEN 2012), by James Jarret and Aurora Teixeira, Assistant Professor with Habilitation, Faculdade de Economia, Universidade do Porto; Associate researcher of CEF.UP, INESC Porto & OBEGEF.

4.1 Evaluation - UTEN Surveys of TTOs

In 2012 the third annual UTEN network survey of technology transfer offices was conducted to develop a more comprehensive view of technology transfer in Portugal from 2007 to 2011. The summary of key findings follows.

- The primary functions of TTO employees continue to be: grants and fund-raising (27%), intellectual property (18%), and entrepreneurship/spin-outs (14%) with smaller amounts of time devoted to coordination, licensing, and industrial liaison;
- On average, approximately half of the revenues received by TTOs are from grants, with another 20% from external fees and services; only one fourth of TTO revenues are provided by their institution;
- Compared to last year, there was a substantial increase (42%) in the number of invention disclosures reported by the TTOs;
- There are no clear trends with patent applications, while there has been an upward or stable trend over time for the three main types of patents granted. In the last two years, the impact of the economic crises in the use of patents seems clear;
- Licenses, option agreements, and assignments in 2011 matched the strong number in 2010, and the trend over time continues to be positive;
- Total license income increased once again in 2011, by about 6% over the prior year;
- R&D agreements were 38% higher in 2011 than in 2010 and
- TTOs reported a large number of new companies established: 141 in 2011 compared to 95 in 2010.

EMPLOYEE DUTIES: The number of full-time technical/professional employees ranges from 1 to 14 per office. Twelve of the 18 TTOs have five or fewer technical/professional employees. The offices that responded have a total of 81 technical/professional employees. Across the different TTOs, on average employees allocate their time to several key functions.

SOURCES OF REVENUES: Grants and fund-raising are an important task for TTOs. Only one TTO in 2011 received all of its revenue from its home university. TTOs are in fact quite dependent on grants to perform their functions as nearly half of their revenues, on average, come from grants. In 2011, ten of the TTOs secured at least half of their revenue from grants, with three TTOs above 70%. Two other TTOs were entirely funded from external fees and services. Compared to the prior year, TTOs increasingly relied on external fees and services and grants, and received a smaller proportion from their home institution.

ROYALTIES: Seventeen TTOs provided information about royalties, and 15 reported that royalties are split between their institutions and the inventors in varying proportions. In eight of the institutions, royalties are split 50%-50%. In another seven institutions, the inventors receive 55% or more, including two institutions that provide 80% to inventors. One university alters the allocation depending on the total amount of royalties received—for smaller amounts the inventor receives a higher percentage, while for larger amounts the university receives more and the organizational unit receives some proportion. Compared to last year, inventors now are receiving a larger share at a number of institutions.

INVENTION DISCLOSURES: Compared to last year, there was a substantial increase (42%) in the number of invention disclosures reported by the TTOs. As shown in Figure 1, invention disclosures in 2011 reached 282.

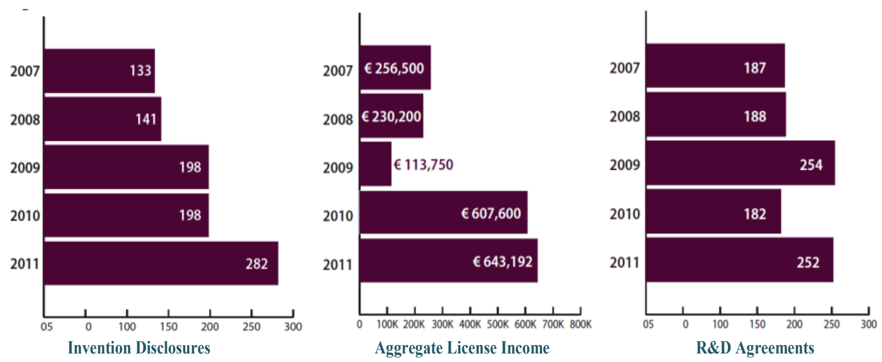


Figure 1 – Indicators – 2007 to 2011

PATENT APPLICATIONS (PRIORITY FILINGS): The trend is less clear on patent applications as shown in Table 1. In one category (provisional), the trend is clearly upward, while in the other four categories there are no clear trends. In 2011, there was one application in Spain and another in India.

PATENT APPLICATIONS BY SUBJECT AREA: More than half of the TTOs applied for some type of a biomedical (diagnostic, devices, pharmaceutical etc.) patent in 2011. Six of the TTOs applied for a patent related to computers or communication equipment, while four applied in the area of nanotechnology/new materials, and two in low or zero carbon energy technologies. Other areas in which TTOs applied for patents were agricultural sciences, life sciences, mechanics & electromechanics, and the food industry.

PATENTS GRANTED: The trends has been upward or stable over time for the three categories. In 2011, two TTOs reported receiving Canadian patents.

Table 1
TTOs patents and applications.

TTOs	Patent Applications (Priority Filings)					Patents Granted: The trends has been upward or stable over time for the three categories				
	2007	2008	2009	2010	2011	2007	2008	2009	2010	2011
Provisional Filings	4	23	66	80	100					
Portuguese	71	88	76	78	69	24	32	38	56	52
EPO	12	13	12	4	6	4	5	5	7	8
USPTO	11	17	5	11	7	5	3	5	4	2
PCT	29	30	74	43	17					

LICENSES, OPTION AGREEMENTS, AND ASSIGNMENTS: As in prior years, the large majority of the licenses, agreements, and assignments have been executed with Portuguese partners as shown in Figure 1. The total in 2011 nearly matched the very strong number in 2010, and the trend over the past five years continues to be positive.

About an equal number of licenses and options were granted to start-up companies and firms with fewer than 250 employees. The remaining licenses and options, about 20%, were granted to companies with more than 250 employees.

LICENSE INCOME: The total amount of license income increased once again in 2011, following the dramatic increase in 2010. Seven of the TTOs reported license income, with three TTOs reporting license income of at least €100,000 in 2011. Therefore the aggregate amount of nearly €650,000 is not due to a single transaction or single TTO. Three TTOs reported international license income.

COMMERCIALLY PROFITABLE PRODUCTS: Eleven TTOs indicated that their institution's licensed technology or knowledge had resulted in commercially profitable products or processes in the past three years.

RESEARCH AND DEVELOPMENT AGREEMENTS: TTOs reported a dramatic increase in the number of executed agreements in 2011, up 38% from the prior year. The number in 2011 essentially matches the strong performance in 2009 and considerably surpasses the levels in 2007 and 2008 as shown in Figure 1.

INSTITUTIONAL RESEARCH RESOURCES: For the first time in this series of surveys, TTOs were asked questions about their institution's research resources. The total number of research personnel (researchers, technicians, and administrative support personnel) at 14 institutions in 2011 was 22,377. Six TTOs reported more than 1,000 researchers each. The aggregate research budgets at nine institutions were €112,908,866, with two institutions accounting for three-quarters of the total. Privately funded research at institutions varied considerably. One TTO said 35% of total research expenditures came from private companies, a second TTO said that figure was 24% at their institution, and a third TTO reported 19%. One TTO each reported 12%, 11%, 10%, and 9%, while three TTOs reported 5%. Other TTOs did not provide a response.

SPIN-OFF & START-UP COMPANIES: Data from the TTOs show that a large number of new companies are being established. In 2011, TTOs reported 141 new companies were established, while nine companies from prior years ceased operations. The total number of new companies and the total number of active spin off and start-up companies until 2010 is shown in **Figure 3**.

Figure 3 – New Academic Spin Offs (ASOs) and total ASOSs at end of year.

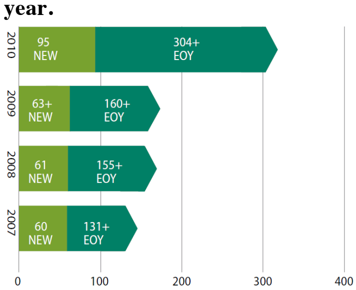
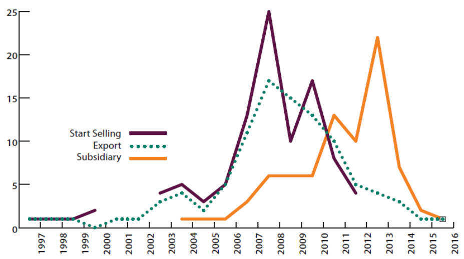


Figure 3 - Beginning of the activity/sales/exports/ subsidiary of ASOs. (Teixeira, A. in UTEN 2012)



We argue that UTEN program has improved not only the OI ecosystem but, more deeply, the co-creation relationships. The indicator is the number of ASOs that started selling earlier in the last years (**Figure 3**). In this case, one could state that the ecosystem boot up the user driven innovation with some network actors.

4.2 Discussion

It was not until the middle 2000s though that, in Portugal, a definitive academic entrepreneurial wave entered effectively and explicitly into the agenda of both politicians and academics. In 2006 three major international cooperation programs (Carnegie Mellon | Portugal, MIT | Portugal and UT Austin | Portugal) have started with a central aim, among others, to promote the commercialization of scientific knowledge (Heitor and Bravo, 2010).

The TTOs have been established to assure professional commercialization of the knowledge generated within the universities. These developments have received extensive attention worldwide with researchers focusing initially to a larger extent on the direct implications of licensing and patenting (Rothaermel et al., 2007).

In the previous discussion, we present summarized data of the main traits and dynamics of TTOs and some information about ASOs in Portugal over the last years. We argue that such trends, depicting TTOs and ASOs as key university related technology transfer mechanisms, might in large part be connected with the institutional changes observed in Portugal in this period, associated with the creation of transnational programs, namely UTEN - The University Technology Enterprise Network (Gibson and Naquin, 2011).

As the TTOs and ASOs are linked to the universities in our study, we can continue our discussion with some more indicators of university patent applications. In Portugal, university national patent applications have continuously increased between 2006 and 2009, with growth rates above 20% per year, as seen in **Table 1**. In 2010, it is possible to observe a slight decrease, partly recovered in 2011. The effects of the financial restrictions, resulting from the economic crisis, are visible in the number of patents applied for, in these last years, namely after 2010.

Table 1 - University National Patent Applications

	2006	2007	2008	2009	2010	2011	June 2012
University of Aveiro	12	5	19	21	17	12	9
University of Minho	8	12	13	12	14	12	11
University of Évora	3	4	1	5	2	1	1
University of Porto	12	8	12	11	3	10	9
University of Coimbra	2	1	1	9	7	9	4
University of Algarve	3	2	5	13	14	5	4
University Nova of Lisboa	3	13	13	11	3	2	0
University of Beira Interior	1	2	1	6	16	17	2
University of Trás-os-Montes and Alto Douro	1	8	6	7	7	13	5
Instituto Superior Técnico	35	43	54	38	9	15	6
Other	4	10	14	36	30	42	17
TOTAL	**84**	**108**	**139**	**169**	**122**	**138**	**68**

Source: Portuguese Institute of Industrial Property (INPI)

In general, the main applicant universities increased the number of patent applications over the last six years. On an individual level, between 2006 and 2011, University of Beira Interior (UBI) and University of Trás-os-Montes and Alto Douro (UTAD) showed the most distinct growth. In 2006, these universities had the lowest number of patent applications. However, in 2011, UBI had the lead and the UTAD had the third highest number of patent applications. While Instituto Superior Técnico (IST) has significantly decreased the number of patent applications in the last two years, it remains the university with the highest number of accumulated applications (194) in the period 2006-2011.

As shown in **Table 2**, except for the United States, the national and international (WIPO and EPO) patent applications have risen until 2009. In the last two years, the impact of the economic crises in the use of patents seems clear. There was a decline in the number of patent applications in all routes of protection. It was at national level that this effect was less visible, to a certain extent this can be explained by the fact that the protection in Portugal is the one which requires the lowest investment.

The number of patents applied for directly in the United States increased in 2007, but in the following years the level of applications has been more or less maintained. Moreover, it is interesting to observe that in 2010 there was even a rise in the applications in the United States contrary to the behavior in other routes/territories.

In 2011, EPO published 89 patents applications and WIPO published 185 applications, in several technology areas, belonging to Portuguese enterprises, higher education and R&D institutions, and independent inventors. The majority of these applications came from enterprises, followed by universities and then by individuals. The U.S. Patent and Trademark Office (USPTO), in 2011, published 27 patents submitted by Portuguese entities; enterprises filed 23 of those patents, and while universities filed the remaining four.

Table 2 – National and international patent applications, 2006 - 2011

	2006	2007	2008	2009	2010	2011
Portuguese Institute of Industrial Property (INPI)	219	283	405	600	527	598
World Intellectual Patent Organization (WIPO)	68	93	100	163	117	96
European Patent Office (EPO)	78	70	84	112	81	77
United States Patent and Trademark Office (USPTO)	23	35	39	36	43	–

Source: Portuguese Institute of Industrial Property (INPI)

Increasing opportunities for science and technology within increasingly globalized and specialized markets of OI have brought new challenges and opportunities to international technology transfer and commercialization. UTEN have worked the last five years, with national and international partners to leverage existing professional technology transfer and commercialization know-how, to generate new knowledge for successful S&T co-creation and commercialization, and to promote Portuguese economic development in the global economy.

5 Final Notes and Conclusions

The UTEN program was launched in 2007 by the Portuguese Government and the IC^2 Institute, The University of Texas at Austin (UT Austin) to provide a commercialization outlet for Portuguese S&T resulting from in-country investments. Over the years, UTEN's mission has been gradually evolving to build a professional, globally competitive and sustainable technology transfer and commercialization network in Portugal which is oriented toward international markets. As noted below, the outcomes from the UTEN program have been quite impressive:

- Networking of all major research institutions throughout the Portuguese mainland and associated islands;
- Development of a technology transfer office (TTO) infrastructure at all major nodes within the UTEN network;
- Delivery of more than 50 workshops hosting over than 1,500 participants providing broad training for in-country professionals and scientists;
- Intensive infrastructure investment in 12 TTO's from leading universities, providing intensive assessment, development and process improvement;
- Deep training of more than 30 TTO professionals who have interned in the US receiving immersion training in best practices in commercialization of technologies;
- Disclosure of over than 150 new technologies in the form of inventions from Portuguese researchers, which is an almost 50% increase in disclosure rate compared to the pre-UTEN environment;
- Catalyzing a 1,900% increase in provisional patent filings and almost 20% increase in issued patents to Portuguese researchers;
- Supporting the launch of more than 100 new technology-based companies and their support with regards to international markets and business strategies;
- Driving a 132% increase in academic start-up rate compared with pre-UTEN, where the young companies show more than 125% increase in revenue and 38% growth in hiring annually;
- In-person meetings with more than a dozen Fortune 500 companies and US subsidiaries for three companies and

- Development of five Portuguese companies in the US market through the UTEN "US Connect" pilot program resulting in business, services, and manufacturing deals.

These metrics demonstrate the success of the UTEN program and argue for its continued and critical role connecting the innovation of Portuguese entrepreneurs and the growth in scientific output with real economic impact – both in GDP and employment. The outcomes of the UTEN program and the pilot US Connect program in 2012 were highly impactful and indicative of the success that can be expected from a continued program in terms of: (1) capturing leading scientific accomplishments as inventions; (2) practicing effective technology transfer in support of out-licensing and spin-out activities; (3) developing human capital to support entrepreneurial activities; and (4) preparing Portuguese companies for international market expansion. This success provides the impetus to propose a more comprehensive strategy for the coming five-year period, from January 2013 to December 2017 with further improvement "taking the last mile" internationally.

Acknowledgments

The authors would like to thank the Portuguese Science and Technology Foundation (FCT) for financial support of this work within the UTEN project. The authors would also like to thank all of the Portuguese TTOs for their cooperation and effort in providing information and generously shared their time and experience with us and acknowledge the support from all research staff at the IC2 Institute (Austin – Texas).

References

Coughlan P, Coghlan D (2002) Action research for operations management. International Journal of Operations & Production Management, 22 (2), 220-240

Gibson D, Rogers E (1994) R&D collaboration on trial: The Microelectronics and Computer Technology Corporation. Boston: Harvard Business School Press

Gibson D, Naquin H (2011) Investing in innovation to enable global competitiveness: The case of Portugal. Technological Forecasting and Social Change, Vol. 78, Issue 8, pp. 1299-1309

Heitor M, Bravo M (2010) Portugal at the crossroads of change, facing the shock of the new: People, knowledge and ideas fostering the social fabric to facilitate the concentration of knowledge integrated. Technological Forecasting and Social Change, Vol. 77, Issue 2, pp. 218-247

McAdam R, Miller K, McAdam M, Teague S (2012) The development of University Technology Transfer stakeholder relationships at a regional level: Lessons for the future. Technovation 32 (1), 57-67

Remenyi D, Williams B, Money A, Swartz E (1998) Doing research in business and management: an introduction to process and method. London: Sage Publications, 309p

Resende D, Gibson D, Jarrett J (2013) BTP—Best Transfer Practices. A tool for qualitative analysis of tech-transfer offices: A cross cultural analysis, Technovation, Volume 33, Issue 1, January 2013, Pages 2-12

Rogers E, Yin J, Hoffmann J (2000) Assessing the effectiveness of technology transfer offices at U.S. research universities. Journal of the Association for University Technology Managers, 12, 42-80

Rogers E, Takegami S, Yin J (2001) Lessons learned about technology transfer. Technovation 21 (4), 253-261

Rogers E (2003) Diffusion of innovations. New York Free Press. 5th edition

Rothaermel F, Agung S, Jiang L (2007) University entrepreneurship: a taxonomy of the literature. Industrial and Corporate Change, Vol. 16 (4), pp. 691–791

Tharenou P, Donohue R, Cooper B (2007) Management research methods. Cambridge. Cambridge University Press, 338p

Todorovic ZW, McNaughton RB, Guild P (2011) ENTRE-U: An entrepreneurial orientation scale for universities. Technovation 31 (2-3) 128-137

UTEN Portugal (2012) 2007 – 2012: A Progress Report. Austin

SERVICE SYSTEMS

[Extended Abstracts]

Delimiting the linear area on the problems of assembly line balancing with minimal ergonomic risk

Bautista J[1], BatallaC[1], AlfaroR[1]

Abstract: In this paper we propose to incorporate some working conditions to the assembly lines. For this, used a mathematical model to solve the assembly line balancing problem whose objective is minimizing the ergonomic risk, imposing the limitation of the cycle time, number of workstations and the maximum linear area for each station. A study is presented through a case study that corresponds to an assembly line from Nissan's plant in Barcelona.

Keywords: Ergonomic Risk; Linear Area; Assembly Line Balancing.

1 Introduction

During the last decades academic literature has defined ergonomics as the science that allows to study employees' working conditions and assess the risks they are exposed to so that measures seeking to alleviate these risks can be adopted. How-ever, a wide array of factors should be taken into account when it comes to design ergonomic studies (e.g., jobs and workloads assessment and the analysis of work-ing conditions and environment, among others) and this complicates the use of a single method for assessing risks at work.
The Spain's regulatory framework provides guidelines on how risks at work should be assessed as well as what measures should be adopted to protect workers and individuals who might be affected by work risks. This creates the conditions for adapting workplaces and minimizing monotonous and repetitive work tasks.
The primary objective of ergonomic studies is to minimize work risks, and this requires the identification of all hazards at the workplace including all factors that could potentially cause workrelated illnesses. The poor adaptation of the workplace and the lack of space available to workers to develop their tasks is one of the most commonly referred causes of work risk and/or illness.

Ergonomics should have the capacity to evaluate working area in order to provide adequate working space since workers' natural movements jointly with their diverse positions at work are essential elements to effectively develop work tasks.

In this scenario, it is essential to understand that job positions should fit both the workers' physical conditions and the tools and devices so that the latter can be used as independently and naturally as possible.
Nevertheless, as mentioned above, the available space at the workstations should be adapted to both workers and products.

1 **Joaquín Bautista Valhondo** (joaquin.bautista@upc.edu)
Cristina Batalla García (cristina.batalla@upc.edu)
Rocío Alfaro Pozo (rocio.alfaro@upc.edu)
Research Group OPE-PROTHIUS.
Dpto. de Organización de Empresas.
Universitat Politècnica de Catalunya.
Avda. Diagonal, 647, 7th floor, 08028 Barcelona, Spain.

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This research is based on a case study in which products are of great volume and weight (engines, bodyworks, etc.). This means that the analyzed product parts require adequate storage space at the workstation. When it comes to define the assembly line, different components should be taken into account and clearly delimitated, including: the place and storage space, the raw materials necessary to manufacture the product, and the movements and re-allocation of workers within their corresponding workstation.

Therefore, we should design an assembly line that adapts to all these conditions in each of the workstations in order to increase productivity and reduce the potential injuries that workers might be exposed to.

All the problems mentioned, can trigger multiple musculoskeletal disorders that cause inflammatory or degenerative lesions in the musculoskeletal system's tissues such as muscles, tendons, nerves and body joints.

Nowadays, and besides the abovementioned ergonomic problems, the automobile industry suffers from several aspects that interfere with the effective development and execution of labor activities.

Different scientific studies have analyzed aspects related to ergonomics (Salveson, ME, 1955 and Battaïa and Dolgui, 2013) and established different criteria for assembly lines balancing.

Bautista and Pereira (2007) introduced a new variable into the analysis, namely the available space or area (A) of working materials and tools for each workstation, and this led to develop a new family of problems labeled TSALBP (Time and Space Constrained Assembly Line Balancing Problems).

Bautista et al., (2013a) incorporate a new constraint into the TSALBP model that limits maximum and minimum ergonomic risks. The same authors conducted an analysis of the impact of reduced ergonomic risks over the number of workstations (Bautista et al., 2013b).

The works of Bautista et al., (2015a) and Bautista et al., (2015b) solve the problem of lines balancing in order to minimize the maximum ergonomic risk of stations.

Specifically, Bautista et al., (2015a) solve the problem using linear programming and Bautista et al., (2015b) with GRASP algorithms.

Note that both studies minimize ergonomic risk without considerer the impact area.

Therefore, in this work we extend the studies of Bautista et al., (2015a) and Bautista et al., (2015b) considering a linear area available in each station.

2 Ergonomic Risk Assessment

Debates on the design of assembly lines must take into account the factors characterizing the interaction between multiple elements, such as workers' body dimensions as well as their physical and mental attributes, physical movements at work, working tools, physical force demanded by work positions, the duration of tasks, vibration levels, and temperature, among others. The joint interaction of these elements might represent a risk factor for workers.

Existing literature incorporates ergonomic risks in the analysis of balanced lines in order to develop models that contribute to the reduction of these risks (Otto and Scholl, 2011 and Bautista et al., 2013a). Additionally, Bautista et al., (2013c) examine how an additional constraint dealing with the minimization of risks contribute to determine the optimal number of jobs necessary to maximize the lines' operating and produc-tion capacity.

By using the case presented by Bautista et al., (2013c) which depicts three types of problems (SALBP-1, TSALBP-1 and TSALBP-1_erg) we observe that increased constraining factors lead to a greater number of workstations.

Given a set of eight tasks $(|J|=8)$, whose operation times, t_j $(j=1,\ldots,|J|)$, required space, a_j $(j=1,\ldots,|J|)$, ergonomic risk R_j $(j=1,\ldots,|J|)$ and which precedence graph are shown in figure 1 (left), each task must be assigned to a single stations satisfying the limitations: (1) *c = 20 s*; (2) *A = 20 dm*; and (3) $R^{\max}$= 60 e-s (ergo-seconds).

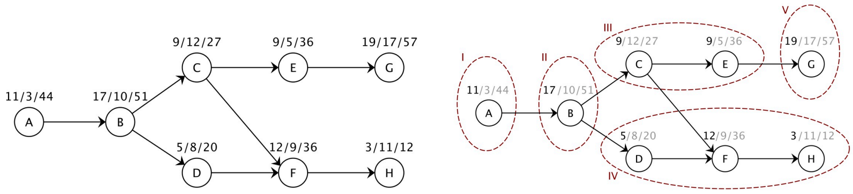


Fig.1
Precedence graph of tasks. At each vertex we can see the tuple $t_j / a_j / R_j$ corresponding to the task (left). Solution obtained by SALBP-1 (m = 5) (right).

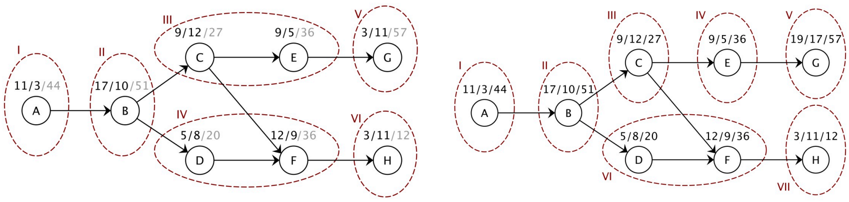


Fig.2
Solution by TSALBP-1 (m = 6) (left). Solution by TSALBP-1_erg (m = 7) (right).

The ergonomic risk presented a big variety of factors to which are exposed the workers, therefore not easy to obtain a single value associated the ergonomic risk.

In this study we propose unify three ergonomic methods for obtain a only value for the ergonomic risk associated with each of the tasks.

The methods chosen are: OCRA (Colombini, et. al., 2002) method for analysis the repetitive movements, the NIOSH (Waters, et. al., 1994) method for manual handling and the RULA method (McAtamney and Corlett, 1993) for the postural load.

The determination the risk associated with each task can see in work presented by Bautista et al., (2015a).

In such conditions, the following model is proposed for the line balancing problems whose parameters and variables are:

Parameters	
J	Set of elemental task $(j = 1,\dots,\lvert J\rvert)$.
K	Set of workstations $(k = 1,\dots,\lvert K\rvert)$.
Φ	Set of ergonomic risk factors $(\phi = 1,\dots,\lvert\Phi\rvert)$.
t_j	Processing time of the task j $(j = 1,\dots,\lvert J\rvert)$ at normal activity.
a_j	Linear area required by the elemental task j $(j = 1,\dots,\lvert J\rvert)$.
$\chi_{\phi,j}$	Category of the task j $(j = 1,\dots,\lvert J\rvert)$ j $(j = 1,\dots,\lvert J\rvert)$ associated to the risk factor ϕ $(\phi = 1,\dots,\lvert\Phi\rvert)$. ϕ $(\phi = 1,\dots,\lvert\Phi\rvert)$
$R_{\phi,j}$	Ergonomic risk of task j $(j = 1,\dots,\lvert J\rvert)$ j $(j = 1,\dots,\lvert J\rvert)$ j $(j = 1,\dots,\lvert J\rvert)$ associated to the risk factor ϕ $(\phi = 1,\dots,\lvert\Phi\rvert)$ ϕ $(\phi = 1,\dots,\lvert\Phi\rvert)$. Here, $R_{\phi,j} = t_j \cdot \chi_{\phi,j}$ $F_{\phi,j} = t_j \cdot \chi_{\phi,j}$.
P_j	Set of direct precedent tasks of the task j $(j = 1,\dots,\lvert J\rvert)$ j $(j = 1,\dots,\lvert J\rvert)$ j $(j = 1,\dots,\lvert J\rvert)$.
c	Cycle time. Standard time assigned to each workstation to process its workload (S_k)
m	Number of workstations. In this case, $m = \lvert K\rvert$.

A Available space or linear area assigned to each workstation.

Variables

$x_{j,k}$ Binary variable equal to 1 if the elemental task j $(j = 1,\ldots,|J|)$ $j\ (j = 1, \ldots, |J|)$ is assigned to the workstation k $(k = 1,\ldots,|K|)$ $k\ (k = 1, \ldots, m_{max})$, and to 0 otherwise.

R_ϕ Maximum ergonomic risk, associated to the risk factor ϕ $(\phi = 1,\ldots,|\Phi|)$, allowed to each workstations.

$\overline{R}(\Phi)$ Average ergonomic risk due to the set of factors Φ related to the production line.

TSALBP-R_erg:

$$\min \overline{R}(\Phi) = \frac{1}{|\Phi|}\sum_{\phi=1}^{|\Phi|} R_\phi \tag{1.1}$$

Subject to:

$$\sum_{\forall k \in K} x_{j,k} = 1 \qquad (j = 1,\ldots,|J|) \tag{1.2}$$

$$\sum_{\forall j \in J} t_j \cdot x_{j,k} \le c \qquad (k = 1,\ldots,|K|) \tag{1.3}$$

$$\sum_{\forall j \in J} a_j \cdot x_{j,k} \le A \qquad (k = 1,\ldots,|K|) \tag{1.4}$$

$$R_\phi - \sum_{\forall j \in J} R_{\phi,j} \cdot x_{j,k} \ge 0 \qquad (k = 1,\ldots,|K|) \wedge (\phi = 1,\ldots,|\Phi|) \tag{1.5}$$

$$\sum_{\forall k \in K} k\left(x_{i,k} - x_{j,k}\right) \le 0 \qquad \left(1 \le i,j \le |J| : i \in P_j\right) \tag{1.6}$$

$$\sum_{\forall k \in K} k \cdot x_{j,k} \le m \qquad (j = 1,\ldots,|J|) \tag{1.7}$$

$$\sum_{\forall j \in J} x_{j,k} \ge 1 \qquad (k = 1,\ldots,|K|) \tag{1.8}$$

$$x_{j,k} \in \{0,1\} \qquad (j = 1,\ldots,|J|) \wedge (k = 1,\ldots,|K|) \tag{1.9}$$

In the model, the objective function (1.1) expresses the minimization of the ergonomic risk of the line. This risk is measured as the average ergonomic risk due to a set of factors Φ . Constraints (1.2) indicate that each task can only be assigned to one workstation. Constraints (1.3) and (1.4) impose the maximum limitation of the workload time and the maximum linear area allowed by the workload of each workstation. Constraints (1.5) determine the ergonomic risk associated to the factor $\phi \in \Phi$ at each workstation. Constraints (1.6) correspond to the precedence task bindings. Constraints (1.7) and (1.8) limit the number of workstations and force that there is no empty workstation, respectively. Finally, constraints (1.9) require the assignment variables be binary.

3 Computational Experience

By means of the proposed model we analyze the influence of the constraint of maximum available area (A = 4m and A = 5m) on the maximum risk to which workers are subjected, given number of workstations and a cycle time for each of them.

For this was used a production plan corresponding to a Nissan's engine plant in Barcelona (NMISA: Nissan Motor Ibérica - BCN). In this plant are assembled nine different kinds of engines grouped in 3 families: p_1, p_2 and p_3 are engines for crossovers and SUVs; p_4 and p_5 are for vans; and p_6, p_7, p_8 and p_9 are intended for medium tonnage trucks; all this engines require 140 operations.

The formulation was solved with the CPLEX (v11.0) software, running on a Mac Pro computer with an Intel Xeon, 3.0 GHz CPU and 2 GB RAM memory under the Windows XP operating system. In all the executions, the CPU time was limited to 2 hours.

Computational experience initiates from a number of workstations that ranges between 19 and 25, inclu-sive, a cycle time of 180s and two values of available space for workers at the station (A = 4m and A = 5m).

The purpose is to observe how it affects the establish areas in relation to minimize ergonomic risks in the assembly line.

Figure 3 present a Pareto frontier (m versus $\overline{R_\phi}$) for three values of the linear area (4, 5 and ∞) assigned to each station.

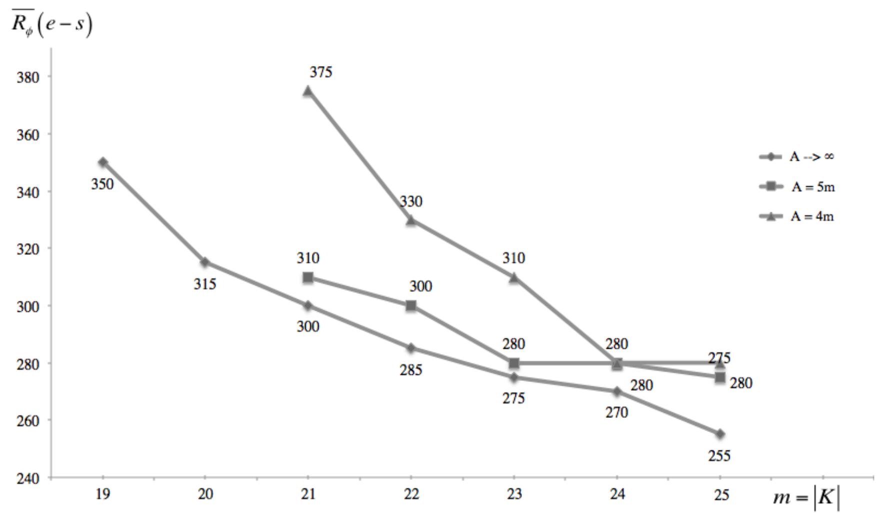


Fig.1

Pseudo-optimal solutions, m versus $\overline{R_\phi}$, without limiting the linear area and limiting it to 4 and 5 meters.

It is worth noting that increases in the number of workstations lead to a reduction in the maximum ergonomic risk in all cases. When the line comprises 19 stations only found solution for a infinite area; however, when the work area is limited to 4 and 5 meters feasible solutions materialize for 21 workstations.

The maximum risk for an infinite area is 350 e-s (a risk category value of 1.94) with 19 stations, whereas the minimum ergonomic risk found is 255 e-s (a risk category value of 1.42) with 25 stations.

When to analyze the results to limiting the area to 5 and 4 meters, we find a maximum ergonomic risk of 310 e-s (a risk category value of 1.72) and 375 e-s (a risk category value of 2.08) with 21 stations and the minimum ergonomic risk found is 275 e-s (a risk category value of 1.53) and 280 e-s (a risk category value of 1.55) respectively.

4 Conclusions

Given the increased relevance of all movements and postures performed by employees at work, it is desirable to establish a workspace that meets a number of requirements regarding occupational health and safety conditions. Thus, the adaptation of job position to the operator dimensions is required to enhance mobility, to delimit sufficient space for equipment, tools, and work materials. In this way the security and accessibility are guaranteed.

On the above and drawing upon the family of models TSALBP, we propose a new model to balance assembly lines minimizing ergonomic risks and complying the constraints in regard with the linear workspace by workstation.

To analyze the space effects on workers' occupational health conditions, we have used a case study in Nissan's engine plant in Barcelona. The obtained results allow us to conclude, for this experiment, that both a greater number of stations on the line and increased available space reduce the ergonomic risk of the assembly line without changing its production capacity.

In future works it would be interesting to analyze other case studies in order to extend the conclusion of this work to different industrial sectors.

5 References

Battaïa O, Dolgui A. (2013) A taxonomy of line balancing problems and their solution approaches.J Prod Econ 142: 259-277.

Bautista J, Pereira J (2007) Ant algorithms for a time and space constrained assembly line balancing problema. Eur J Oper Res177:2016–2032.

Bautista J, Batalla C, Alfaro R et al. (2013a)Incorporating Ergonomics Factors into the TSALBP. Advances in Production Management Systems. Competitive Manufacturing for Innovative Products and Services IFIP Advances in Information and Communication Technology Volume 397, Springer, Holanda, pag. 413-420. ISBN: 978-3-642-40351-4.

Bautista J, Batalla C, Alfaro R (2013b) Impact of Ergonomic Risk Reduction in the TSALBP-1. Industrial Engineering and Complexity Management. Book of Proceedings of the 7th International Conference on Industrial Engineering and Industrial Management - XVII Congreso de Ingeniería de Organización ISBN: 978-84-616-5410-9, 436-444

Bautista J, Batalla-García C, Alfaro-Pozo R (2015a) Ergonomic Risk Minimisation in Assembly Line Balancing. Enhancing Synergies in a Collaborative Environment. Lecture Notes in Management and Industrial Engineering, Springer International Publishing, Switzerland, pag. 85-93. ISBN: 978-3-319-14077-3.

Bautista J, Batalla C, Alfaro R et al. (2013c). Extended Models for TSALBP with Ergonomic Risk Constraints, IFAC Conference on Manufacturing Modeling, Management and Control (MIM 2013) Saint Petersburg (Rusia).

Bautista J, Batalla C, Alfaro R et al. (2015b) Algoritmos GRASP para el equilibrado de líneas con riesgo ergonómico mínimo, X Congreso Nacional sobre Metaheurísticas, Algoritmos Evolutivos y Bioinspirados, MAEB2015. Doi: 10.13140/2.1.4011.6005

Colombini D, Occhipinti E, Grieco A. (2002) Risk Assessment and Management of Repetitive Movements and Exertions of Upper Limbs Job Analysis, Ocra Risk Indices. Prevention Strategies and Design Principles.ISBN: 978-0-08-044080-4.

McAtamney L, Corlett EN (1993) Rula: a survey method for the investigation of work-related upper limb disorders. Appl Ergon 24:91–99.

Otto A, Scholl A (2011) Incorporating ergonomic risks into assembly line balancing. Eur J Oper Res212:277–286.

Salveson ME (1995) The assembly line balancing problema. J Ind Engineering 6:18–25.

Waters T, Putz-Anderson V, Garg A (1994). Applications Manual for the Revised NIOSH Lifting Equation, PB 94-176930 (US Department of Health and Human Services). Cincinnati, Ohio 45226.

Grocery Supermarket Business Model: finding out Operations Management advantages

De Castro R[1], **Llach J**[2]

Abstract: The success on grocery stores depends on the efficiency of the operations to be carried out. The incursion of information technology in the supermarkets is not new, but the applications that can be developed in order to optimize operation times of employees can facilitate the implementation of Lean principles in the store management. From a case study, and through the implementation of the Business Model Canvas, preliminary results are presented. These results point out to competitive advantages through the programming and prioritization of the operations which are carried out in the store back office and customer order of the grocery list by Internet. The innovation is eliminating the delivery of the last mile and optimizing the planning and execution of the operations management in the store.

Keywords: Inventory; picking; scheduling; Canvas Model.

1 Introduction and objective

Internet has facilitated the emergence of new strategies and business models in various industries. The major changes, in the retail trade of supermarkets, are the introduction of online purchasing, especially in terms of channel development and coordination, the redefining business model, the development and improvement of basic processes, new ways of creating value for the customer and information use advantages (Yousept and Li, 2004).

The development of supermarkets online has been occurred in two main phases. The first phase occurred during the Internet boom, when the virtual supermarkets were established in the USA and UK. Most of them have closed over the boom of Internet. However those who survived have been purchased by larger supermarkets (Van Beek, 2009).

The main contribution of this paper is to highlight the opportunities of new business models in this field, taking advantages of use of appropriate operations strategies, basically focus on scheduling priority rules, and in a high defined business processes management environment.

The way of going to a supermarket to buy the grocery list is changing (Van Beek, 2009). The business model of traditional supermarket has to adapt to new technologies and new customer behavior. There are many cases in literature of online groceries which failed in last mile delivery, when the model requires this final stage. However, this article presents a part of a Business Model which takes advantages of the online supermarket and avoids the last mile distribution by ordering to pick the shopping order in the store (Boyer et al, 2003).

This contribution is part of a larger project we are developing in collaboration with a firm; nevertheless, we are interested in highlighting what are the main operative advantages to use an information system to determine scheduling warehouse operations.

1 **Rodolfo de Castro** (rudi.castro@udg.edu)
2 **Josep Llach** (josep.llach@udg.edu)
Dpto. de Organización, Gestión Empresarial y Diseño de Producto.
Escola Politècnica Superior Universitat de Girona.
C/ Ma Aurèlia Capmany, 61 17071 Girona

2 Methods

Case study methodology is used in this contribution. By means of the Business Model Canvas we determine the advantages of (only) online configuration in front of the traditional supermarket. The determination of the elements which make up the Canvas and emphasizing the differences with a traditional store will be the framework we use to present the results.

The determination of every element is based on experience and literature revision (Boughen, 2008; King and Park, 2004); this problem in an Operations Research framework (Gu et al, 2007; Ernst et al, 2004) is going to be dealt in the large project we are conducting, however we focus on required operations in a supermarket are the key activity assigned by a high definition of main operative processes. This is the huge opportunity we want to highlight in this contribution, because by the determination of every task, it is possible to schedule and plan following optimization functions. Nevertheless, these tasks are classified depending on their processes they belong and they have diverse features to determine the priority index.

The Business Model Canvas is a strategic management and entrepreneurial tool (Osterwalder, 2012). It allows practitioners and researchers to describe, design, challenge, invent, and pivot the business model. It could be applied in existing models or in new ones. It was developed by Alex Osterwalder and it has a huge impact in new business generation. The Canvas is composed of the 9 following segments, which have to be filled out by answering some key questions. Following there is a description of each question:

Key partners. Who are your key partners/suppliers? What are the motivations for the partnerships? **Key activities**. What key activities does your value proposition require? **Value proposition**. What core value do you deliver to the customer? **Customer relationship**. What relationship that the target customer expects you to establish? **Customer segment**. Which classes are you creating values for? Who is your most important customer? **Key resource**. What key resources does your value proposition require? **Distribution channel**. Through which channels that your customers want to be reached? How can they be integrated into your and your customers' routines? **Cost structure**. What are the largest costs in your business? Which key resources/ activities are most expensive? **Revenue stream**. For what value are your customers willing to pay? How much does every revenue stream contribute to the overall revenues?

The description of the case we are working on in the canvas Model allows us to give a framework to allocate the operational advantages we are expecting by scheduling warehouse operations. The description was made by interviews with Operators, computing Engineers, and Head of Operations manager. We have used estimated data and real data from the firm we were studying.

3 Firm and how it runs

The Process of buy in this online grocery is the same of other virtual stores: the customer can browse in the webpage over all the products classified by categories. The information of every product is defined by photos, size, weight, etc. When the buyer decides to acquire a list of products (the usual grocery products in a weekly shop), he/she has to log in the system and he/she has to add the products in the virtual trolley.

When the shopping list is finished the checkout starts. At this point is where there is the main difference between the case study analysed and the regular online supermarkets. While the regular online supermarket demands where to send the purchase, in the supermarket we have analysed is the costumer who must move to the store to pick up its purchase in at last 2 hours later. Therefore, the firm avoids the delivery of the order, so it avoids the cost of distribution in last mile (Boyer et al, 2003). The cost of shopping list is more or less in the average of the sector and there is no extra charge or a minimum of quantity to invoice.

The building, as a key resource, is similar to a traditional store, but without cash registers because the checkout is done electronically by web-based interaction. Internally, the building is very similar to a traditional one, but all the shelves in the corridor are marked and codified in concreted placements.

4 Findings

The findings we want to present are the success of the increment of efficiency related to operation management. By the clear process definition as Key activities it is possible to assign operations to personnel based on efficiency criteria.

The results we can present are the determination of every of 9 elements in the case we have studied. In the next sections the elements of Business Model Canvas will be explained. However, it will be in Results section where the Key activities are explained to highlight the competitive advantage of this innovative system.

4.1 Customer Segment

This virtual store is focus on people who do not want to spend time in grocery supermarkets, because their value of time is high or because their main dedication is on other topics: kids, work, etc. They usually do the same grocery list and spend more or less the same products. However they have to be familiar in e-commerce and to use the car in commuter's mobility. This is the main segment they are focused on.

4.2 Value proposition

The Value Proposition is time and commodity. In traditional supermarkets the client is who picks up all the products and then is who has to check out the purchase in the cash lines. This is a considerable amount of time and worries. Therefore, the emergence of ecommerce is centred on 24 hours/365 days with the chance to order the grocery list at time client wants and to pick it at time client plans depending on personal matters.

4.3 Distribution channel

The way to send the products to customer's home is different that the traditional store. In the store we are studying, customers have to do the grocery list at last 2 hours before picking the order. They have to come to store but they save the time to pick the list of products. However, the distribution channel till the store is exactly the same as traditional one.

4.4 Customer relationship

As the contact with customer is very short, and the buy experience is virtual, it is very important to use ICT to establish customer relationships. The use of special discounts, newsletters, is usual but it does not differ from traditional ones. However, the personal contact with personnel who delivers the order when customer comes to pick the grocery list is a key moment for this firm.

4.5 Key partners

As the supplying is the same as traditional stores, the key partners related to supply are exactly the same. So if they belong to a wider group of grocery stores, the wholesaler, and distribution channels are the same.

4.6 Key activities

The main activity to take competitive advantage is to be more efficient and operational level: this means activities as shelves' replenishment operations, picking customers' orders, customer orders delivery and knowledge of customer behaviour are key activities. These clear Operations definitions allow Information System to standardise work, stablish pace in personnel in operations assignment and level operations in order to achieve application of heijunka tool (Womack and Jones, 2003; Rother and Shook, 2003).These particular characteristics will be developed in Results Section.

4.7 Key resource

Apart from human resources, the building is the main physical key recourse. The codification of all shelves as well as their level control is key as input for computer system. But the most important resource is the internet platform and ERP which controls the inventory levels of each product in the shelves and monitors all the operations personnel have to do in operative processes. The inventory control has to be strict because it allows to customer to select in the web application. One of the biggest problems in traditional ones is to use product substitutes when the inventory is broken.

The computer criteria to monitor and plan the Shop Floor Operations, is the main resource to take advantage from operations management perspective.

4.8 Cost structure

The cost structure, compared with a traditional one, is the same, but the cost of operations is changing, from cash registers to picking customer orders. Apart from that there will be an increment of maintenance of information system, because it has to be sourced with every movement in inventory levels (inbound and outbound movements) and allocation of all products.

Therefore the maintenance of computer platform is the main difference in cost structure compared to traditional stores.

4.9 Revenue stream

The revenue stream is exactly the same as traditional ones, because the product price is not incremented and neither a minimum quantity to order. Therefore the viability of the project is only attributable to reduction of cost structure by increment of operational efficiency.

5 Results

The results we present in this contribution are partial because it is a project in process. We highlight which are key activities which increase the operative system efficiency in this particular grocery store. The main focus is on the Key activity of programming or scheduling tasks in warehouse personnel, who participates in the two main processes. They are 1) to refill the shelves in supermarket lines (we called Inbound) and 2) to pick the products to make up the shopping list ordered by customer (we called Outbound). The lead time to finish the second process is determinated by the customer when he decides to pick the order in the store and it is at last 2 hours. The other traditional task of checking out in cash-line is not required in this store because is done by credit card on web page (with no possibilities to pay in cash). The determination of Operative tasks from Operative Processes management is the main results explained in this contribution

5.1 Inbound

It starts when purchasing order is sent to supplier and the delivery hour assigned. This process is composed by 4 tasks. The ERP can schedule the task of *receive supplier order* (1), but it will not be available to do until the supplier arrives to the dock. Then we will need to *check goods* (2), to ensure that there is no error and, after that, we will have to *split the supplier order* (3) in inbound orders, so that this will generate as *many inbound placement orders* (4) of products as required. The criteria for generation of these orders will be of two types: (a) the location within the shelves and b) the required time to finish the order so that they are orders that can be carried out in a maximum time, keeping the equilibrium between various operations, following the heijunka tool. When this operation is completed, it may increase the inventory in the ERP so that the inventory is updated in real time.

Therefore in the Inbound process there are 4 types of operations that are consecutive between them or can be prioritized on the basis of criteria in the efficiency of the system. Among these criteria include: to ensure the inventory level of the products, and keep the dock as empty as possible, with a constant flow of inbounds.

5.2 Outbound

This process is composed by diverse tasks, but only 2 have to be scheduled to do by personnel. This process begins with the generation of the customer order in the enterprise web application. After selecting all the products that make up the grocery list, customer should choose the day and time that will collect the purchase order. This time shall be one of the prioritization criteria and also determines the maximum lead time that has the system to complete the customer order. From the customer order converted into already confirmed orders, we are be able to *generate as Outbound orders* (1) as it will be required on the basis of the following criteria, similar to the process of the inbound orders (a) the location within the shelves (b) the required time to finish the order in a maximum time keeping the equilibrium between various operations, following the heijunka tool and (c) taking into account the final location of the complete customer order, so that it is waiting for the arrival of the customer to collect the order.

With the customer order ready, all the outbound orders already implemented, the order only is waiting that the customer comes to collect it. So the operation of *delivery to customer* (2) is only being enforced when the customer arrives in the store. The maximum time that can take this operation is 5 minutes. In this way the outbound process is completed that consists of preparing and delivering the grocery list order to the customer.

Therefore the Outbound process appears 2 types of operations that are consecutive between them or can be prioritized on the basis of criteria based on the efficiency of the system. Among these criteria include: minimize the movements in the store and keep the final locations of the customer orders with a high level of rotation, with a constant flow of outbounds orders.

6 Conclusions

The clear and precise determination of all processes operations of Inbound and Outbound processes that are carried out in the store, allows us the application of dispatching rules based on the criteria explained in the Results section to optimize operations efficiency. Behind the optimization criteria appear concepts related to the lean management principles (Womack and Jones, 2003; Rother and Shook, 2003), as would be assigned to the staff only the operations which add value to the customer, determination of the value stream through clear definition of the processes, maintain constant flow by leveling operations (heijunka).

These conclusions are from preliminary results we are carrying out. However we are recollecting more information by case Study methodology to develop a more detailed and definitive Case Study to use in Student sessions to demonstrate the use of more sophisticated dispatching rules to increase efficiency in warehouse management operations.

7 References

Boughen D. (2008) An examination of the use of operations management within the British supermarket industry as a means to develop a competitive advantage. Dissertation in University of Northampton

Boyer, K., Hult, T., Splinder, M. and Santoni, R., (2003): Bridging the Last Mile: Online Shopping in UK and US, MIT Sloan School of Management.

Ernst A.T., Jiang H., Krishnamoorthy M. and Sier D.(2004) Staff scheduling and rostering: A review of applications, methods and models. European J of Operational Research 153:3-27

Gu J., Goetschalckx M. and McGinnis L.F. (2007) Research on warehouse operation: A comprehensive review" European J of Operational Research 177:1–21

King, R.P. and Park, T.A. (2004) Modeling Productivity in Supermarket Operations: Incorporating the Impacts of Store Characteristics and Information Technologies. J of Food Distribution Research 35(2):42-55

Osterwalder, A., (2012) "Business Model Generation" 12 ed. Ed Deusto

Rother M. and Shook J. (2003) Learning to see. Lean Enterprise Institute

Van Beek, B. (2009) "Online grocery stores: New style. The best business model" PhD Disseratation Universiteit Twente. Faculteit Management en Bestuur

Yousept I and Feng Li (2004) "Online Supermarkets: Emerging Strategies and Business Models in the UK" in Proceedings of 17th Bled eCommerce Conference eGlobal. Bled, Slovenia, June 21 - 23, 2004

Proposal for a low-cost technique for remote monitoring of body temperature: An application for work safety

Pereira S G M[1], Medina F A S[2], Andrade S S[3], Gonçalves R F[4]

Abstract: This study aims to propose a cost-effective technical solution in monitoring the distance of workers operating in hazardous areas or under strong external influences. A prototype was built to measure body temperature, relative air humidity and ambient temperature through of an applied research. Body temperature data is display in a graph, within a predetermined period, wherein the measurement range can be easily set. As a result, the system first tests were stable solution and for using open source tools, it was possible to develop a low cost prototype.

Keywords: body temperature, mobile health, occupational health, safety.

1 Introduction

Safety in the workplace is a topic that triggers many studies and raises some discussions on appropriate measures to be met by the organizations.

Sinelnikov et al (2015) asserts that when organizations increase health and safety at work for an important organizational value, it is expected considerable investments in resources for measurement and performance. The growth and popularization of systems aimed at occupational safety and health had significant rise in the world from the 90's which generates a significant increase in concern and adequacy of performance measurement techniques and tools.

When dealing with occupational health and safety, you can see two approaches, one which deals with security related to handling equipment and the second addressing workers' health (Sinelnikov et al, 2015).This research addresses the prevention of accidents with a focus on health and well being of the person, considering that working environments should provide good conditions for workers, as follows: appropriate temperature and humidity, light enough, among others.

An important point is the well being of workers who labor in environments with extreme situations, external work is an example where they face very high or low temperatures. worker excessive exposure to heat can suffer elevation of body temperature and sleepiness can lead to physical collapse (Steen, 2001; Alahmer et al, 2011; Medeiros et al, 2013).

In this context, the biggest challenge is to detect the oscillation of the worker's body temperature in the workplace, performed remotely, and that health professionals can intervene before any type of abnormality will occur which can cause more serious accident. When exists the necessity to maintain a continuous patient monitoring.

1 **Sergio Gustavo Medina Pereira** (medinasergio@yahoo.com)
2 **Franciele Alves dos Santos Medina** (cieli_fran@yahoo.com.br)
Programa de Pos-Graduação em Engenharia de Produção.
Universidade Paulista - UNIP.
Dr. Bacelar, 1212, SP 04026002 São Paulo, Brazil.
3 **Sergio Schina de Andrade** (sergioschina@hotmail.com)
Ecil Informática Indústria e Comércio LTDA,
Europa, 54, SP 06543-325, Santana de Parnaíba, São Paulo, Brazil.
4 **Rodrigo Franco Gonçalves** (rofranco@osite.com.br)
Programa de Pos-Graduação em Engenharia de Produção.
Universidade Paulista - UNIP. Dr. Bacelar, 1212, SP 04026002 São Paulo, Brazil.

The updating of vital data is essential for obtaining successful treatment of diseases considered critical, such as the treatment of diabetic patients in which the aim is to keep the level of insulin at a level considered stable and vital to the survival of the same. Thus, there are systems capable of monitoring the insulin level in real time, such as equipment CGMS (continuous glucose monitoring system) of Meditronic - Multinational development of medical equipment, which ended up being the most widely used equipment worldwide (Minicucci and Franco, 2010).

The choice of remote monitoring system topic of body temperature wireless emerged in order to give more aid to those involved in risky activities and who need real-time monitoring. A large part of the initiatives related to safety and health of workers are still evaluated precariously. Outdated based on metrics such as the mortality rate and injury accidents.

It is noticed that these measures focused on failure ever conducted, evaluated after the incident, are less useful to assist organizations in their decision-making and actions for continuous improvement. (Sinelnikov et al, 2015). The system helps the efficiency of diagnosis by providing the data in real time, allowing health professionals to greater safety due to the possibility of a historical analysis of data, allowing predict or foresee a situation that may expose the worker to a hazardous situation which consequently lead to occurrence of an accident.

This study it is an applied research that aims to present a low-cost solution for remote and real-time monitoring of body temperature. This aimed at workers who put up with in hazardous areas. The device performs the measurements and makes access and the faster and more accurate service, acting to prevent possible accidents

This work is organized as follows: initially it presented the theoretical concepts of health and safety at work, telemetry and related work. Section 3 deals with the methodology adopted. Section 4 examines the issues relating to the monitoring system. Section 5 is the results. This paper concludes in section 6, where the final considerations, limitations and future work are presented.

2 Literature Review

2.1 Occupational health and safety at work

For Fiedler et al (2010), the work environment consists of a combination of several interrelated factors. They act directly or indirectly on the quality of life of workers and of their own work results. Some of these negative factors cause malaise, discomfort, thereby increasing the risk of accidents, which can cause considerable damage to workers' health.

Was identified by Lida (2005), a major source of stress at work are unfavorable environmental conditions such as excessive heat, humidity, noise and vibration, that influence directly and negatively on the performance of human labor.

Sinelnikov et al (2015), discusses the differences in terms used in the measurement of indicators related to safety at work, although there is a standardization there are still many close terms, and used interchangeably. The main points observed on the indicators are: feasibility, significance, transparency, ease of communication, validation, utility, they were identified as part of the utmost importance on the quality of metrics. Emphasizes that the most important of the main indicators is the use of the object itself, that is, its main purpose is to identify the steps to reduce or eliminate the risk.

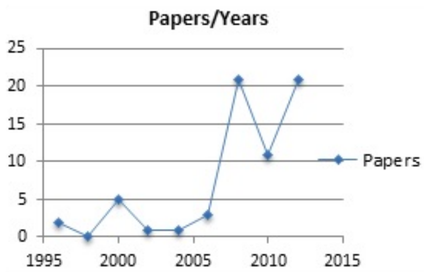
Al-Shanini et al, (2014) addresses the accidents in process / factory plants in order to keep the economy at desired levels,. It also debate the process plants are often equipped with a comprehensive process control system to ensure smooth operation and to prevent accidents. The system provides protection through different degrees of automation, facilitated by human intervention and protected by additional layers of protection as mitigating measures in case the system fails. An effective means of combating accidents is to formulate appropriate preventive measures. However, this is difficult to realize unless accidents can be predicted and are completely understood, before it's identified the occurrence of an accident.

Koskela (2014) discusses about the social responsibility of corporations, which identifies three key factors in this process: the economy, the environment and social impacts. In their study the author uses the backdrop of this division, but addresses the issue of health and safety at work in the section on social impacts. In this context the responsibility of organizations is internal or external. It is understood that the company should provide a safe and healthy work environment in both cases.

In their studies Fan et al (2014), discusses the economic factors involved in occupational safety and health. He assert that the governments of developed countries have to pay close attention to security issues and Occupational Health. These numbers was observed that approximately U$ 583 million are earmarked for this sector annually. Despite these investments occupational accidents and diseases are still common factors in the removal and termination of employees. It was found that in the US about 4 million are injured in their workplace each year and about 13 workers die each day. Related losses amount to U$ 170 billion each year according to 2003 data, with a significant increase when compared to the '90s.

The study of the development of DIMOR-TC, also dealing with the prevention of accidents but focused on the person / employee before the employee has any ailment that can take you to shoot a possible accident the device to recognize and avoid the failures and incidents that refer to workers' health and can be minimized.According to Lee (1996), the safety is directly involved with the organizational culture and the culture he defined as a "product of the individual and the group as: values, attitudes, perceptions, competencies and patterns of behaviour that determine the health management commitment and safety of the organization.

Fan et al (2014), in his literature systematic review report relevant data on the number of studies conducted in the area. Through Figure 1, can be seen that the concern for occupational health and safety had considerable growth in 2008, with a fall in 2010 and grows back in 2012.



Adapted from Fan et al. (2014)

Fig.1
Growth of the number of safety and health publications in the workplace.

From these data we note that studies focused area still have much importance, the increasing amount of publications shows the interest in the subject matter.

2.2 Telemetry

The word Telemetry is from Greek origin, and it means far remote, and metron, meaning measure (Dias, 1992).

The possibility of monitoring remote systems is applied when the systems are classified with a high level of importance or dangerous, unhealthy or not favor the existence of human life, and when there is the need for a high level of monitoring. Systems capable of performing such activities are called telemetry systems.

With the progress of technology, telemetry has become necessary for the development of various systems and is applied to the aid of different fields such as medicine, engineering, safety, geography and so on. Telemetry is also used in the biological area allowing the collection of biological data from aquatic animals (ABECASIS, 2009), the monitoring of agricultural machinery used in planting, cultivating and harvesting products (Piovesan, 2008), among others.

2.3 Related work

As technological advances occur, there are a variety of electronic devices. A problem observed in technological innovations is that for the most part of these artifacts reaches the consumer with a very high price.

Table 1
shows the similar research conducted in the field of health informatics.

General Objective	References
System that connects the patient, located in your home, health professionals, integrating the various relevant services to remote monitoring of patient health.	Carvalho and Filho (2011).
System that connects the home of the patient and a web server where mobile phones interact with a service Webservice for sending patient information.	Machado et al (2011).
A Pervasive and intelligent approach Low Cost for Patient Monitoring with Cardiovascular Diseases.	Silva and Siebra (2012).
Shimmer – a wireless sensor platform for noninvasive biomedical research	Burns et al (2010).
Information about the NeXus-10	Mind Media (2011).
AMON: a wearable multiparameter medical monitoring and alert system	Anliker et al (2004).
Mobile wearable device for long term monitoring of vital signs. Computer methods and program in Biomedicine.	Klingeberg and Schiling (2012).

3 System Development method

For the first phase of the research, the literature search method through a literature review was used, available both in national international databases, for analysis of similar systems conducted in telemedicine, health informatics.

The second phase of the research involves the development of the prototype, construction and device test, hardware, to perform the sensing body temperature signals, environment and relative humidity, with the transmission of data collected to the WebService in real time. Finally after analysis of the data, they will be displayed graphically on an interface, within a predetermined period of time.

The developed system, referred to herein Body Temperature Monitoring Device (DIMOR-TC), consists of a device (hardware) with ability to perform body temperature sensing worker.Figure 2 shows a block diagram, picturing the system development stages, from the measurement of data generated by the sensors, which is captured by the microcontroller and processes the data, eliminating noise and make the necessary amplification.

The prototype is connected to the worker's phone, so using the device's battery in the low power mode. An application shall transmit the data to a device chosen by the health professional who can view the data in graph form. The measurement data can be easily set, at predetermined time intervals.

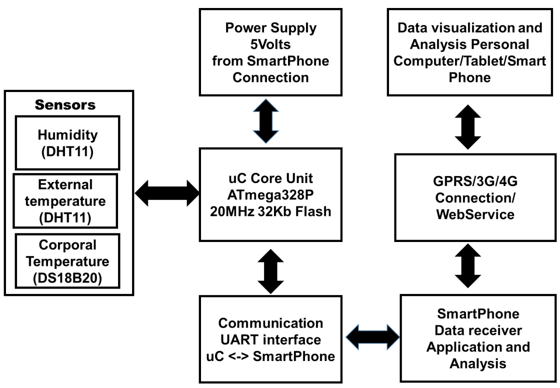


Fig.2
Blocks Diagram System.

Table 2 lists the current consumption in active mode and Low Power Mode.

Table 2
Current requirements in active mode and low power mode.

Component	Required current at Active Mode	Required current at Low Power Mode
DHT11 – Humidity and Temperature	2.5mA	150uA
DS18B20 - Temperature	9mA	7.8nA
Atmega328P	9mA	1nA

5 Results

The remote device signals, specifically in this paper deal with the body temperature, relative humidity and ambient temperature (DIMOR-TC). Hardware and software have been developed with free platforms and open-source tools, allowing a reduction in costs and also in the final price.

By monitoring, the recorded data allow you to create a history of the user, which allows the initiation of an abnormal event, sending alert signals to the health team and then to users themselves, which may stop or decrease your pace, or activity being performed. The device (DIMOR-TC) intends to act before there is a negative event, working to prevent these events.

Development of a system with an architecture that integrates sensors, mobile devices and WebService to: i) continually monitor the health of workers by sending alerts in case of emergency and ii) the development of technical solution, considering a complete system (hardware and software) aimed at targeting telemetry wireless data transmission and real-time, with low cost limitations considered from the perspective of Systems Engineering.

6 Conclusion

The choice of remote monitoring of vital signs via wireless system theme emerged in order to give more aid to those involved in risky activities and who need real-time monitoring.

Because it is a mobile device, it has numerous applications, for instance: monitoring workers at risky areas or of difficult access, or in execution of tasks that can be considered dangerous to the worker. Thus, a skilled team can monitor workers without displacement and provide greater safety to the worker.

The system may assist in the diagnosis efficiency by providing the data in real time, allowing a professional of health greater safety due the possibility of a historical analysis of data.

In the market there are several products that measure body temperature, but the differential of DIMOR-TC is that it keeps a history of measurements performed on an electronic medical record but also measures the temperature and humidity of the environment where the measurement is being performed. This can be visualized in a graphic body temperature within a predetermined period. The measurement range can be easily configured.

In this paper, only one type of monitoring was addressed a, the body temperature. As future work, it is planned to implement new aspects to the project, such as monitoring of heart rate, blood pressure, and galvanometer resistance (for measurement of stress), which would allow the system to perform more accurate diagnoses.

7 References

ABECASIS D (2009). Telemetria: Conceitos e Aplicações. Algarve Portugal: Centro de Ciências do Mar- Universidade do Alga

Alahmer A, Omar M A, Mayyas A, Dongri S (2011). Effect of relative humidity and temperature control on in-cabin thermal comfort state: Thermodynamic and psychometric analyses. Applied Thermal Engineering 31 (2011) 2636e2644

Al-Shanini A, Ahmad A, Khan F (2014). Accident modelling and analysis in process industries. Journal of Loss Prevention in the Process Industries 32: 319-334

Anliker J A, Ward P, Lukowicz G, Tröster F, Dolveck M B F. Keita E B, Schenker F, Catarsi L, Coluccini A, Belardinelli D, Shklarski M, Alon E, Hirt, R, Schmid M (2004). AMON: a wearable multiparameter medical monitoring and alert system, IEEE Transactions on Information Technology in Biomedicine 8:415–427

Burns B R, Greene M J, McGrath T J, O'Shea B, Kuris S M, Ayer F, Stroiescu V (2010). Cionca Shimmer – a wireless sensor platform for noninvasive biomedical research, IEEE Sensors 10:1527–1534

Carvalho S T, Copetti A, Filho O G L (2011). Ubiquitous computing system in home health care. J. Health Inform. 2: 51-7

DIAS O (1996). Telemetria e sensoriamento remoto**.** São Paulo: Copel.

Fan D, Lo C K Y, Ching V, Kan C W (2014). Occupational health and safety issues in operations management: A systematic and citation network analysis review. Int. J. Production Economics 158: 334–344

Fiedler N C, Guimarães P P, Alves R T, Wanderley F B(2010). Avaliação ergonômica do ambiente de trabalho em marcenarias no sul do Espírito Santo. Revista Árvore 34:5 - 12.

Koskela M (2014). Occupational health and safety in corporate social responsibility reports. Safety Science 68:294–308

Klingeberg T, Schilling M (2012). Mobile wearable device for long term monitoring of vital signs. Computer methods and program in Biomedicine 106:89-96

Lee T R (1996). Perceptions, atitudes and behaviour: the vital elements of a safety culture. Health Saf.10:1–15

Lida I (2005) Ergonomia: projeto e produção. Edgard Blucher Ltda, São Paulo

Machado A, Padoin E L, Salvadori F, Righi L, Campos M De, Sausen P S. E, Dil S L (2011). Utilização de Dispositivos Móveis, Web Services e Sotfware Livre no Monitoramento Remoto de Pacientes. CBIS

Medeiros E G S de, Filho F A G, Silva L B da (2013). Proposta de avalização termoambiental em viaturas utilizadas nos serviços de radioparulhamento no estado da Paraiba. XXXIII ENCONTRO NACIONAL DE ENGENHARIA DE PRODUCAO

Mind M B V, Available via Information about the NeXus-10. http://www.mindmedia.nl/english/nexus10.php/. Cited July 2011

Minicucci W J, Franco D (2010). Monitorização contínua da glicose: Novas tecnologias. http://ebook.diabetes.org.br/component/k2/item/90-capitulo-2-monitorizacao-continua-da-glicose-novas-tecnologias

Piovesan F C (2008). Telemetria Aplicada na Mecanização Agrícola Utilizando o Datalogger CR 1000. Santa Maria

Sinelnikov S, Inouye J, Kerper S (2015). Using leading indicators to measure occupational health and safety Performance. Safety Science 72: 240–248

Silva M D, Siebra C A (2012). Uma Abordagem Pervasiva e Inteligente de Baixo Custo para o Monitoramento de Pacientes com Doenças Cardiovasculares. XII Workshop de Informática Médica

Steen R. American Red Cross Offers Travel Safety Tips. The American National Red Cross. http://www.redcross.org/ title of subordinate document. Cited 27 Dez 2014.

Gestalt and its influence on graphical touchscreen interface for elderly people

Medina FAS[1], Pereira SGM[2], Silva VR[3], Gonçalves RF[4]

Abstract: This study aims at pointing out the needs in touchscreen interfaces for smartphones by elderly people. For this, we use the Gestalt theory and visual perception as theoretical basis. The sample chosen for the pretest of the questionnaire were 5 people. The Likert scale was used. For the theoretical framework, we present a review of the literature in national and international databases. One can conclude that despite the popularity of these devices, there is still a gap in relation to the elderly users. There is still difficulty in assimilating new features. Users who already have smartphones use it as a common cellphone.

Keywords: Human Computer Interaction, Gestalt, Intuitive Interaction, Elderly people, Mobile Devices.

1 Introduction

The growing use of smartphones causes a change in the context of use of interfaces, which had been firstly established for personal computers and laptops. Such changes require a new way of Graphical User interface (GUI) development, graphical interfaces touchscreen.

The construction focused on user interfaces has been neglected in the Information and Communication Technology (ICT) throughout its development. When an interface is not friendly, it requires the user to have a better understanding of the system (Boubeta et al., 2014). Users only will waste their time learning a system if it is fundamental to their routine. Otherwise, they will migrate to a simpler and user-friendly system.

With the expansion of the Internet and social networks, the number of people who use technology also increases, since they want to stay connected with their loved ones through a new form of communication that was not available in previous generations (Silva & Correia, 2014).

When considering the population over 60 years, one can see that the decline in cognitive abilities occurs gradually and is inherent in the physiological process of normal aging and, therefore, arises as a natural consequence of advancing chronological age, and is not automatically an obstacle to normal operation (Moreira & Oliveira, 2005).

The popularization of the use of computer systems, along with mobile devices, tablets and smartphones, included new forms of interaction in daily life. Mobile computing has become a rapidly growing field. The rapidly evolving ecosystem of mobile devices, based on the touch screen (smartphones and tablets), along with advances in cellular and wireless network did as well. Mobile devices also revolutionized the way users interact with computers (Hedrick and PU, 2012).

The new mobile phones go beyond communication. With touch screens, smartphones are more affordable and technically more powerful. With the growing number of features built in these devices, the need for the designers to have to consider the intuitive interaction in the creation of new design devices (interfaces) increases. (Britton et al., 2013).

Zhou et. al. (2012) analyzed that with the development of mobile computing devices and sensors reduced in size, the innovative capacity regarding technical and interfaces has greatly increased. These

1 **Franciele Alves dos Santos Medina** (cieli_fran@yahoo.com.br)
2 **Sergio Gustavo Medina Pereira** (medinasergio@yahoo.com)
3 **Vanessa Rodrigues da Silva** (van117@live.com)
4 **Rodrigo Franco Gonçalves** (rofranco@osite.com.br)
Dpto. de Pós Graduaçao em Engenharia de Produçao.
Universidade Paulista. Dr. Bacelar, 1212, 04026-002 São Paulo.

new methods of interaction are changing our lifestyles, facilitating the implementation of activities, whether in day-to-day or in their functioning.

The change in the context of use also causes a change in user behavior. Nowadays, the tasks that were performed in a restricted environment are performed in different locations, it is common to see people using their mobile devices on the street, on public transport, in airports - in fact, the smartphone has become an extension of the individual, either for business purposes or entertainment only.

This article aims at supporting the construction of accessible mobile interfaces for elderly people, through visual aids, particularly regarding visual perception. Gestalt as a tool for the creation of a pattern that can help designers and developers in design aesthetically pleasing and with high power of usability interfaces.

This paper discusses an applied research through a questionnaire and is organized as follows. Initially, the literature review examines the relevant theoretical concepts on graphical interfaces. Section 3 deals with the aesthetics of issues that can be applied as an aid in interface design. Section 4 discusses the methodology used in the article. In Section 5 the results are presented. This study is concluded in section 6, where the final considerations, limitations and future work are presented.

2 About graphical interfaces

The interaction models change as the features are inserted in these devices, and their already standardized use of personal computers and laptops is reformulated to a size / lower screen resolution, incorporating the keyboard (touchscreen), decreasing the size of the interface, which directly affects the human-computer interaction (HCI) (Choin and Lee, 2012).

Park (2010) points out that few studies aimed at the users of mobile devices were held until the present date, and that this gap allows more detailed studies on the user's efforts in the use of mobile devices to be developed. Whereas in comparison to other information communication technologies (ICTs), mobile technologies are still under development.

2.1 Touchscreen interfaces

The touchscreen interfaces promote changes in the way of interaction. The standard ISO 9241-Ergonomics of Human Interaction Systems, 2010, defined principles and guidelines for studies aimed at Human Computer Interaction (HCI), which includes definitions of the design process for user centered interactive systems.

Intuitive interaction can be understood as a user experience in which the user feels at ease to and is able to successfully use it immediately, providing satisfaction in use when the interface allows the user to achieve their ultimate goal (Spool, 2005). The user experience (UX) is defined as: an easy perception of use in user interfaces and inflicts emotional aspect.

Mohs et al. (2006) defines a set of principles for creating intuitive interfaces, which highlight the suitability for the task, compatibility, consistency, laws of Gestalt, feedback and affordances. Some of these principles are related to the use of the interface metaphors inserted.

Besides the interaction through the interface, buttons, icons, etc., there are gestures involved in the touchscreen, as shown in Figure 1.

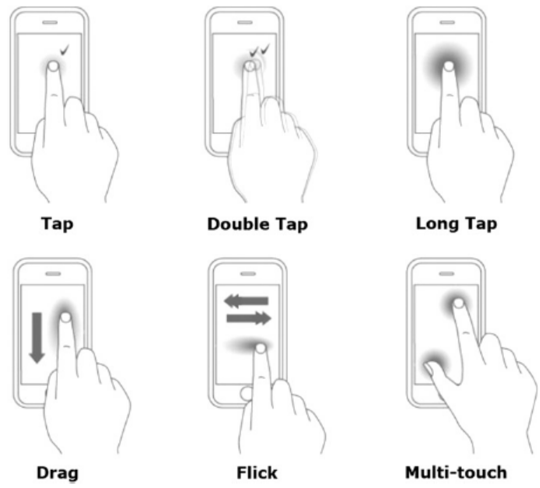


Fig.1
Six basic types of actions on a touchscreen interface (Choi, 2008).

According to Britton et al., 2013, some studies address the importance of the user experience of return with the touchscreen. The interaction must be effective and intuitive. Feedback is of fundamental interest because those touchscreen devices are supported in visual forms due the absence of physical buttons.

3 The aesthetic and its influence on the design of the interfaces

3.1 Gestalt and its definitions

This is an original German term. It can refer to the form, or pattern. It has been applied to a number of scientific principles extracted from experiments that address the sensory and visual perception (Arnheim, 1974; Lin, 2013).

The Gestalt psychology, from its origins, was related to art. Art has always permeated the studies of Max Wertheimer, Wolfgang Köhler and Kurt Koffka (Arnheim, 1974). Some theorists of Gestalt emphasize that the whole is not merely a sum of its parts. They proposed principles such as similarity, proximity, good continuity and symmetry (Lin, 2013).

The Gestalt approach generally refers to a minimalist way. This dimension refers to the perceptions of the minimum of ornamentation in design features and maximum resistance to perceptual separation (Chou, 2011). The author adopts in their paper 5 laws of Gestalt, as follows:

Proximity: is based on perception as a collection of objects is grouped with nearby objects mentally each other as forming a whole.

Similarity: based on the idea that the elements are grouped by the perceived if they are similar to each other.

Continuity: refers to the tendency to see patterns. When the perception of nearby elements to mental creation of some kind of continuous pattern.

Symmetry: captures the idea that the priority in the cluster of perception is facing more natural, balanced and symmetrical shapes on asymmetric.

Closing: posits that we perceive closed elements themselves. It makes the brain produce contours and / or locks that do not exist.

This concept is extremely used in the development of touchscreen interfaces, the gesture involved and the dimensions of the devices. It also requires displays to be as simple as possible, making browsing more enjoyable.

3.2 Visual Perception

As Gestalt psychology, minimalist principles provide an important perspective on visual perception. It is appropriate to apply these principles in the evaluation of product design quality. The perception of Minimalist Gestalt deals with perceptual dimensions for the minimum ornamentation of the characteristics of design and maximum resistance to perceptual separation (Chou, 2011).

> "The observer views the attractions and repulsions in the visual patterns as genuine properties of the perceived objects themselves. If, however, it is reasonable to conjecture that every aspect of a visual experience has its physiologic counterpart in the nervous system, one can anticipate, generally, the nature of brain processes. It can be stated, for example, that there should be field processes. This means that everything that happens anywhere is determined by interaction between the parts and the whole." (Arnheim, 1974)

4 Methodology

Technological changes that occur very quickly impact each individual category differently, and, although it is part of the old life, such resources can not be completely and instantly absorbed by them and instantly, the way as with as young people do (Tuch et. al., 2012).

As informed by the demographic studies presented by IBGE (2010), Brazil has a growing elderly population in the country, which represented more than 20 million people in 2010. The survey carried out shows that this number is expected to increase in the coming years and may exceed 30 million people older than 60 by 2022, which should represent almost 13% of the population in our country.

This paper aims at exploring and identifying gaps in the creation of graphical user interfaces for mobile devices using the touchscreen interface focused on the elder public.

The theme is justified by the data of two increasing numbers, 1) the growth in new users with Internet access and, 2) the increase in the elderly population. These two factors imply the need for studies that provide guidelines for building graphical interfaces accessible to the entire population, especially the age group above 60 years.

In this research, the aesthetic aspects needed for a good interface were identified through literature review, focusing on themes: Gestalt and Visual Perception. Scientific articles were researched as from 2010. And the book Arnheim, R., 1974. Art and Visual Perception: A Psychology of the Creative Eye was used as base for visual perception.

From the frame formed by the intersection of the common themes among articles, it was possible to extract information for the design of visually pleasing interfaces.

The second stage consisted of test questionnaires applied on people over 60 years old. At first, the questionnaire test was applied on 5 users. The purpose of the tasks was to measure the satisfaction and the appropriateness of users with the use of mobile devices.

Was asked them to fill out two questionnaires, the first to identify the characteristics of users, such as age, education, familiarity with devices, among others. The second questionnaire aimed at deepening the research on the experience of users through questions about their opinion about the typing process and some gestures used in touchscreen interfaces.

The questionnaire used a Likert scale ranging from very satisfactory to unsatisfactory, as shown in Figure2.

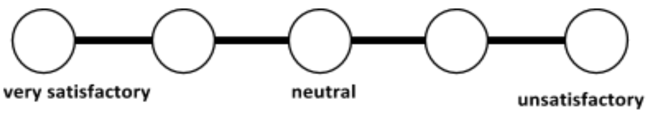


Fig.2
Scale used in the questionnaire. Developed by the authors.

This study included 5 users. The average age of participants was 64.2 years. From the sample, 3 participants were female and 2 males. The sampling procedure was done for convenience.

5 Results

Among the five respondents, three of them already use mobile Smartphone type. The biggest complaints refer to the screen size, including font sizes and buttons.

The two respondents not yet using mobile Smartphones showed interest in their use, but they believe they need help to start the basic tasks.

There is resistance on part of respondents to operate many existing applications. The Smartphone is widely used as a common cell phone for making calls and sending text messages. Among the sample, only one user uses it to access the Internet, including social networks.

From the study of the Laws of Gestalt, you can use the law of similarity to assist the elderly to realize that the keys are equivalent. For example: the numbers must have a distinct form of letters, and each symbol should have a key with different colors. From this, creating a pattern of typing that is purely intuitive.

By itself, the form is a better means of identification than the color, not only because it provides more types of qualitative difference, but also because its distinctive features are much more resistant to environmental variation (Arnheim, 1974).

The limitations of this study are: the sample size being small, which is still in the stage of adaptation of the questionnaire.

6 Conclusion

Despite the wide diffusion of technology that has occurred recently, there is still a gap in studies aimed at the type of touchscreen interfaces, particularly when addressing accessibility for the elderly user, in which the number is further reduced.

According to the questionnaire, it can be observed that users older than 60 want to be included, but they hesitate when finding barriers, giving up their use often due the lack of incentive or direct support.

In this study, it was possible to understand that some aesthetic factors such as Gestalt and visual perception, especially the shapes and colors, can be used in such a way to minimize the difficulties in accessing the graphical touchscreen interfaces.

For future research, new tasks will be included for users to perform on a Smartphone. Thus, with the pre-defined tasks and through the SAM methodology (Self-Assessment Manikin) it will be possible to measure user satisfaction. In the next steps of the research, it will be possible to draw up a screen prototype that reaches the goals of elder users.

References

Arnheim R (1974). Art and Visual Perception: A Psychology of the Creative Eye. University of California Press, Berkeley.

Bradley M M, Lang P J (1994). Measuring Emotion: the self-assessment manikin and the semantic differential. J. Behavior Ther & Exp. Psichiat 25: 49-59

Boubeta J P, Ortiz G, Bulo I M (2014). A model-driven approach for facilitating user-friendly design of complex event patterns. Expert Systems with Applications 41: 445-456 .

Britton A, Setchi R, Marsh A (2013). Intuitive interaction with multifunctional mobile interfaces. Journal of King Saud University – Computer and information sciences 25:187-196

Choi W (2008). A Study on the User Interface Design of Touch Screen Mobile Phone. M.S. Thesis, Kookmin University, Korea.

Choin J H, Lee H (2012). Facets of simplicity for the smartphone interface: a structural model. International Journal of Human-Computer Studies 70: 129–142

Chou J-R (2011). A Gestalte Minimalism-based decision-making model for evaluating product form design. International Journal of Industrial Ergonomics 41 : 607-616

Hedrick A, PU K Q (2012). Authoring relational queries on the mobile devices. Procedia Computer Science 10: 752-757

International Organizations For Standartization (2010). ISO 9241-1. Ergonomics of Human-System Interaction.

Lin J (2013). Development of scales for the measurement of principles of design. International Journal of Human-Computer Studies 71:1112–1123

Mohs C, Huetienne J, Israel J H, Naumann A, Kindsmüeller M C, Meyer H A, Pohlmeyer A (2006). Intuitive use of user interfaces. In: BOSENICK, T.; HASSENZAHL, M.; MÜLLER-PROVE, M.; PEISSNER, M. (Eds). Usability professionals. German chapter of usability professionals´association. Stuttgart 130-133

Moreira P, Oliveira C (2005). A fisiopatologia da doença de alzheimer e de outras demências. In: Caldas A, Mendonça A (Eds). A doença de alzheimer e outras demências em Portugal. Lisboa: Lidel

Park J, Han S H (2013). Defining user value: A case study of a smartphone. International Journal of Industrial Ergonomics 43 : 274 -282)

Silva M, Correia S (2014). ActiveBrain: Online social platform for active and healthy ageing. Procedia computer science 27: 38-45

Spool J (2005). What makes a design seen intuitive? User interface engineering. http://uie.com/articles/design_intuitive/. Cited 25/April/2014

Tuch A N, Roth S P, Hornbæk K, Opwis K, Bargas-avila J A (2012). Is beautiful really usable? Toward understanding the relation between usability, aesthetics, and affect in HCI. Computers in Human Behavior 28-1596:1607

Zhou Y, David B, Chalon R (2012). Mobile Paper Access: Ubiquitous Paper-based Interfaces for Mobile Interactions. The 3rd International Conference on Ambient Systems, Networks and Technologies - Procedia Computer Science 10: 282 – 291

Towards a Cost Management Methodology for Industrial Product-Service System Environment

Americo Azevedo[1], **Mar'atus Sholihah**[2]

Abstract: Increasing global competition has forced manufacturing companies to involve more services in their offering. Industries are very eager to add services not only as "add-on" of their products but rather as a bundle of product-service offering. This shifting of companies' mind-set leads them to implement Industrial Product-Service System (IPS^2) as an innovative strategy. Besides giving wide range of benefits, implementation of IPS^2 will also bring challenges for their internal organization particularly in terms of cost management. Literature has shown that number of IPS^2 implementation among manufacturing companies is continuously increasing but at the same time there is very limited studies discuss about their cost management and estimation. Cost estimation for IPS^2 environment remains a new concept and have not further developed. In line with that literature finding, this research project intent to investigate how IPS^2 companies calculate their costs and to verify the fit between the existing costing system and the IPS^2 environment needs. The main focus of this study is functional-oriented IPS^2 environment where machinery industry in Portugal will be the case study to further explore the desire research.

Keywords: Costing System, Industrial Product-Service System (IPS^2)

1 Introduction to the Problem

As continuous increasing of global competition which force industries to provide more values to their customers, nowadays western economics have shifted their orientation from only selling manufacturing-based products becoming more product-service oriented systems. Industries are keen to add services not only as "add-on" of their products but more as a bundle of total offering. This strategy is called Product-Service System (PSS) where companies are offering an integrated products and services which emphasizes on value in use rather than ownership (Baines, Lightfoot et al., 2007). The organizational transformation experienced by companies is called *servitization* (Martinez, Bastl et al., 2010). *Servitization* commonly happens due to financial aspect, strategic aspect and marketing aspect (Baines, Lightfoot et al., 2009).

In area of PSS, there is a particular case called Industrial Product-Service System (IPS^2). It is characterized by an integration and mutual planning, development, usage of product and service share in Business-to-Business (B2B) applications while original PSS is Business-to-Customer (B2C) application (Meier, Roy et al., 2010). The main distinguish character between PSS and IPS^2 companies is their customers. PSS company is dealing with the end user (B2C context) whilst the customer of IPS^2 company is other companies who are using the IPS^2 products and services to doing their businesses (B2B context).

IPS^2 is believed as an innovative strategy to face global competition but at the same time gives some challenges in their internal organization particularly in terms of cost dimension assessment. In fact, cost as one of the core competitiveness dimensions (the other ones are quality, responsiveness and flexibility) needs to be effectively estimated and calculated in order to stay competitive in the market. In practice, companies use traditional costing which gives emphasize only on their physical products and implicitly disregard costing of services (Hansen, Mowen et al., 2007). It seems relevant to study the challenges of

1 **Americo Azevedo** (ala@fe.up.pt)
Inesc TEC and Faculty of Engineering,
University of Porto, Portugal.
2 **Mar'atus Sholihah** (up201401931@fe.up.pt)
Faculty of Engineering, University of Porto, Portugal.

cost assessment for integrated product-service offering since literature has showed that manufacturing companies are in consistent track to become more service provider but at the same time there is very limited information about their costing methodologies (Datta and Roy, 2010).

The purpose of our research is to analyze how to calculate cost in a *servitization* environment. In particular, we are interested in define and specify a suitable methodology for machine-builders manufacturing company as practical case of IPS^2. The main research proposition is: How could a cost management system be applied to meet the IPS^2 environment of a machine-builder manufacturing company? In order to contribute to research progress in this field and to address the research proposition, the present paper aimed to answer to the following research questions:

1. What is the current situation of cost assessment in IPS^2 environments?

2. How to assess and calculate cost of IPS^2 machine-builder manufacturing company using given existing costing system?

As an initial step of the research and considering our focus on machine-builder manufacturing company, the research scope will be particularly focus on function-oriented IPS^2, related to the first type of IPS^2 business model proposed by (Tukker and Tischner, 2006). The first research approach to answer the research questions is an intensive review of the literature. The same approach has been adopted by many authors to classify or develop a framework or a research agenda on different topics regarding accounting (Resta, Powell et al., 2015). Furthermore, a case study methodology has been adopted. In fact, the research questions we have posed are of an exploratory nature and aim at dealing with operational links and a case study are a recommended research methodology (Yin, 2013).

The following work will present the first stage of the research completion that consists of literature review related to IPS^2 environment and existing costing systems, which help to construct the theoretical understanding. At the end, conclusion and future work as the next step to accomplish the research design would be presented.

2 Literature Review

2.1 Evolving Industrial Product-Service System (IPS^2)

As increasing global competition, particularly due to numerous threats from emerging industries in developing countries, selling product no longer can be a sufficient valuable economic basis for company success. Markets have learned to change their focus from products to customer-based requirements which emphasize the importance of services (Rese, Karger et al., 2009). This reality has been a trigger for manufacturing companies to be the IPS^2 practices.

IPS^2 is defined as an integrated offering of product and services which gives values in use that apply only in B2B application (Baines, Lightfoot et al., 2007). There are four main stakeholders in IPS^2 environment are identified as the Original Equipment Manufacturer (OEM) who is the IPS^2 provider; the customers; the suppliers and the society which include government and competitors (Meier, Roy et al., 2010).

IPS^2 business model can be altered from function-, availability-, and result-oriented use models (Tukker and Tischner, 2006). A function-oriented use model is the initial stage of IPS^2. Product remain the focus center but accompanied by a maintenance contract. OEM provides the necessary services to guarantee the functionality of the products during agreed period of time. In an availability-oriented use model, OEM provides wider range of services. OEM will guarantee the usability of the means of production because the main performance criteria of services delivery is based on the availability for use by the customer. Meanwhile, in a result-oriented business model, OEM will completely responsible for the customer production processes. The customer will only pay the final result which specifications are agreed in the contract (Meier, Roy et al., 2010). Each business model will gives different degree of risks and uncertainties that create unique characteristic of each type of IPS^2.

The most typical practice of IPS^2 comes from the machine builder manufacturing companies, which provide high value machines/tools for industrial companies. They start the *servitization* journey by providing standard after sell services or maintenance services contract around their products. One example mentioned in literature, which is doing this functional-oriented IPS^2, is Mori Seiki the machine tool manufacturer company in Japan (Meier, Roy et al., 2010). The journey toward a full IPS^2 application is obviously long and tough. Company has to deal with risks and uncertainties involving many stakeholders to provide combination of products and services. Implementing functional-oriented IPS^2 is a good starting point for a company who wants to take a part in this new business environment. Certain fields around IPS^2 remain as interesting topic to be further explored including area of its costing system.

2.2 Cost of IPS^2

One of the most promising benefits to be IPS^2 provider is the possibility to generate higher profits due to services provision. In contrast, some cases of *servitized* companies are able to generate more revenues but tend to achieve lower profits especially for large industries (Neely, 2008). It leads to a conclusion that estimating costing is very challenging particularly when it is associated with uncertainties during time period of contract. Defining the whole costs throughout life cycle of contract plays important role in company success. Some previous researches have tried to identify relevant cost elements occurred in IPS^2 providers which is summarized at Table 1.

Based on this findings, it can be concluded that pertinent cost elements of IPS^2 are costs that incurred throughout the whole life cycle of products and services, started from design development stage until disposal stage with additional cost element which are hidden costs and risk/uncertainty costs. This additional costs happened due to long-term partnership agreement between IPS^2 provider to provide an integrated solution through combination of products and services. Cost management methodology needed in IPS^2 environment should be concerned with all those cost elements.

2.3 Existing Costing System

Costing system is considered as an important aspect in any companies due to its sensitive influences for companies to design and execute their strategies as well as to make any related policies and decisions for their businesses. Misleading information issued by inappropriate costing system will lead to misleading decision. An appropriate costing system, including cost estimation, plays very important rule to determine the successful to compete in competitive market (Niazi, Dai et al., 2006).

Table 1
Cost element in IPS^2 environment.

Cost Elements in IPS^2 Provider	Sources
Relevant cost of IPS^2 is related with total cost of ownership which includes cost of capital investment, manufacturing activities, logistics activities and customer life cycle support	(De Coster, 2008)
Key cost elements of IPS^2 can be identified and categorized as recurring cost (RC) which includes labour cost, materials cost, machining costs, and logistics and sub-contract costs; non-recurring cost (NRC) which includes investment on company's equipment, facilities, capital goods, design development efforts are examples of non-recurring cost; Overheads (OH) for instance personnel, development of personnel, infrastructure, administration cost and hidden costs and risk/uncertainty (R&U). This cost relates with relationship management, communication costs, cost of lack of detailed level data, cost of reverse logistics and flexibility of response, cost of cultural changes or change management	(Datta and Roy, 2010)
Another cost element is cost due to product obsolescence and disposal. Under IPS^2 contract, IPS^2 providers are required to manage the obsolescence of products. Hence, it is important to include all the related costs which are used to deal with obsolescence into the agreed fixed cost paid by customer	(Meier, Roy et al., 2010)

Activity-Based Costing (ABC) is initially used as product costing technique but recently has been adopted in service organizations. ABC is considered as the most widely applicable method both in practice and literature. ABC gives high degree of accuracy to estimate cost since it provides very details cost information which incurred in company. ABC helps manager to see that not all revenues is good revenue and not all customers is potential customer (Drury, 2008). But, due to the excessive requirements (people, time and money) to implement and maintain, a lot of companies have given up to use this system (Huntzinger, 2007).

Time-Driven Activity-Based Costing (TD-ABC) then proposed to overcome the ABC weaknesses by simplify the steps to allocate the overhead costs. The usage of time as main cost driver helps company to allocate their indirect cost easier yet more relevant to the cost objects. TD-ABC is claimed has succeeded to overcome the drawbacks of traditional ABC but keeps giving as good as ABC's result (Kaplan and Anderson, 2003).

Meanwhile, literature shows there is very limited research conducted so far to discuss particular costing system in IPS^2 environment. The most recent and comprehensive research in this area is done by Datta and Roy (2010) which create cost modeling techniques for IPS^2 availability-oriented use model. They argue that cost estimation for availability contract follows the service costing methodology but having particular parameters i.e. availability target and customer budget. The model is using different combination of product cost estimation techniques and service cost estimation techniques, including ABC, which is varied based on two dimensions i.e. life-cycle stages of the integrated offering and the information availability. Fig. 1 shows the detailed proposed model by Datta and Roy.

Then some interesting questions arise. Can those systems encourage company to doing continuous improvement towards the long journey of IPS^2? Can those systems give high value to company? It is clear that market environments are rapidly changing and in order to stay competitive company should be doing continuous improvement whilst traditional costing system or even ABC cannot provide the sufficient information to support it (Gunasekaran, Williams et al., 2005). The ability to adapt is no doubt vital key to keep survives in today's market.

Continuous improvement is highly related with lean principle. This principle has been adopted in costing system to maintain company's financial aspect to be in line with continuous improvement program, called lean accounting. Lean accounting is defined as a business management system, created based on lean thinking principles, and consists of several related tools in financial and operational measure that support company's continuous program as well as control at level of cell, value stream and company (Ruiz-de-Arbulo-Lopez, Fortuny-Santos et al., 2013). Specific technique under the lean accounting to calculate cost is called value stream costing (VSC). VSC is created based on value stream concept. It aims to capture all costs directly within company value stream and encourages continuous improvement through combination of financial and non-financial performance measures. The major aim of lean accounting is not only to know "how much does the product/service cost?" but "how can company improve the process to cut those costs?" (Ruiz-de-Arbulo-Lopez, Fortuny-Santos et al., 2013).

After literature review, we conclude that costing system for IPS^2 environment is remain limited available in literature. The most recent research in this field is done by Datta and Roy (2010) but their focus is availability-based IPS^2. The proposed framework seems comprehensive enough to consider life cycle of product and service, available information input, risks and uncertainties. But in contrast, it seems clear that the proposed framework remain complex and require a lot of resources to be executed and doesn't motivate to continuous improvement in very tight markets.

3 Conclusions and Future Research

Costing system and cost estimation is certainly important consideration for companies to set and direct their businesses. It remains as powerful sources for decision-makers to evaluate, control as well as to innovate their businesses. In contrast, literature have shown that IPS^2 companies do not discover yet what costing system is appropriate for their IPS^2 strategy. In practice, many IPS^2 companies are continuing to use the traditional costing system which does not give balance emphasize for both physical product and service aspect. Moreover, these costing systems tend to provide misleading information since naturally it only focuses on physical products of companies' offerings.

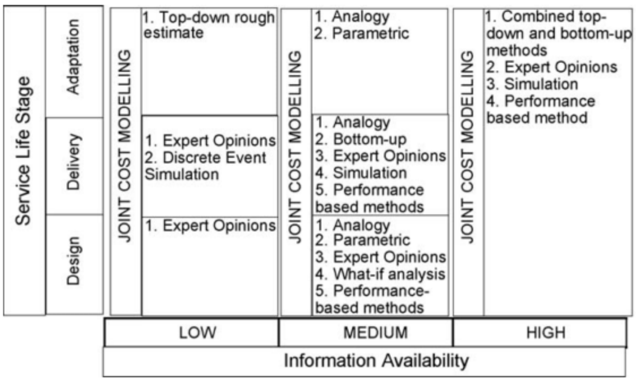


Fig.1
Cost assessment framework of availability service contracts.
(source:(Datta and Roy, 2010)

Through this stage of our research progress, we realize that current costing system have to be customized to address the IPS^2 environment's characteristics and needs. IPS^2 companies need a costing system which answer some critical requirements. It has to be straightforward in terms of time, cost and effort needed to build, implement and maintain without ignoring the complexity of company's activities. It has to consider product and service aspect in whole its life cycle in balance way since company is providing a bundle and integrated solution of products and services in period of contract time. Furthermore, IPS^2 companies require a cost management methodology, which is easily updated and adjusted to meet continuous changes due to the customer's variety demands to get more customized and overall solution. It has to be consider risks and uncertainties as well as encourage to do continuous improvement.

Based on those criteria, it is clear that lean accounting with its value cost streaming is good candidate to be implemented and adjusted for IPS^2 environment, particularly for functional-oriented use model. This method considers all the cost within value stream (life cycle) in how companies provide its products and services. It gives good emphasis in how to calculate cost in acceptable degree of accuracy with affordable resources (time, people and cost). Furthermore, the adoption of lean thinking in cost management can lead company to increase their effectiveness and efficiency of their IPS^2 design, development, management and delivery toward the full *servitized* company (Resta, Powell et al., 2015).

All those findings would be basic insight to further proceed our research. As sequential stages to carry out the desire research, at the next stage we intend to identify and construct sequential steps as cost management methodology for IPS^2 environment. Appropriate costing system would be important finding for IPS^2 companies to further specify their price and strategies in facing more competitive and global market.

Acknowledgements

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References

Baines, T.S., Lightfoot, H.W., Benedettini, O. and Kay, J.M. 2009. The servitization of manufacturing: a review of literature and reflection on future challenges. *Journal of Manufacturing Technology Management* 20(5) 547-567.

Baines, T.S. et al. 2007. State-of-the-art in product-service systems. *Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture* 221(10) 1543-1552.

Datta, P.P. and Roy, R. 2010. Cost modelling techniques for availability type service support contracts: a literature review and empirical study. *CIRP Journal of Manufacturing Science and Technology* 3(2) 142-157.

De Coster, R. 2008. Differences in forecasting approaches between product firms and product-service systems (PSS).

Drury, C. 2008. Management and cost accounting.

Gunasekaran, A., Williams, H.J. and McGaughey, R.E. 2005. Performance measurement and costing system in new enterprise. *Technovation* 25(5) 523-533.

Hansen, D., Mowen, M. and Guan, L. 2007. *Cost management: accounting and control*: Cengage Learning.

Huntzinger, J.R. 2007. *Lean cost management: accounting for lean by establishing flow*: J. Ross Publishing.

Kaplan, R.S. and Anderson, S.R. 2003. Time-driven activity-based costing. *Available at SSRN 485443*.

Martinez, V., Bastl, M., Kingston, J. and Evans, S. 2010. Challenges in transforming manufacturing organisations into product-service providers. *Journal of Manufacturing Technology Management* 21(4) 449-469.

Meier, H., Roy, R. and Seliger, G. 2010. Industrial product-service systems—IPS 2. *CIRP Annals-Manufacturing Technology* 59(2) 607-627.

Neely, A. 2008. Exploring the financial consequences of the servitization of manufacturing. *Operations Management Research* 1(2) 103-118.

Niazi, A., Dai, J.S., Balabani, S. and Seneviratne, L. 2006. Product cost estimation: Technique classification and methodology review. *Journal of manufacturing science and engineering* 128(2) 563-575.

Rese, M., Karger, M. and Strotmann, W.-C. 2009. The dynamics of industrial product service systems (IPS2)–using the net present value approach and real options approach to improve life cycle management. *CIRP Journal of Manufacturing Science and Technology* 1(4) 279-286.

Resta, B., Powell, D., Gaiardelli, P. and Dotti, S. 2015. Towards a framework for lean operations in product-oriented product service systems. *CIRP Journal of Manufacturing Science and Technology*.

Ruiz-de-Arbulo-Lopez, P., Fortuny-Santos, J. and Cuatrecasas-Arbós, L. 2013. Lean manufacturing: costing the value stream. *Industrial Management & Data Systems* 113(5) 647-668.

Tukker, A. and Tischner, U. 2006. *New business for old Europe: product-service development, competitiveness and sustainability*: Greenleaf Publications.

Creating a continuous improvement structure to implement lean healthcare

Garcia-Sabater, Julio J[1], Vidal-Carreras, Pilar I[2], Marin-Garcia JA[3]

Abstract: Kaizen, or continuous improvement, forms part of the foundations for continuous improvement as seen in the classic representations of the Toyota Production System. This article presents the way in which the structure of a hospital must adapt to be able to improve processes in a structured, sustainable fashion. Not only the way that the new “to-be-created” work teams must present is proposed, but also the new roles of the workers who will appear, and the tasks that they all must perform as work team members. This proposal is developed based on data from public reference hospitals in their field of activity.

Keywords: lean healthcare, continuous improvement, kaizen.

1 Introduction

Implementing the lean manufacturing philosophy in industrial settings is well-documented in both tools and culture terms, which must have the suitable organisation available for this implantation to be considered successful. The objective of lean manufacturing in industrial settings is to obtain a product of maximum quality at the lowest cost and in the shortest time possible (Marchwinski, Shook 2003). Implementing lean manufacturing into a healthcare setting implies obtaining a healthy patient in the shortest time at the lowest cost possible. There is a considerable body of literature on this theme, which centres on creating a flow of patients and material, and shows how this flow can help minimise not only the time the patient needs to be in hospital, but also the costs deriving from traditional management (Jackson 2013). Despite there being literature on the need to create working structures that focuses on continuous improvement in industrial settings, no works are available on the structure that must support continuous improvement in the healthcare setting.

The present work addresses the problem of creating a structure, and also that of creating new job posts that do not exist in most hospitals, to be able to create, in turn, a hospital that focuses on continuous improvement.

For this purpose, an example of a public hospital in a national health system is used. Based on its current structure, a new structure and the new roles that should be present in its organisation are proposed.

Initial situation prior to continuous improvement

Spanish hospitals normally present organisation charts of classic functional departments. The organisation charts of two important Spanish hospitals are analysed: the La Paz Hospital in Madrid or the La Fe Hospital in Valencia. These are reference hospitals in their fields of activity and both were included in the TOP 10 public hospitals in the last year (http://www.rincondelasalud.com/)

1 **Julio Juan García Sabater** (jugarsa@omp.upv.es)
2 **Pilar Isabel Vidal Carreras** (pivicar@omp.upv.es)
3 **Juan Antonio Marín García** (jamarin@omp.upv.es)
Grupo ROGLE. Dpto. de Organización de Empresas.
Universidad Politécnica de Valencia.
Camino de Vera S/N, 46022 Valencia.

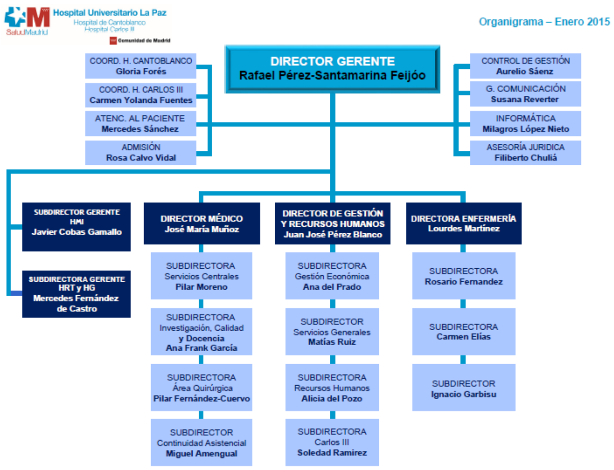

Fig.1
Organisation chart of the La Paz Hospital in Madrid.

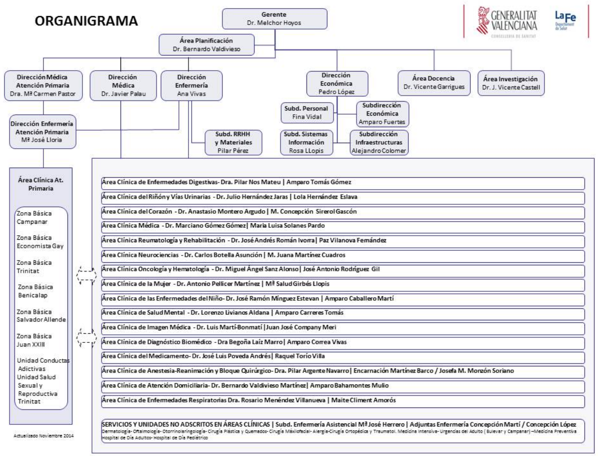

Fig.2
The organisation chart of the La Fe Hospital in Valencia.

In these organisation charts only those classic functional departments in any organisation (human resources, finances, etc.) and the typical departments of the sector under study (medical management, nursing) can be seen. Despite them being leading hospitals of acknowledged national and international prestige, they have no departments that centre on healthcare areas (outpatients, hospitalisations), which in the lean philosophy can be identified as an organisation chart arranged into value flows, or even departments, that work on improving management since improvement in the medical area is carried out in each medical management subdepartment (clinical specialities).

If the lean philosophy centres on identifying value chains and on creating flow to eliminate waste, to do this, it is necessary to create a structure prepared for this purpose, or at least some department that works on improving and coordinating the flow of patients between various hospital sections, known as an all-round clinical process in the healthcare setting. Although this may appear to be a new matter in the healthcare field, identifying healthcare processes, such as outpatients, accidents and emergency (A&E), hospitalisations, or other similar ones, is usual in any hospital, even though they do not appear as such on their organisation charts (Garcia-Sabater et al, 2014)

3 Creating the structure of value chains

The first change to be made in the organisation is to create "value stream managers" (Rother y Shook, 1999) and for this chart to show the hierarchical posts. The aim is to place improvements in a similar rank to any other department in order to prioritise improvements (Garcia-Sabater et al, 2011). The objective is to create leaders capable of understanding the relevance of value chains and of tackling the problems and improvement areas that appear cross-sectionally to the organisation, which centre on customer satisfaction and on improving process indicators.

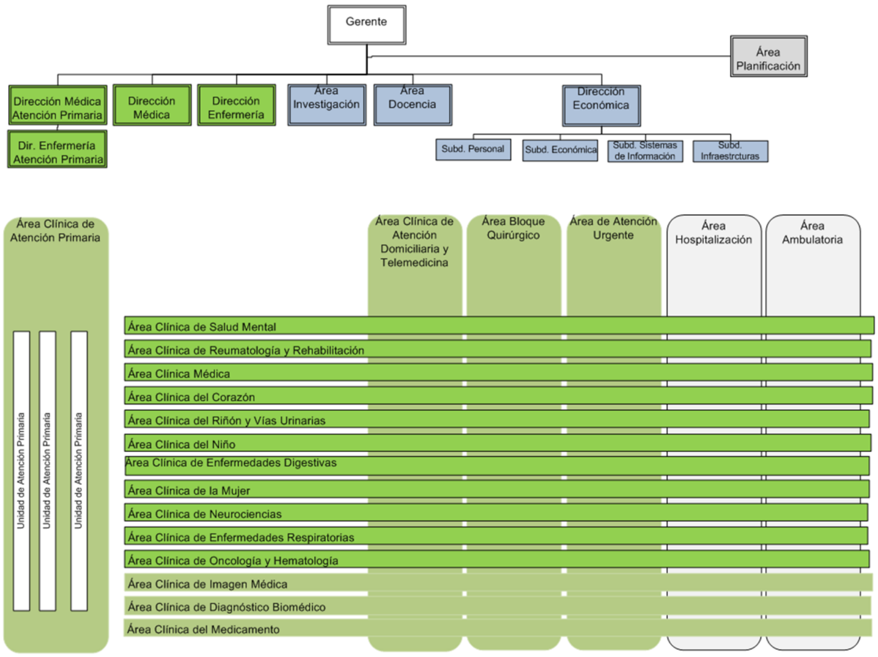

Fig.3
New organisation chart proposed.

In hospitals, the organisation chart would be similar to that shown in Figure 3.

Having created and appointed the hierarchy in the organisation chart, it is necessary to create the structures of all the newly created areas. To this end, we based our work on the continuous improvement structure considered by Liker&Meier (2005) and on the continuous improvement structure style created in "standard factories" with autonomous work groups.

Those responsible for each value chain in the hospital will depend on the Area Director. In the case presented in Figure 3, the responsible person would be from outpatients, the person in charge of hospitalisations, the person in charge of A&E, the person responsible for hospitalisation at home and the person in charge of the surgery section. The people responsible for all these areas are in charge of coordinating with all the directors of medical specialities so that patients can "flow" through each hospital process.

The people responsible for all the points at which patients progress through value chains, normally known as subprocesses (e.g. in A&E, there will be: selection, consultations, techniques, among others), will depend on process managers, or value stream managers. Finally, the last division is left, which will correspond to the person in charge of subprocesses or the team leader with all the team members, who are doctors, nurses or hospital porters on wards: this in Liker terminology corresponds to "team members".

Evidently this structure may vary according to the complexity and size of the supply chain, but seems to be the most usual one given their size.

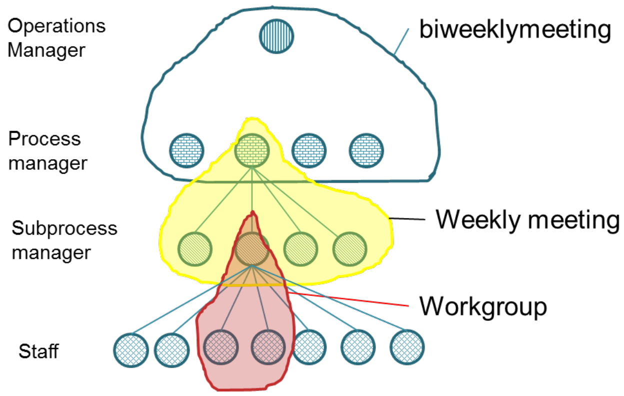

Fig.4
The continuous improvement structure.

As in many organisations with existing improvement teams, holding 5-minute daily meetings between the person in charge of the subprocess (or team leader) and team members is recommended. This will be known as the TOP 5 meeting, when the working day beings, or a kaizen meeting (depending on the company).

The people in charge of the subprocess (group leaders) must meet weekly for 60 minutes with team leaders to deal with any matters that may have escaped the notice of the people on wards, and which require coordination of the whole process.

Finally, there are the continuous improvement meetings, held biweekly, where the people in charge of processes meet with the Hospital Operations Manager to go over any problems that require the coordination of different value chains.

During all these meetings, the main indicators of all the work areas must be analysed, bearing in mind that the indicator studied in a 5-minute meeting is not the same as in a continuous improvement meeting held with the Operations Manager.

4 Roles and tasks of each member of the new organisation.

As the structure in the organisation is new, the roles and tasks assigned to each member of the new continuous improvement structure must be defined.

4.1 Team members

They are responsible for performing typical hospital tasks. They are doctors, nurses, hospital porters or administration staff, and they carry out traditional tasks to which the new continuous improvement structure tasks need to be added:

- Performing the planned actions that correspond to their tasks (attending to patients, dealing with papers, etc.)
- Proposing improvement actions based on visible organisational aspects that can clearly
  be improved or by means of an analysis along with all the other team members of the indicators for which they have competence.

4.2 People responsible for subprocesses, or team leaders.

Apart from the usual operations, which sometimes do not differ from those of any team member, at times they have tasks that deal more with coordinating work (depending on the magnitude of the process). The person in charge of a subprocess is partly freed to carry out the following typical continuous improvement tasks:

- Preparing the daily 5-minute meetings with team members (calculating indicators, incidences, etc.)
- Coordinating, if necessary, shift changes with other team leaders
- Analysing area indicators and leading the proposal of improvement actions along with team members
- Heading and controlling that the actions which correspond to their field of action are carried out
- Reporting area indicators to the person responsible for the process (or group leader) during the weekly 60-minute meetings
- Collaborating with members of other subprocesses of the same value chain in implementing improvements that require the participation of several subprocesses
- Defining the work standards, ensuring that they are properly met by team members and training new workers in these standards
- Being responsible for subprocesses correctly operating (schedules, order and cleanliness, managing incidences, problems of quality)

4.3 People responsible for processes, or group leaders

These people normally work to ensure that the process properly operates in terms of both the process and continuous improvement. Depending on the nature of the process, a doctor is needed who masters the speciality in question (A&E, surgery section) or these people can be personnel without medical training. Their tasks are:

- Controlling the correct operation of each subprocess
- Controlling the correct operation of all the subprocesess while changes in shifts occur
- Preparing and heading the weekly process management meetings
- Conducting a daily follow-up of the process indicators and proposing overall process improvement actions
- Managing and controlling contingency plans, if required
- Restructuring personnel according to the daily requirements among subprocesses
- Analysing incidences or anomalies on a daily basis
- Visiting working areas to check anomalies regarding: security, job post order, following-
  up standards, job queues, etc.
- Attending the usual hospital coordination meetings
- Setting up an action plan to ensure that the process operates properly and meets objectives
- Coordinating with managers of conventional clinical areas and other healthcare processes
  (value chains) to ensure their process operates properly
- Prioritising and "pursuing" the implementation of the improvement actions that their process carries out

4.4 Lean Champion

This person does not feature in the organisation chart in Figure 4, but corresponds to a person previously identified by other authors (Bateman y Rich, 2003; García-Arca y Prado-Prado, 2008) This person is even more important in this sector because the continuous improvement and lean manufacturing philosophy is still quite unknown to people. So people who know the methodologies and the new ways of working are needed. The tasks performed by this person include:

- Supporting the methodology with all those teams that need it to implement new tools or to continue the correct problem-solving process
- Supporting team leaders and group leaders to define and follow-up the indicators (especially in the first stages)
- Promoting improvements being implemented at all organisational levels
- Documenting all the process and work standards (if time is conferred to the team leaders or group leaders)

- Auditing the proper operation of work teams or improvement teams
- Monitoring processes and subprocesses, and periodically using analysis tools

5 Conclusions

Implementing continuous improvement structures is perfectly feasible in public hospitals and those that can be extrapolated almost directly from other sectors are commoner. The only problem is that the lean champion and previously creating a culture are essential, which should be considered as a long-term change (3 or 4 years) in the organisation, although the authors have participated in implementing these teams into other better adapted sectors after only 1 year. As in other sectors, it is necessary to carefully select team leaders as present team leaders may not necessarily be apt for improvement because executing the process is not the same as improving the process.

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6 References

Bateman, N. & Rich, N. (2003). Companies' perceptions of inhibitors and enablers for process improvement activities. International Journal of Operations & Production Management

Jackson, T.L., 2013. Mapping Clinical Value Streams. CRC Press.

García-Arca, J. & Prado-Prado, J. C. (2008). Logistics Redesign through Systematic Personnel Participation. A Case Study. 9th International CINet Conference, Valencia, España.

Garcia-Sabater, J.J., Maheut, J. Vidal-Carreras, P.I. (2015) Utilización del mapa de la cadena de valor en un entorno sanitario: un caso de estudio. 8th International Conference on Industrial Engineering and Industrial Management, Malaga, España

Garcia-Sabater, J.J., Marin-Garcia, J.A., Perello-Marin, M.R.. (2011) Is Implementation of Continuous Improvement Possible? An Evolutionary Model of Enablers and Inhibitors. Human Factors and Ergonomics in Manufacturing & Service Industries 00 (0) 1–14

Liker, J. and Meier, D., 2005. The Toyota Way Fieldbook. McGraw Hill

Marchwinski, C. and Shook, J., 2003. Lean lexicon: a graphical glossary for lean thinkers. Lean Enterprise Institute.

Rother, M. and Shook, J., 1999. Learning to see. Lean Enterprise Institute, Boston, MA,

The experience of public-private partnerships hospitals in UK: what can we learn in Spain?

Rionegro O[1], Rodríguez-Monroy C[2]

Abstract: Most developed countries maintain important relationships with the private sector. The best-known case is United Kingdom, whose many years of experience developing public-private partnerships for the construction projects and management of hospitals has turned UK into a reference for others countries. In the case of Spain, with its limited experience, there is still no certainty whether this model has been beneficial for society or not. Based on the conclusions of the last official audits by the British public authorities, this paper presents the situation of the Spanish model in relation to the two most committed aspects of such systems: the cost-profit ratio and risks.

Keywords: Public Private Partnerships; Project Finance Initiative; Hospital Management; British National Health System; Spanish Healthcare.

1 Introduction

The delivery of health services in most OECD countries involves some kind of model of public-private partnership (PPP). In systems with an investment that is mostly public, they are provided with pharmaceutical products and services from the private sector. Meanwhile, in the mostly private, the State influences through capital injections and regulations. But in the case of hospital management this kind of symbiosis as these functions and level of detail increase becomes more complex: care service, maintenance, training, research and development, among others.

The privatization of many public services became widespread after 1980, with the development of liberal movements to reduce the role of the state. In the health sector, this system was rejected due to the existence of market failures. Instead, quasi-market models were developed with two differentiated agents: the private sector and the public sector.

In this article we are going to analyze the British and Spanish models in projects of public-private partnership for the construction and management of hospitals, in order to know how the relation between both agents is and the results that it generates.

2 Historical Developments in the UK

The United Kingdom was the first country in the world to develop the concept of public-private partnerships for public services by allowing the provision of efficient, cost effective and measurable services within modern facilities. This fact has become UK in the world leader of the development of public-private partnerships in the health sector.

The development of this model in public hospitals began in 1992 with the introduction of the 'Private Finance Initiative' (PFI) by John Major's Conservative Party as a way to "make use of the capacities of management and business experience in the private sector, leading discipline in the delivery of public infrastructure" (HM Treasury, 2012).

1 **Oscar Rionegro Sotillo** (rionegro.sotillo@gmail.com)
2 **Carlos Rodríguez-Monroy** (crmonroy@etsii.upm.es)
Dpto. de Ingeniería de Organización, Administración de Empresas y Estadística.
Escuela Técnica Superior de Ingenieros Industriales.
Universidad Politécnica de Madrid.
C/ José Gutiérrez Abascal, 2. 28006 Madrid.

In 1996 the first contract for the construction, funding and operation of a hospital of thousand beds in Norwich was signed. Five years later this hospital was delivered five months before the planned completion date and within the budget.

Since then the National Health System (NHS) in the UK has developed a considerable experience in the management of this type of public-private partnerships in the healthcare sector, with more efficient procurement systems that minimize costs when establishing the contract with diverse agents for the construction and the management of the service contracts.

The results show that the PFI model has been the dominant formula for the development of large projects of the NHS, with more than 10.4 million pounds sterling invested in the last decade to build hospitals in the UK (European Commission, 2014). The fact is that 75% of new hospitals built between 1997 and 2008 were financed privately (House of Commons, 2011).

3 The Audit

The first reports were realized in the initial stage of the implementation of hospitals under the PFI model and yielded positive data. It was found that this system allowed to increase significantly the advance in hospital actions over the possibilities offered by the traditional financing, allowing payments along the life cycle of the infrastructure without representing a high initial impact in the public finances. They also found, in contrast of the conventional government contracts, a higher guarantee in complying with the deadlines (since only 24% of projects suffered delays, in opposition to the 70% that had taking place before), a lower deviation costs (22 % of cost overruns, compared to 73% in the conventional system) and even in non-clinical services savings in costs between 5 and 10% during the periods of construction and operation were even reflected (Mattocks, 2006).

However, since 2008 a higher number of criticisms related to the hospitals under the PFI model began to appear when it started to collect an “unclear and inexplicit form the justification and evaluation for the use of PFI models in terms of profitability” (Parliamentary Treasury Committee, 2011), being able to understand that the public authorities did not assess in a correct form the different alternatives for the construction of new hospitals.

3.1 National Audit Office 2011

The consequences of this option to seize the future budgets appear in this report, with the knowledge of the existence of unmanageable pressures of debt to which the UK Ministry of Health had to respond in 2012 with an additional financial support of more than 1,500 million pounds for only 22 hospitals, and maintaining other 16 in the state of specific financial review.

They also presented the “existence of risks for the long-term profitability of these contracts” (National Audit Office, 2011) due to the complexity of managing them, where the capacity was limited to generate savings due to efficiency in some areas and the promotion of continuous improvement. The long-term agreements, between 30 and 60 years generally, made the reconfigurations and the adoption of new models enormously difficult.

Finally it was stated in this report that the maintenance of the lifecycle of the infrastructure, which represented the key benefit of this model, was not satisfied in more than 20% of the expectations.

3.2 Parliamentary Treasury Committee 2011

In this report it was found that hospitals under the PFI model were turning out to be “always more expensive than the public borrowing” (Parliamentary Treasury Committee, 2011), especially from the economic crisis when the cost of private equity was 8% while that of the government was 4%, representing a significant cost for the taxpayers.

Besides the concern not only focused on the financing costs, but also on the “inability to find evidences of savings and benefits in other areas of PFI that compensate these costs”. Only in some cases savings in the construction and in some of the services were found.

In this report the existence of any signs of real innovation was not noted either, although it was appreciated that the quality in the infrastructure was worse in general terms in the PFI hospitals.

This report concluded by giving the only benefits of PFI hospitals models were not related to qualitative or financial issues, but with the possibility that the authorities could leverage their budgets without using the one they had assigned (Moreno, 2013).

4 The Spanish Case

In 1991 the first reflection on the sustainability and the future of the NHS was performed in Spain. Four years later a new phase began in the development of private management models under the Law on Foundations of 1994, with four hospitals in Galicia, one in Mallorca, one in Madrid and another in La Rioja. This model was not developed due to its inability to demonstrate its advantages over traditional management system.

The biggest turning point in public-private partnerships for hospitals in Spain took place in 1999 in Alzira. In this year, in this Valencia village, Alzira Hospital was started up, initiating a new stage of administrative concessions where a private company built a hospital and then it was in charge of its maintenance and, in some cases, the healthcare assistance in an area. Although in the first moment it only included specialized care, from 2005 onwards primary and geriatric care was also introduced (López, 2013).

From 2007 Spain began to adopt the British model of PFI hospitals in Madrid, Baleares, Castilla y León and Galicia. This model is more advantageous for the public sector because it is not necessary to make a large down payment at the start (López and Gonzalo, 2013).

The results in Spain of public-private partnerships in the construction and management of hospitals in Spain are conclusive: at the end of 2012 there were a total of 22 PFI hospitals and over 3,300 million Euros investment (Mendoza, 2013).

5 Challenges and Opportunities

In Spain does not exist, nor has existed, an effort by the government to inform the public opinion about the reasons for public-private partnerships and their potential benefits, contrary to what the UK has been doing. To this day in Spain, we cannot find comparisons within the public sector, the publication of the contracts, monitoring reports, etc. It is a fact that, in the words of analysts as Gayle Allard, this generates "a significant risk of opacity and information asymmetries that may prevent the public sector from obtaining value for money" (Allard and Cheng, 2009).

5.1 Cost-benefit ratio

Being a public hospital, the search for efficiency is focused on minimizing the payments recognizing that risks transfer to the private sector and the inclusion of incentives for the same one compensates higher financial costs. The assessment of the suitability of a financing system over another, it is usually realized with the analysis of the future cash flows of the project.

Due to the mentioned lack of transparence, especially in something as simple as the financial aspects of a hospital project, it is found that a high number of publications in relation to this aspect with opposite conclusions. It is also surprising that in Spain the value for money is taken into account in contracts for public-private partnerships but not in public concession contracts.

In favor of the justification of value for money in public-private partnerships projects for hospitals we can highlight the conclusion given by a simulated model for a hospital with an investment of 100 million Euros by a regional government and that with "a discount rate the social marginal return on investment, has as result that the profits overcome 10%" in respect of direct production by the public sector (Contreras, 2008). Especially relevant when the Autonomous Communities are the promoters, which currently have the competences in this matter.

It is necessary to emphasize in this section the existence of different situations that although in the studies they are not included, they exist and have taken place in reality. For example the fact that public authorities begin easily the construction of hospitals that, due to the economic difficulties of putting them into operation, they have not been opened while the taxpayers have had to realize committed payments without receiving any services.

Others question the efficiencies that these models present in the hospital management raising for the new Hospital of Vigo an analysis of future cash flows for three types of contracting: conventional financing, through a public company and under the PPP model.

This analysis concludes with results that reflect the lowest costs for the conventional system where the public company has 14% higher amounts and the costs for the public-private partnership model are multiplied by 2.4 for the regional healthcare service (Reyes, 2012).

5.2 Risks

The risk transfer to the private initiative is one of the fundamental pillars of the public-private partnership models. Through this obligation, which is imposed in the context of the European Union, the need to avoid taking excessive risk by the public sector during the lifetime of the infrastructure is expressed, especially in the appearance of future effects on debt and national deficit. This motivates the public-private partnerships the search for optimizing risk by transferring it to the most prepared party to bear it with the minor cost.

There are mainly three risks that must be managed in projects of public-private partnership of hospitals: construction, availability and demand (Masso and Horta, 2008).

The demand risk, which is supported mainly by the private sector, was the first to be addressed. An example is the case of the first seven PFI hospitals in Madrid, where the expected data were lower than the real demand, forcing the regional government to increase the annual fee (Sánchez, 2014).

A risk also evidenced in the British experience is the replacement of the initial private partner for a wider array of actors through the creation of secondary markets. This possibility is not regulated in Spain and it is possible that this condition occurs identically.

In other risks, the majority supported by the private sector, there still have not taken place situations in the context of the construction and management of hospitals by private entities.

Furthermore, for a better risk transfer, a series of sanctions are set forth in the contractual relations in case of qualitative or quantitative non-compliance. Although the reality indicates that these actions are executed with difficulty by the public sector, giving a sense of ‘impunity’ to the system. This aspect supports the idea of many authors who consider the hospital concession as ‘too big to fail’ (Minue and Martín, 2013). Thus it results in a fictitious risk transfer, where the public sector is always the one which should assume them ultimately (Sánchez et al, 2013).

6 Conclusions

The lack of transparency is the biggest criticism of public-private partnership models in Spain. Not only because the damages that this level of opacity involve of sociopolitical statements, which are many and varied, but also the disadvantages that this situation creates for the public sector itself to encourage the creation of situations with asymmetric information. This hinders the creation of value for the public sector through the comparative study and the mistakes and successes analysis based on their experiences.

Therefore it is intended to outline in this article the main self-criticism that the British do on their system, with the aim of bringing it to the Spanish reality on the field.

On one hand, the main concern is the cost-benefit ratio. In the case of Spain, only simulated studies justify this option. These studies have not taken into account the effects of the crisis on the cost of capital, which in the British case were fundamental to justify the loss of interest in this type of project. Also it is necessary in these studies to include various alternatives which imply the payment of additional amounts and which have occurred in reality.

The main potential of these models is to minimize the risks in the construction, as it has been verified in the United Kingdom. In Spain, although it is not currently available in the official data, the contracts collect payment systems to the private sector related to the situation of the construction, so in this case the public sector is protected against these risks.

Concerning the other risks transfer, the Spanish model has similar characteristics to those in the UK. Even existing abundant literature related on the importance of generating contractual relations with clarity and high level of detail, we share the idea that this point is the Achilles heel of the public sector when these projects are considered ‘too big to fail’.

One of the biggest criticisms of the model is that the implementation of a significant number of outsourcing projects generates budgetary obligations hardly manageable in the future, as it has already been seen in the UK. In the case of Spain, the absence of a shield on the traditional health system can generate in the medium term a transfer of funds from it to face the payment of the acquired obligations.

Finally we consider that it is necessary to create in Spain a State office that coordinates public-private partnerships projects for Spanish hospitals. This office should serve to inform the public opinion and the public sector itself, in order to minimize the shortcomings that asymmetric information has today for public administrations.

7 References

Allard G and Cheng A (2009) Public-Private Partnerships in the Spanish Health Care Sector. Journal EPPPL

Contreras C (2008) Análisis económico financiero de la colaboración público-privada en hospitales: el caso español. Financial Analysis Review, 106.

European Commission (2014). Health and Economic Analysis for an Evaluation of the Public-Private Partnerships in Health Care Delivery across Europe. Brussels.

House of Commons (2011). Private Finance Iniciative. London

HM Treasury (2012) A new approach to public private partnerships. London

López JM and Gonzalo L (2013). Producción pública, gestión privada y eficiencia económica del Servicio Nacional de Salud. Doctoral thesis. UNED, Barcelona

López JM (2013) La gestión privada de los servicios sanitarios públicos: los modelos Alzira y Madrid. Quarterly journal from the Faculties of Economic Sciences and Law ICADE. 2013:90:173-193

Masso G and Horta M (2008) La colaboración público-privada en el sector público español. PWC

Mattocks R (2006) PFI. La experiencia británica. Management and evaluation of medical costs review. Vol. 6 - Number 4

Mendoza MJ (2013) Privatizaciones en el País Valenciano. La Catarata Books. Madrid

Minue L and Martín JJ (2013) Gestión privada: ¿más eficiente?. Economy and Health Journal. 78. P. 15-29

Moreno M (2013) Experiencias en el ámbito de la gestión sanitaria de las fórmulas de colaboración público-privadas. Extraordinario XXII Congress Law and Health. 26:77-82. Health Lawyers Association. June 2013. Toledo

Murillo J (2009) Diez años del modelo Alzira. Association for the Advancement of Management Journal 240:38-39

National Audit Office (2011). Lessons from PFI and other projects. London

Parliamentary Treasury Committee (2011) Private Finance Initiative. 17th Report. London

Reyes F (2012). Análisis económico-financiero de la colaboración público-privada (PFI) del nuevo hospital de Vigo. Salud 2000 Journal, 2012:137:10-18

Sánchez F, et al (2013). Gestión pública y gestión privada de servicios sanitarios públicos: más allá del ruido y la furia, una comparación internacional. Real Instituto Elcano, T4/2013

Sánchez M (2014). La privatización de la asistencia sanitaria en España. Laboratorio de Alternativas. Working document 182/2014

Exploring recent literature on Lean Healthcare

Vidal-Carreras PI[1], Garcia-Sabater JJ[2], Marin-Garcia JA[3]

Abstract: This paper aims to give an overview of recent literature on lean healthcare. In order to achieve this purpose a systematic literature review of reviews of lean healthcare was carried out. After reviewing the literature is that several sets of works can be distinguished according to the topic. Those which analyze the implementation of lean and indicate the area where interventions and outcomes are done. Those which go further and seek facilitators or context variables. And those which focus seek interaction/relationship between implantation Lean and other areas, the area of IT, safety and quality of patients, or effects on the workers. Future lines raised by the review analyzed present potential new challenges it faces lean healthcare, where it can be highlighted the need to report those experiences not as positive in which a lot can be learned and better document the results of the studies.

Keywords: lean thinking, lean healthcare, healthcare quality, hospital, literature review.

1 Introduction

Nowadays, accreditation requirements, needs and expectations of patients, social and ethical values, all coupled with funding pressures, demand continuous improvement in healthcare quality. According to the Agency for Healthcare Research and Quality (1997), healthcare quality is doing the right thing, at the right time, in the right way, for the right person and with the best possible results.

In this context, the use of some quality improvement (QI) methodologies or approaches from the manufacturing industry has increased in healthcare organizations. One is named Lean Healthcare and is being increasingly adopted worldwide. This is based on the approach Lean. The work of Jacobson (2006) and clearly describes reasons why lean is applicable to lean health care and to other environments. Apart from health care, the lean approach has been adapted to other areas, such as software development (Pernstal, Feldt, & Gorschek 2013) and information management (Hicks 2007).

The lean approach derives from the Toyota Production System, which was created by Taiichi Ohno in 1940 (Ohno and Bodek 1988), and was subsequently popularized by James Womack and Daniel Jones in 1990 (Jones, Roos, & Womack 1990). More recently, the same authors coined the new term lean thinking (Womack and Jones 2010). The primary goal of the lean philosophy is to be extraordinarily customer-oriented and responsive by ridding the entire waste system to thereby deliver to a customer exactly what (s)he wants, when (s)he wants it, defect-free and on time. Considering the lean approach or lean philosophy is considering an integration of concepts, methods and tools.

Health care, like manufacturing, is composed of a series of processes or actions which intend to create value for customers, or patients. Although there are many differences between patients and cars, medical care, like the manufacturing sector, is delivered in extraordinarily complex organizations with thousands of interacting processes. According to (Dahlgaard, Pettersen, & Dahlgaard-Park 2011), lean health care is a management philosophy to develop a hospital culture characterized by increased patient, and other stakeholder, satisfaction through continuous improvements, in which all employees (managers, doctors, nurses, laboratory people, technicians, office people etc.) actively participate in identifying and reducing non-value-adding activities (waste).

1 **Pilar Isabel Vidal Carreras** (pivicar@omp.upv.es)
2 **Julio Juan García Sabater** (jugarsa@omp.upv.es)
3 **Juan Antonio Marín García** (jamarin@omp.upv.es)
Grupo ROGLE. Dpto. de Organización de Empresas.
Universidad Politécnica de Valencia.
Camino de Vera S/N, 46022 Valencia.

The first well-publicized lean healthcare application occurred in 2001, in the Virginia Mason Medical Center (VMMC), a 336-bed hospital integrated medical system with 5,000 employees, which wanted to reform its financial performance. Borrowing from the Toyota Production System and using its foundational ‘‘Lean Principles,’’ VMMC created the Virginia Mason Production System (VMPS) and claimed it as the business strategy that it would use in an effort to reduce costs and to eliminate defects towards improved quality and profit margin (Nelson-Peterson and Leppa 2007). Since then diverse papers have been published on lean health care: case studies, reflections, literature reviews, etc. In order to achieve a global vision of the latest most important studies published on lean health care, a systemic literature review was conducted. This review focused specifically on lean healthcare literature reviews because they include previous experiences and offer new suggestions for future research that could be useful, considering the scope of this research.

2 Methods

The protocol for the systematic literature review (SLR) has been generated including the following steps: a) Conceptual discussion of the problem; b) Literature review purpose; c) Search strategy; d) Paper selection criteria; e) Single paper analysis; f) Descriptive analysis of the extracted database; g) Synthesis and content analysis. Summary of the phases a) and b) of this SLR is showed in the above section, named introduction. According to the search strategy, the academic database searched was Web of Science (ISI), concretely Science Citation Index Expanded (SCI-EXPANDED), Social Sciences Citation Index, Conference Proceedings Citation Index (CPCI-S) and Conference Proceedings Citation Index Social Sciences & Humanities (CPCI-SSH). The key terms researched in the topic of the papers are: (LEAN OR "SIX SIGMA" OR KAIZEN OR "PROCESS IMPROVEMENT") AND (HOSPITAL OR HEALTHCARE) AND ("LITERATURE REVIEW" OR REVIEW OR SLR). The topic of the paper includes: title, abstract, author keywords and keywords plus. The time span was from 2010 to 2015. Both this search as the searches realized in the papers reviewed are restricted to papers in English language. According to the paper selection criteria, the retrieval and assessment of articles for inclusion in the literature review consisted of stages following. Firstly, 98 references was retrieval from de WOS database according research strategy. Secondly, the titles and abstract of this 98 articles were screened, excluding not reviews and single-unit case studies. As a result 12 articles were assessed for eligibility. After a full-text review another 3 articles were excluded by the criteria not really SLR. So, the final review included 9 articles.

3 Analysis

All papers were read and subject to a quality assessment. In the single-paper analysis, the following was recorded: title, authors, year, name of the publication, citations, aim of the paper, search strategy including data bases, time span and key terms, nº of papers reviewed, findings ,and further research proposed. The most significant information of this analysis is shown in Table 1, 2 and 3. As shown in the tables, the research questions /aim posed in this works are very diverse. However, they can be grouped into the following sets according to the tables:

1. Compilation of case studies by relating interventions and outcomes (Holden 2011; Mazzocato, Savage, Brommels, Aronsson, & Thor 2010;Wright and McSherry 2013).

2. Identification of contextual or enabling factors that promote successful lean implementations in hospitals. They may be specific to Lean (Andersen, Rovik, & Inge-brigtsen 2014; Mazzocato et al 2010) Quality Improvements (QI) including among other approaches Lean (Kaplan, Brady, Dritz, Hooper, Linam, Froehle, & Margolis 2010).

3. Analysis of interaction between implantation Lean and other areas:

   - Relations between the implantation of Lean and patient safety from Clinical Risk Management (CRM) (Crema and Verbano 2013a; Crema and Verbano 2013b). In Holden (2011) the effect of lean discussed in patient care in Emergency Department.

- Impact of Lean on workers (Holden 2011)
- Lean interaction with IT, Health Information Systems (HIS) (Kalong and Yusof 2013)

Table 1
Summary of paper analysis group 1.

(Authors, Year)	(Mazzocato et al 2010)
Aim	Which components of lean thinking have been put into practice and in which settings? What outcomes have been attributed to lean applications in healthcare? Which components, in which contexts, produce which results? What are the mechanisms that make this possible?
Time Span	Jan 1998 -Feb 2008. NºReferences 33
Findings	The authors articulated interactions between context, lean interventions, mechanisms and outcomes. They found common contextual aspects which interact with different components of the lean interventions and trigger four different change mechanisms: understand processes to generate shared understanding; organize and design for effectiveness and efficiency; improve error detection to increase awareness and process reliability; and collaborate to systematically solve problems to enhance continual improvement. While lean theory emphasizes a holistic view, most cases report narrower technical applications with limited organizational reach.
Future Research	Future studies of lean could focus on the role of management to improve implementation and sustainability. Moreover, learning could be enhanced by employing more rigorous approaches to research and reporting, for example the SQUIRE guidelines
(Author, Year)	(Holden 2011)
Aim	How does Lean transform work structures and work processes? How does Lean affect patient care (quality, safety, efficiency)? How does Lean affect employee working conditions (eg,autonomy, workload) and outcomes (eg, motivation, satisfaction) indirectly by transforming work structures and processes? How does Lean affect employee outcomes directly, independent of changes to work structures and processes? How are patient care effects and employee effects of Lean linked? How are patient care and employee effects of Lean contingent on the features of (a) the organization implementing Lean and (b) the design and implementation of Lean?
Time Span	Jan 2005 to Jan 2010 NºReferences 18
Findings	Lean does not simply alter the process of work: numerous work structure changes accompanied process change, having indirect and direct effects of Lean on employees. Lean affected patient care in the studied Emergence Departament.. Unfortunat ly, most of the employee effects described above were not systematically assessed and were either implied or based on anecdotal evidence.
Future Research	More work remains in understanding Lean in the ED and in health care more generally, including better assessment of Lean's effects on patient safety and quality outcomes and on employees, as well as identifying the factors on which Lean's success depends.

Table 2
Summary of paper analysis group 2.

(Authors, Year)	(Kaplan et al 2010)
Aim	Identify contextual factors that might influence QI success; to categorize, summarize, and synthesize these factors; and to understand the current stage of development of this research field
Time Span	01/01/1980- 07/09/ 2008 NºReferences 47
Findings	66 contextual factors could be related to QI success.
	Although the current body of literature lacks adequate definitions and is characterized by considerable variability in how contextual factors are measured across studies
Future Research	Future research should focus on identifying and developing measures of context tied to a conceptual model that examines context across all levels of the health care system and explores the relationships among various aspects of context.
(Authors, Year)	(Nicolay, Purkayastha, Greenhalgh, Benn, Chaturvedi, Phillips, & Darzi 2012)
Aim	Identify and evaluate the application and effectiveness of these QI methodologies to the field of surgery. These methodologies include Lean.
Time Span	Jan 1998 -Feb 2008. NºReferences 34
Findings	There is also overlap between the methodologies. The literature is dominated by simple observations without statistical analysis. It is not possible to make evidence-based recommendations for different indications, as different studies implemented different aspects of various methodologies to varying extents, and in different contexts
Future Research	Rigorously designed high-quality studies with low risk of bias using these frameworks for reporting are clearly needed
(Authors, Year)	(Crema & Verbano 2013b)
Aim	Are there any connections/overlaps between health lean care management and clinical risk management in hospital environment? If yes, which are the connections and the outcomes?
	Can lean healthcare management help/support CRM in hospital environment? If yes, how?
Time Span	All NºReferences 47
Findings	No specific studies focus on the relationship between HLM and CRM.
	In most of the papers there are objectives, methodologies and results that are related to both HLM and CRM approaches. “double-sided” results are usually achieved accidentally, without a declared intention, adopting only methods that mostly belong to one approach, even if some common methodologies are considered
Future Research	Future research stream that studies how to improve health care management combining HLM and CRM approaches.

Table 3
Summary of papers reviewed analysis group 3.

(Authors, Year)	(Andersen et al 2014)
Aim	Are there any connections/overlaps between health lean care management and clinical risk management in hospital environment? If yes, which are the connections and the outcomes? Can lean healthcare management help/support CRM in hospital environment? If yes, how?
Time Span	2000–2012 NºReferences 18
Findings	23 factors classified according two-dimensional conceptual framework developing by combining Shortell's Dimensions of capability (Shortell 2005) with Walshes' Domains of an intervention (Walshe 2007).
Future Research	Further specification and practical content to guide future effective quality improvements to healthcare organizations to measure and analyze outcomes in the context of this framework, with the identified facilitators as explanatory variable
(Authors, Year)	(Crema & Verbano 2013a)
Aim	What are the tools, practices, and key critical factors needed to successfully implement HLM, stressing safety performance (CRM)?
Time Span	No NºReferences 46
Findings	The results demonstrate that a variety of managerial tools are being implemented to achieve these aims, HLM and CRM. The proposed guidelines concern: 1) culture, organization, and communication; 2) process management; 3) error management; and 4) customer/patient management and the issues that support it, such as ICT, quality, sustainability, and compliance
Future Research	Future research should further test, formalize, and develop knowledge and experience in the field to determine the potential synergy between HLM and CRM, developing in depth the reference scheme presented and defining operative guidelines.
(Authors, Year)	(Kalong & Yusof 2013)
Aim	Provide an insight into the nature of waste in HIS from the perspective of LM
Time Span	No NºReferences 8
Findings	20 waste categories were presented. The proposed additional categories except external quality enforcement and environmental waste were actually covered in the existing Ohno's model (8 waste) or an adaptation of that.
Future Research	More studies related to Lean waste identification in HIS

4 Conclusions

In this paper a review of reviews of Lean Healthcare is performed. Lean, in the health care research domain, is considered included in the package of methodologies for the Quality Improvement (QI) in healthcare. This package also includes PDSA, PDCA, Six Sigma, CQM, SPC, Lean Management, TQM (Kaplan et al 2010). Six Sigma and Lean becomes recently the most popular of this package of methodologies. However as Nicolay et al. (2012) notes there are overlap between QI methodologies. SPC and PDSA cycles, for example, are common elements to CQI, TQM, Six Sigma and some lean programs.

Regarding the influence of context or factors in the implementation of Lean while there are authors who can get results (Andersen et al 2014;Mazzocato et al 2010) there are others as Nicolay et al. (2012) for the surgical area which states It is not possible to make evidence-based recommendations for different indications, as different studies implemented different aspects of various methodologies to varying extents, and in different contexts. Other authors state that a better understanding of the "critical success factors" for Lean remains necessary (Holden 2011).

In a generalized manner several criticisms of the results presented in the literature appear. First, there are a clear publication bias, since all articles report positive (Mazzocato et al 2010;Wright & McSherry 2013). Surely there are instructive failed lean applications waiting to be studied. (Nicolay et al 2012). On the other hand, the literature is dominated by single observations without statistical analysis (Nicolay et al 2012). Holden (2011) states that most of the employee effects described in their review were not systematically assessed and were either implied or based on anecdotal evidence. So, it is demanded in research domain lean healthcare rigorously designed high-quality studies with low risk of bias (Mazzocato et al 2010; Nicolay et al 2012).

Highlighting also as point Mazzocato (2010) that while lean theory emphasizes a holistic view, most cases report narrower technical applications with limited organizational reach. To better realize the potential benefits of lean, healthcare organizations need to increase solution retention, involve senior management, work across functional divides, pursue value creation for patients and other customers, and nurture a long-term view of continual improvement.

As stream research fields note Lean Healthcare IT environments, particularly Health Information Systems (HIS) (Kalong & Yusof 2013). The interaction of Lean With Clinical Risk Management focusing on the safety and quality of patient service (Crema & Verbano 2013b) as well as effects on the workers of Lean Healthcare implementations (Holden 2011).

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5 References

Agency for Healthcare Research and Quality. Testimony on Health Care Quality. AHRQ Publications. http://archive.ahrq.gov/news/test1028.htm. 1997. Rockville. 25-2-2014.

Andersen, H., Rovik, K.A., & Ingebrigtsen, T. (2014) Lean thinking in hospitals: is there a cure for the absence of evidence? A systematic review of reviews. Bmj Open, 4, (1)

Crema, M. & Verbano, C. (2013a) Guidelines for overcoming hospital managerial challenges: a systematic literature review. Therapeutics and Clinical Risk Management, 9, 427-441

Crema, M. & Verbano, C. (2013b) Health Lean Management and Clinical Risk Management: A Systematic Literature Review. Confronting Contemporary Business Challenges Through Management Innovation 659-673

Dahlgaard, J.J., Pettersen, J., & Dahlgaard-Park, S.M. (2011) Quality and lean health care: a system for assessing and improving the health of healthcare organisations. Total Quality Management & Business Excellence, 22, (6) 673-689

Hicks, B.J. (2007) Lean information management: Understanding and eliminating waste. International Journal of Information Management, 27, (4) 233-249

Holden, R.J. (2011) Lean Thinking in Emergency Departments: A Critical Review. Annals of Emergency Medicine, 57, (3) 265-278

Jacobson, J.M. & Johnson, M.E. (2006) Lean and Six Sigma: Not for Amateurs First in a 2-Part Series. Lab Medicine, 37, (2) 78-83

Jones, D.T., Roos, D., & Womack, J.P. (1990) Machine that Changed the World Simon and Schuster

Kalong, N.A. & Yusof, M.M. (2013) Understanding Waste for Lean Health Information Systems: A Preliminary Review. Medinfo 2013: Proceedings of the 14Th World Congress on Medical and Health Informatics, Pts 1 and 2, 192, 749-753

Kaplan, H.C., Brady, P.W., Dritz, M.C., Hooper, D.K., Linam, W., Froehle, C.M., & Margolis, P. (2010) The Influence of Context on Quality Improvement Success in Health Care: A Systematic Review of the Literature. Milbank Quarterly, 88, (4) 500-559

Mazzocato, P., Savage, C., Brommels, M., Aronsson, H., & Thor, J. (2010) Lean thinking in healthcare: a realist review of the literature. Quality & Safety in Health Care, 19, (5) 376-382

Nelson-Peterson, D.L. & Leppa, C.J. (2007) Creating an environment for caring using lean principles of the Virginia Mason Production System. Journal of Nursing Administration, 37, (6) 287-294

Nicolay, C.R., Purkayastha, S., Greenhalgh, A., Benn, J., Chaturvedi, S., Phillips, N., & Darzi, A. (2012) Systematic review of the application of quality improvement methodologies from the manufacturing industry to surgical healthcare. British Journal of Surgery, 99, (3) 324-335

Ohno, T. & Bodek, N. (1988) Toyota Production System: Beyond Large-Scale Production Productivity Press

Pernstal, J., Feldt, R., & Gorschek, T. (2013) The lean gap: A review of lean approaches to large-scale software systems development. Journal of Systems and Software, 86, (11) 2797-2821

Shortell, S. M. 1998, Assesing the implementation and impact of clinical quality improvement efforts:abstract, executive summary and final report.

Walshe, K. (2007) Understanding what works - and why - in quality improvement: the need for theory-driven evaluation. International Journal for Quality in Health Care, 19, (2) 57-59

Womack, J.P. & Jones, D.T. (2010) Lean thinking: banish waste and create wealth in your corporation Simon and Schuster

Wright, S. & McSherry, W. (2013) A systematic literature review of Releasing Time to Care: The Productive Ward. Journal of Clinical Nursing, 22, (9-10) 1361-1371

Research Methodologies in Studies on Concentration of American Hospitals

Migowski S[1], Migowski E[2], Libânio C[3]

Abstract: The objective of this study is to know which methodologies and databases that were used in articles treat variables, such as efficiency and costs in the hospital segment and their relationship with the concentration of American organizations. The quantitative methodologies used were, by order of preference, the multivariate statistical analysis and the econometric analysis. The most used data basis was the Annual Report of the American Hospital Association (AHA), followed by data made available by insurance companies having long lasting relationships with the hospitals analyzed, besides the specific case studies. Finally, it was observed that the concentration in the sector is reflected in the reduction in competition and efficiency gains, notably in the first year after the fusion, which does not mean that there was reduction in the prices charged by the hospitals.

Keywords: Hospital; Research method; Concentration; Cost.

1 Introduction

The concentration of hospitals worldwide seems to be an irreversible tendency. There are several reasons, with the major one being, according to the results found by many studies, related to the search for efficiency for maintaining the sustainability of the organizations involved. On one hand, clients (individual taxpayers, insurance companies, and health insurance providers) loose due to the expressive reduction of service options, causing an impact on the waiting time for these services. On the other, they gain because the operational efficiency increases, which means fewer errors in the assistential processes and provided services (Kobis & Kennedy, 2006; Bazzoli, 2006; Burns et al., 2008; Delia & Wood, 2008; Ferrier, Leleu, & Valdamanis, 2009; Weil, 2010; Rechel et al., 2010; Cutler & Morton, 2013).

Specifically in the United States, the tendency of consolidations occurred in two different times. In the 1990s, there was the first wave of concentration of hospitals in large groups, which ended up by reflecting on the rise of the prices set by insurance companies and health insurance providers. They reacted with a fusion of several insurance companies as a way to retrieve their dominating position in their capacity of negotiation (Moriya, Vogt, & Gaynor, 2010).

A new wave of concentrations of hospitals happened again in the following years particularly after the creation of *The Affordable Care Act* (more commonly known as Obama Care). This program financially rewards hospitals that exceed quality measures and at the same time punishes the ones with poor performance. As most part of the quality improvement is connected to the development and upgrading of the diagnostic technology, the increase of investments has led to new fusions, acquisitions, or affiliations, as a way to reduce costs and risks (Brown Jr. et al., 2012).

Despite this tendency to concentration of hospital organizations, some American studies (Porter & Teisberg, 2007; Bohmer, 2012; Porter & Lee, 2013) identify the environment of the American hospitals as being competitive. However, there is an uncomfortable situation for the clients of hospital services: when they need a service, customers have less bargain power due to the reduction of options.

1 **Sérgio Almeida Migowski** (sergiomigowski@gmail.com)
IFRS Osório (RS) Brasil.
2 **Eliana Rustick Migowski** (elianamig@yahoo.com.br)
EST São Leopoldo (RS) Brasil.
3 **Claudia de Souza Libânio** (clasl@terra.com.br)
UFCSPA Porto Alegre (RS) Brasil.

In this context, this study aims to identify the academic studies that analyze the variables efficiency and cost of American hospital organizations, after the processes of fusions and which methodology and data basis are used by them to achieve the results found. Finally, it is aimed to check if the rise of the first variable and the reduction of the second variable implicate a transfer of the gains to the customer.

2 Theoretical Background

From the customer's point of view, the rise in prices of health services has been a reality worldwide (Chapman, Kern, & Laguecir, 2014; Porter & Lee, 2013). On the other hand, the search for a solution to the increasing costs and unsatisfactory quality has led to the concentration of hospitals, in order to reduce the double services, through the scale economy (Groff, Lien, & Su, 2007).

This search is marked by partnerships (Fink & Burns, 2014) that can occur through affiliation (without changing the management of each hospital); joint venture (shared management); joint operating agreement (new governance, but each hospital with their own board); fusion (debts and assets are absorbed); and acquisition, where there is the possibility to function semi-independently or being totally subordinated to a single governance (Burik & Dixon, 2013).

The tendency of increasing the acquisition processes has been responsible for a reduction of 18% in the number of American hospitals and 31% in the number of hospital beds since 2006 (Costello, West JR., & Ramirez, 2011). The reduction of American hospital beds can be translated into numbers: in 1981, there were 4.6 beds/1000 people and, in 2008, 2.7 beds/1000 people (Weil, 2010).

While the market does not reach a balance point that is interesting for all those involved (fair price, quality, economic sustainability), fewer options are offered (Porter & Lee, 2013; Porter & Teisberg, 2007). The reasons for the concentration to continue and the consequent reduction in the number of hospitals and beds are linked to some factors: technology has advanced to such an extent that several procedures can be administered in an outpatient setting (where there is no need of hospitals beds); and the concentration rises the negotiation power, including receiving more financial resources, when the expansion of facilities is needed (Burik & Dixon, 2013).

Other factors explaining this phenomenon can be added: scale economy; qualification and more efficient use of the investments in technology; reduction of the bargain power of plaintiffs, caused by fewer choice options (Kuramoto, 2014); demographic factors; fees paid by health insurance companies; number of doctors available; quality and variety of the services being offered (Bazzoli, 2006); deterioration of the cash flow; and search for partnerships (Fink & Burns, 2014).

3 Methodology

For the present study, an applicable, exploratory, systematic review was developed. It was carried out a survey with international articles dealing with the relationship between the consolidation of American hospital organizations and the variables efficiency and costs.

According to Sampaio & Mancini (2007), a systematic review is a research medium based on literature data sources on a specific topic, enabling a summary of all studies about a given intervention. Systematic reviews enable the incorporation of a wider range of relevant results, instead of restricting the conclusions of a single study to the reading of few materials. However, they depend on the quality of the primary sources being researched.

For a coherent development of a research process, in a systematic review, a successful sequence of methodological steps must be observed. In this study, the methodology by Sampaio & Mancini (2007) was adopted, as it is shown in Table 1.

Table 1
Steps for the systematic review versus steps
for the development of this study.
Source: Adapted from Sampaio & Mancini (2007).

Steps for the Literature Systematic Review	Steps for the Research of Theses and Dissertations in Brazil
1) Defining the scientific question	What is the relationship between the consolidation of American hospitals and its influence on the variables cost and efficiency*?*
2) Identifying the databases to be consulted and defining keywords and search strategies	The research was carried out in the EBSCO *Information Services* basis with the following keywords: *healthcare consolidation cost, healthcare merger cost, hospital consolidation cost, hospital merger cost, hospital acquisition cost, hospital merger efficiency, hospital acquisition efficiency, hospital efficiency gain*.
3) Establishing criteria for the selection of articles considering the search	The abstract and the methodology sections of the studies were read and two groups were created: studies about the relationship between consolidation and efficiency and the ones about the relationship between consolidation and costs.
4) Conducting a search on the chosen databases following the defined strategies	From September 1st to October 2nd 2014, international articles published between January 1st 2007 and October 2nd 20104 were searched.
5) Comparing the search from the examiners and defining the initial selection of articles	Once the studies searched were analyzed, 117 papers were selected for this research.
6) Applying the criteria in the selection of the articles and justifying potential exclusions	The papers were only selected if addressed a relationship between consolidation and efficiency and consolidation and cost of American hospitals. Besides, they should present a quantitative methodology and the databases used. Papers not addressing this topic nor the methodology and databases were excluded. Thus, 8 articles were included in the group related to cost, and 6 articles were included in the efficiency group. From the 103 papers that were excluded, 7 made econometric analyses based on projection and not on empirical databases; 34 are non-academic articles, though this filter was used during the search; 37 are analyses of European hospitals; and 25 result from qualitative analyses of studies by other authors.
7) Analyzing critically and assessing all the studies included in the review	Information of the papers was organized and tabled, in order to develop analyzes from this.
8) Preparing a critical summary, with the information made available by the articles included in the review	A critical summary was written in a table, where the information of each paper considered as relevant for this study was listed, such as authors, year of publication, periodical, data basis, method, and results found.
9) Presenting a conclusion with the evidence on the intervention effects	From the analysis of the information in the 15 articles, it was possible to understand the relationship between the consolidation of American hospitals, costs, and the resulted efficiency, as well as the potential relationships between consolidation and prices charged.

From the refinement used to meet the requirements of the present study, 14 articles were selected and divided into 2 groups. They were published in the following periodicals (Table 2) and were entirely read to understand the results found:

Table 2
Periodicals with the selected publications.
Source: Elaborated by the authors.

Cost Group	
Periodical	**Number of published articles**
International Journal of The Economics of Business	**3**
American Journal of Management Care	**1**
Journal of American Medical Association	**1**
Economic Inquiry	**1**
Health Affairs	**1**
Biomedical Central Health Services Research	**1**
Quantity of articles	**8**
Efficiency Group	
The Quarterly Review of Economics and Finance	**1**
Atlantic Economic Journal	**1**
Journal of Healthcare Management	**1**
International Journal of The Economics of Business	**1**
Managerial and Decision Economics	**1**
Healthcare Financial Management	**1**
Quantity of articles	**6**
Total	**14**

It is interesting to note that the *International Journal of The Economics of Business* presents 4 articles, all of them from the same issue of February 2011, as it can be seen in Table 3. In the same journal, 7 articles were found with the econometric analysis, but as they dealt with projections and not empirical data, were excluded, since this study addresses an empirical relationship between the variables cost and efficiency and consolidations of American hospitals.

4 Description And Data Analysis

As the aim of the present study is to identify the academic studies analyzing the variables efficiency and cost of the American hospital organizations, after the processes of fusion and the methodology and data basis used, the results will be associated with two tables, with Table 3 presenting the title of the articles, authors, title of the periodicals, and other details of the publication:

Table 3
Details of the periodicals selected.
Source: Elaborated by the authors.

	Cost Group			
	Article	**Author(s)**	**Title of the periodical**	**Year, Vol., Pages**
1	The Effect of Hospital Mergers on Inpatient Prices: a case study of The New Hanover-Cape Fear Transaction	Thompson, A.	International Journal of The Economics of Business	V. 18, N 1, pp. 91-101, Feb 2011
2	The Price Effects of Hospital Mergers: a case study of The Sutter-Summit Transaction	Tenn, S	International Journal of The Economics of Business	V.18, N 1, pp. 65-82, Feb 2011
3	Hospital Mergers and Competitive Effects: two retrospective analyses	Hass-Wilson, D; Garmon, C.	International Journal of The Economics of Business	V.18, N 1, pp. 17-32, Feb 2011
4	Hospital Market Concentration, Pricing, And Profitability in Orthopedic Surgery and International Cardiology	Robinson, J.C.	American Journal of Management Care	17 (6): 241-248, 2011
5	Hospital, Market Share, And Consolidation	Cutler, D.M, Morton, F.S.	Journal of American Medical Association	V 310, N 18, November 13, 2013.
6	Do Mergers Really Reduce Costs?	Harrison, T.D.	Economic Inquiry	V 49, N 4, pp. 1054-69, October 2011
7	The Increased Concentration of Health Plan Markets can Benefit Consumers Through Lower Hospital Prices	Melnick, G. A, Shen, Y, Wu, V. Y.	Health Affairs	30, N 9, pp. 1728-1743, 2011
8	Decomposition of the Drivers of The U.S. Hospital Spending Growth, 2001-2009	Wu, V. Y, Shen, Y, Yun, M, Melnick, G.	Biomedical Central Health Services Research	2014
	Efficiency Group			
	Article	**Author(s)**	**Title of the periodical**	**Year, Vol., Pages**
1	Measuring Efficiency Gains From Hospital Mergers	Groff, J.E, Lien, D, Su, J.	Healthcare Financial Management	V 11, N 1, pp 77-90, 2007
2	The Effects of U.S. Hospital Consolidations on Hospital Quality	Mutter, L, Romano, P.S., Wong, H.S.	International Journal of The Economics of Business	V. 18, N 1, pp. 109-126, Feb 2011
3	The Effect of Non-rural Hospital Mergers and Acquisitions: an examination of cost and price outcomes	Spang, H.R, Arnould, R. J, Bazzoli, G.J.	The Quarterly Review of Economics and Finance	49, pp. 323-342, 2009
4	The Focus Efficiency of U.S. Hospitals	Ferrier, G.D, Leleu, H, Moises, J, Valdmanis, V.G.	Atlantic Economic Journal	41: 241-263, 2013
5	Hospital Cost and Efficiency: do hospital size and ownership type really matter?	Coyne, J.S, Richards, M.T, Short, R, Schultz, K. Vingh, S.G.	Journal of Healthcare Management	54:3, May/Jun 2009
6	The Impacts of Hospital Alliance Membership, Alliance Size, And Repealing Certificate of Need, Regulation, on The Cost Efficiency of Non-Profit Hospitals	Granderson, G.	Managerial and Decision Economics	32: 159-173,2011

Table 4 presents an abridged description of the results found according to the group being analyzed:

Table 4
Methodology, data basis, and results.
Source: Elaborated by the authors.

Cost Group				
	Article	**Methodology**	**Data basis**	**Results**
1	The Effect of Hospital Mergers on Inpatient Prices: a case study of The New Hanover-Cape Fear Transaction	Econometric Analysis	Data from 5 insurance companies associated with an organization resulting from a fusion, both before and after the fusion	Reduction of costs did not have an impact on the reduction of prices. 4 out of 5 insurance companies had their prices raised oscillating between 18% and 24%
2	The Price Effects of Hospital Mergers: a case study of The Sutter-Summit Transaction	Econometric Analysis	Data from 2 hospitals that were consolidated and 3 insurance companies associated with an organization resulted from a fusion, both before and after the fusion	Reduction of costs did not have an impact on the reduction of prices. Three insurance companies had their prices raised oscillating between 23.4% and 50.4%
3	Hospital Mergers and Competitive Effects: two retrospective analyses	Econometric Analysis	Data from 2 hospitals that were consolidated and were object of analysis from the Federal Trade Commission (FTC) and 3 insurance companies associated with the organization resulted from the fusion both before and after the fusion	Reduction of costs did not have an impact on the reduction of prices. Four insurance companies had their prices raised in 10% and only one maintained the prices charged before the fusion.

Table 4 (continued)

Cost Group				
	Article	**Methodology**	**Data basis**	**Results**
6	Do Mergers Really Reduce Costs?	Multivariate Statistical Analysis	The 1984 Annual Report of the AHA, from 1984 to 1998, analyzing all the 6,487 hospitals that went into fusion with only one other organization. All fusions with more than one partner were dismissed	Cost economy was found in the following moment after the fusion. When compared with the years after the fusion, the first year is the one that presents more substantial economy
7	The Increased Concentration of Health Plan Markets can Benefit Consumers Through Lower Hospital Prices	Multivariate Statistical Analysis and the Herfindahl-Hirschman Index (HHI)	Data from insurance companies associated with 2,276 hospitals from all the metropolitan regions from 2001 to 2004	2,111 hospitals operate in markets, where their concentration is higher than the concentration indexes of health insurance providers.

Table 4 (continued)

	Cost Group			
	Article	**Methodology**	**Data basis**	**Results**
				For each point in the rise of concentration indexes (HHI) of health insurance providers, there are 2.5 points in the reduction of the hospital prices. On the other hand, for each 1 point in the hospitals' HHI, there is a rise of 8.3 in the hospital prices.
8	Decomposition of the Drivers of The U.S. Hospital Spending Growth, 2001-2009	Multivariate Statistical Analysis	Annual Report of the AHA, from 2001 to 2009, analyzing only hospitals already existing in 2001 that treated acute heart diseases and that later went into fusion	As heart procedures need to incorporate more technology and are not available in a non-specialist hospital, consolidations enable a better use of the facilities in 9% and a real growing of 42% and nominal growing of 64% in prices
	Efficiency Group			
	Article	**Methodology**	**Data basis**	**Results**
1	Measuring Efficiency Gains From Hospital Mergers	Multivariate Statistical Analysis	The 1992 Annual Report of the AHA, with 5,619 short-stay (max. 30 days) hospitals being randomly selected. None of the institutions could have been subject to any kind of fusion in 1992 and 1993	The years 1994 and 1995 were analyzed, when fusions occurred, enabling the analysis of the efficiency in the years 1996 and 1997. Evidence of efficiency improvement was found only in the first year of fusion

Table 4 (continued)

	Efficiency Group			
	Article	**Methodology**	**Data basis**	**Results**
2	The Effects of U.S. Hospital Consolidations on Hospital Quality	Multivariate Statistical Analysis	Annual Report of the AHA, from 1999 to 2000, of 42 markets, where there were consolidations involving 136, in 16 American states	In 1999, the control group (no fusion) included 425 hospitals, whilst in the following year there were 450 hospitals. Evidence indicating the rise in the quality of services provided was not found
3	The Effect of Non-rural Hospital Mergers and Acquisitions: an examination of cost and	Multivariate Statistical Analysis and the Herfindahl-	Annual Report of the AHA, from 1988 to 1997, regarding 1,165	Evidence of efficiency gains was found, but they were

	price outcomes	Hirschman Index (HHI)	hospitals that went into fusion in the period being analyzed	transferred to the customer as minor readjustments of the prices in the high competition markets. In low competition market, higher readjustments were found.
4	The Focus Efficiency of U.S. Hospitals	Econometric Analysis	Annual Report of the AHA, from 2004 to 2007, regarding 1,940 hospitals from metropolitan regions in USA	Location influences the possibility of having efficiency gains, both for scale economy and scope economy, since a bigger distance to other services can determine the offer of more specialties in the same structure
5	Hospital Cost and Efficiency: do hospital size and ownership type really matter?	Multivariate Statistical Analysis	Reports by the Washington State Department of Health, in 2006, with 98% of the existing hospitals	Evidence that the size interferes with the hospital's efficiency and cost reduction was found. Independent hospitals were less efficient.

Table 4 (continued)

	Efficiency Group			
	Article	**Methodology**	**Data basis**	**Results**
6	The Impacts of Hospital Alliance Membership, Alliance Size, And Repealing Certificate of Need, Regulation, on The Cost Efficiency of Non-Profit Hospitals	Multivariate Statistical Analysis	Annual Report of the AHA and the Medical Cost Report Data, from 1996 to 1999, regarding 144 hospitals from the American Mid-West	Being part of only one alliance is more efficient than being part of more than one alliance. The higher the number of members of this alliance, the higher the efficiency is.

Due to the extensive volume of available data, the use of multivariate statistical analysis by 4 of the 8 papers related to costs and 5 of the 6 studies related to efficiency is not surprising. The econometric analysis was the choice made by 4 studies related to costs and only one related to efficiency. Moreover, two studies used the concentration index HHI. This index, when measuring the number of existing organizations of one segment of a market, considers that whenever an index indicates a value equals to or higher than 1,800, there is a high concentration of services/products in few companies.

In general, whenever there is a fusion of hospitals, the efficiency increases, notably in the first year after the fusion, as two of the studies show. Consequently, it implies the cost reduction. However, this does not guarantee that the gains will be transferred to the plaintiffs (health insurance providers and companies, besides the individual clients). Only one study shows that it is possible to have minor readjustments in the prices in markets where there is high competition, but not a reduction of the prices. Seven of the 8 studies addressing the topic cost show that there was a rising in the prices charged by hospitals after the process of fusion.

One of the studies (Spang, Arnould, & Bazzoli, 2009) shows that the rise in efficiency did not trigger the rise in the quality of the services offered. The other studies did not make an association between efficiency gains and quality, probably because they are a subjective criterion, as highlighted by Hass-Wilson & Garmon (2011), when explaining the reason not to include the variable quality in their study.

Other studies present relevant knowledge to other research areas. Ferrier et al. (2013) highlight the relevance of the location of the hospital facility. If it set in a location with few hospitals, it is strategically interesting that more options of specialities are offered (scope gain), which can cause loss in scale, for not focusing on one or few specialties. For the studies on inter-organizational relationships, the paper by Granderson (2011) presents an interesting analysis of alliances, showing that being part of only one alliance is more efficient than being part of many others simultaneously. The author highlights also that the higher the number of members of an alliance, the higher the efficiency is.

In relation to the databases used, the Annual Report of the AHA was the biggest source of information for 8 of the 14 studies presented. Three studies used the data made available by insurance companies associated with hospital organizations before and after the fusion; one used the data from the Washington State Department of Health, since the analysis was concentrated only in that region; and the others analyzed specific cases of fusion, with direct data from hospitals or from the Federal Trade Commission.

5 Final Considerations

The concentration of American hospitals worldwide seems to be an irreversible tendency. There are several reasons, with the major one being the search for efficiency for maintaining the sustainability of the organizations involved. Clients (individual taxpayers, health insurance companies, and health insurance providers), on the other hand, seem to loose due to the expressive reduction of options, causing an impact on the rise of the prices charged. Yet, there is no guarantee that the efficiency gains mean a rise in quality of the provided services.

The access to the information enabled a number of analyzes that can be useful both for the strategic decision-making of the hospitals and for the Public Entity since it regulates the market. In the American case, the Annual Report of the AHA is an accessible database, with important information about American hospitals, besides presenting a historic series, enabling researchers to make *ex-ante and ex-post* comparisons. The use of quantitative methodology, for the analysis of this big volume of data, seems to be the most sensible choice, along with the use of multivariate statistical analysis, followed by the econometric analysis. It is important to emphasize that the mention of the use of the HHI concentration index by only two studies does not reflect what is presented in studies with econometric analysis, since in their formula the concentration of the sector being studied was considered.

The keywords used for searching in the data basis chosen; the exclusion of papers not using empirical data; and the use of the EBSCO base as the only research source can be considered limitations of the present study what reflected on the number of articles presented. However, the ones presented brought new knowledge, such as the impact of the location as a factor to be weighed in strategic decisions, as well as the influence on the number and size of the alliances made.

References

Bazzoli GJ (2006) The Transition from Excess Capacity to Strained Capacity in U.S. Hospitals. Milbank Q 84:273-304

Bohmer RM (2012) Arquitetura e planejamento na gestão da saúde: alinhando o conhecimento médico à administração do sistema de saúde. Bookman, Porto Alegre

Brown TC et al (2012) Current Trends in Hospital Mergers and Acquisitions. Healthc Financ Manage 66:114-118

Burik D, Dixon T (2013) What's Really Happening with US Health Systems Consolidation. Available via Navigant Healthcare Pulse III. http://www.navigant.com/insights/library/healthcare/2013/pulse-issue-3-consolidation-or-not/. Cited 27 February 2015

Burns DJ et al (2008) Hospital Care and Capacity in the Tri State Region of Indiana, Kentucky and Ohio: analysis and insights. Health Mark Q 25:254-69

Chapman C, Kern A, Laguecir A (2014) Costing Practices in Healthcare. Account Horiz 28:353-364

Costello MM et al (2011) Hospitals for Sale. Hosp Top 89:69-73

Coyne JS et al (2009) Hospital Cost and Efficiency: do hospital size and ownership type really matter? J Healthc Manag 54:163-174

Cutler DM, Morton FS (2013) Hospitals, Market Share and Consolidation. JAMA 310:1964-1970

Delia D, Wood E (2008) The Dwindling Supply of Empty Beds: implications for hospital surge capacity. Health Aff 27:1688–1694

Ferrier GD et al (2013) The Focus Efficiency of U.S. Hospitals. Atl Econ J 41:241-263.

Ferrier GD, Leleu H, Valdmanis VG (2009) Hospital Capacity in Large Urban Areas: is there enough in time of need? J Prod Anal 32:103-117

Fink JN, Burns SF (2014) Combining Forces to Manage the Continuum of Care. Healthc Financ Manage 68:58-64

Granderson G (2011) The Impacts of Hospital Alliance Membership, Alliance Size, And Repealing Certificate of Need, Regulation, on The Cost Efficiency of Non-Profit Hospitals. Manag Dec Econ 32:159-173

Groff JE, Lien D, Su J (2007) Measuring Efficiency Gains From Hospitals Mergers. Res Healthcare Management ii:77-90.

Haas-Wilson D, Garmon C (2011). Hospital Mergers and Competitive Effects: two retrospective analyses. Int J Econ Bus 18:17-32

Kobis DA, Kennedy KM (2006) Capacity Management and Patient Throughout: putting this problem to bed. Healthc Financ Manage 60:80-92

Kuramoto RK (2014) Specialties: missing in our healthcare reform strategies? J Healthc Manag 59:89-94

Melnick GA, Shen Y, Wu VY (2011) The Increased Concentration of Health Plan Markets can Benefit Consumers Through Lower Hospital Prices. Health Aff 30:1728-1743.

Moriya AS, Vogt WB, Gaynor, M (2010) Hospital prices and market structure in the hospital and insurance industries. Health Econ Policy Law 5: 459-479

Mutter RL, Romano PS, Wong HS (2011) The Effects of US Hospital Consolidations on Hospital Quality. Int J Econ Bus 18:90-126

Porter M, Lee TH (2013) The Strategy That Will Fix Health Care. HBR 91:50-70

Porter M, Teisberg E (2007) Repensando a Saúde: estratégias para melhorar a qualidade e reduzir os custos. Bookman, Porto Alegre

Robinson JC (2011) Hospital Market Concentration, Pricing, And Profitability in Orthopedic Surgery and International Cardiology. Am J Management Care 17:241-248

Rechel B et al (2010) Hospital Capacity Planning: from measuring stocks to modelling flows. Bull World Health Organ 88: 632-636

Sampaio RF, Mancini MC (2007) Estudos de revisão sistemática: um guia para síntese criteriosa da evidência científica. Rev Bras Fisioter 11:83-89

Spang HR, Arnould RJ, Bazzoli GJ (2009) The Effect of Non-rural Hospital Mergers and Acquisitions: an examination of cost and price outcomes. Q Rev Econ Finance 49:323-342

Tenn S (2011) The Price Effects of Hospital Mergers: a case study of The Sutter-Summit Transaction. Int J Econ Bus 18:65-82

Weil T (2010) Hospital Megers: a panacea? J Health Serv Res Policy 15: 251-253

Wu VY et al (2014) Decomposition of the Drivers of The U.S. Hospital Spending Growth, 2001-2009. BMC Health Services Research 14:230

The current state and use of Public Private Partnerships for health infrastructure investment in France

Rosset C[1], Rodríguez Monroy C[1], Peláez M A[1]

Abstract: The purpose of this paper is to determine the current state and use of Public Private Partnerships (PPP) for hospital infrastructure investment in France. The first chapter aims at describing the situation in the United Kingdom with the Private Finance Initiative (PFI) and its evolution in the health sector. The resource to PPP is justified with the macro-economic objective of investing in health infrastructure while fixing the debt-to-GDP ratio. Its evaluation with the value for money (VFM) method has been very controversial. As the main inspiration for the PPP version in France for hospital investment, the first section about PFI will then be useful in the second section to understand how the PPP market works in France in this sector. The last section relates the way how PPP was promoted and then discredited. Particularly, it is shown that, although PPP was constructed on the basis of PFI, its popularity fell for different reasons. While PFI in the UK was mainly criticized because it turned out to be less profitable in terms of VFM than the Government claimed, France raised the debate about the way health has to be managed.

Keywords: Public Private Partnerships; Hospitals; French National Health System; Private Finance Initiative; UK National Health System.

1 From Private Finance Initiative in the United Kingdom

This section focuses on Private Finance Initiative (PFI) in the British healthcare system. It relates its evolution from its creation by the Government with the purpose to invest in healthcare infrastructure while controlling the debt to the controversy of its value for money.

1.1 The introduction of PFI in the healthcare sector

PFI is a form of a long-term contract, generally at least 30 years, under which a private company not only builds and operates an infrastructure, but also finances the project. It then leases it to the government. We first heard about it in Great Britain under the Conservative Government in 1992. As a result of the Maastricht criteria, the government wanted to find a way to enable capital spending on the public sector while not borrowing (Greenaway et al. 2004, 511). From 1992 to 1997, the Conservative Government set a range of institutions and rules to promote PFI. In the meantime, the Labour party were very critical towards this new form of contract, particularly in the health sector (Private Eye, March-April 2004, 3).

The year 1997 was a turning point in PFI acceptance in the healthcare sector. The party in power changed after the 1997 election, but in the end the Labour Party also ended up recognising that PFI was the most appropriate structure that enabled new investment in the healthcare sector without increasing taxes or debt. In fact, during its mandate the Labour Government encouraged investment in the healthcare sector and increased expenditures. In January 2000, after the winter beds crisis, the Government pledged

1 **Chloé Rosset** (chloe.rosset@eleves.ec-nantes.fr)
Carlos Rodríguez Monroy (crmonroy@etsii.upm.es)
Miguel Ángel Peláez (mapelaez@etsii.upm.es)
Universidad Politécnica de Madrid.
c/ José Gutiérrez Abascal, 2, 28006 Madrid

to increase spending on the National Health System (NHS) by 30% over the next four years (Pollock et al. 2007, 62).

However, those politics were counterbalanced by the public requirement not to increase taxes. Also, the European flourishing fiscal policy encouraged European countries to control their debt with the Stability and Growth Pact of 1997. The Brown's Sustainable investment rule of the same year precisely regulated the prudent debt-to-GDP ratio, which was not permitted to be over 40% (Treasury 1998).

In this context, PFI came to the United Kingdom as the most appropriate alternative to combine high investments in the healthcare sector with the necessity to find an alternative financing source, other than the public sector. In 2003, 117 investment schemes had been approved by the Department of Health with a value of £3.2 billion (Edwards et al. 2004, 8). More than 100 of these were under the PFI model (Davis 2004, page 85). The pattern that had emerged was that most of the smaller capital investments in the NHS continued to be financed directly by the Exchequer, while most of the larger projects were being financed through the PFI.

1.2 From a Macroeconomic rule to a Microeconomic objective

Thus, the Labor Government promoted PPP to fix the debt-to-GNP ratio. However, alongside this macro-economic rule, there have been the micro-economic objectives of providing value for money (VFM) and being cheaper than a public-sector comparator (PSC) (Edwards et al., 2004). In this section, we will examine the consequences of fixing those objectives, and how it led PPP for hospital infrastructure investment in the United Kingdom to be discredited.

The method used by the Government was to demonstrate PFI's VFM in order to promote PFI. It has to been said that there are two disputable components in the latter: discounting and the cost of risk transfer.

The discounting component is a variable that expresses two economic costs: cost of capital and time preference. The Net Present Value (NPV) is obtained by discounting future annual cash flows at this rate. Under public procurement, the costs are accounted for during the construction period, generally up to three years (Pollock et al., 2007). However, under PFI, costs are spread out over 30 years and the more distant payments are, the less they impact on today's results. That is why the value of the discount rate is such a controversial issue.

Regarding risk transfer, its evaluation requires the identification of the future pattern of risks and costs over the life of the private project compared with a publicly financed hospital. The government claims that the apparently lower cost of publicly financed investment is due to the failure to take proper account of the extra costs incurred when things go wrong (Andersen 2000). Thus a key component of the value for money case is to estimate the cost of the risks transferred to the private sector and to add these costs to the public sector comparator.

Using this model, the consulting firm Arthur Andersen published a study for the UK Treasury in 2000, demonstrating the good VFM of PFI. However, it has been demonstrated that they use an unrealistic cost of capital.

In spite of this, the reports of the National Audit Office (NAO) on PFI projects have generally shown PFI to provide value for money compared to a PSC (Andersen, 2000, 6). However these comparisons were usually faulty for two reasons. Firstly their estimates for overruns on publicly funded projects were overs-tated (Flinders, 2005), justified with the risk transfer cost. Secondly, the comparisons were not always done at the same stage (Hellowell and Pollock 2007, table 6).

Thus, this is precisely the VFM, used by the Government to promote PFI, which at the same time discredited it a few years later. In fact, adjusting the results to obtain VFM for PFI not only led the Government to lose credibility with PFI but also showed that PFI for hospital infrastructure were not always profitable. The question is, as the French PPP model for hospital infrastructure is highly inspired from PFI in UK, will the situation be the same?

2 The PPP market in the healthcare sector in France

Now it is necessary to understand how the PPP market works in France, particularly in the healthcare sector. Thus, this section aims at showing the characteristics of its mechanisms and actors. First, we will see that, mainly inspired from PFI in the UK, the *bail emphytéotique hospitalier* (BEH) and the *contrat de partenariat* (CP) are the two main mechanisms available for PPP in the healthcare sector (Epec 2012). To develop and regulate it, different entities have been created. Inherent to the healthcare sector, the *Mission nationale d'appui à l'investissement hospitalier* (MAINH) and then the *Agence nationale d'appui à la* *performance des établissements de santé et médico-sociaux* (ANAP), have played a determining role for the development of PPP, although it is not only dedicated to it. On the contrary, the *Mission d'appui au partenariat public-privé* (MAPPP) exclusively focuses on PPP, but in all sectors (Epec 2012).

2.1 From PFI in the UK to BEH and CP

French health institutions have two different tools available for PPP: the *bail emphytéotique hospitalier* (BEH), which predated the *contrat de partenariat*, (CP) already mentioned. The object of the first one, BEH, is mostly linked to the civil work. Non-building services are limited. This form of contract, specific to hospital infrastructures, was introduced in 2003 to ensure the fast delivery of the "*plan hôpital 2007*" adopted by the government in 2002. The objective of this modernizing programme was to speed up infrastructure projects by simplifying the rules of execution and financing, and by broadening the use of the bail emphytéotique ordinaire (BEA). In practice, the BEA was the first UK PFI-style form of contract for central government projects. Thus, BEH is a tool that permits the transfer of building rights to a private partner on a publicly owned land.

The second one, the so-called CP, pursues a larger scope. Introduced by an *ordonnance* in 2004, we can consider it as the starting point for modern PPP in France. Today, it is the most used form of a partnership contract in France. Under CP, a public authority grants a global mission to design, build, maintain, operate and finance public assets and public services to a private partner over the long-term against an ongoing payment made by the public sector and spread over a period of years. CP contracts are global. In fact, at least three elements need to be brought together to justify its use: the construction, the maintenance and operation, and the financing. It can be used by any public entity: the State, local authorities but also the *établissements publics de santé*. The latter are public bodies of private law in the healthcare sector. It concerns infrastructure investments but also applies to every kind of immaterial investment, like information systems, specific facilities or their maintenance.

2.2 Entities Involved

There are two major entities in the health sector that play an important role in the development and renovation of health infrastructure: the MAINH and ANAP. There is also an exclusively PPP oriented entity, called MAPPP. The latter intervenes in every sector, particularly in the healthcare sector with MAINH and ANAP. This section aims at clarifying the role of each entity.

MAINH was created in 2003 to meet the objectives of the ambitious health program, "Plan Hôpital 2007". Attached to the Ministry of Health, its initial mission was to support existing infrastructure renovation and to develop new innovative ones (Epec 2012). As government-paid PPP models were not common in France at the time, MAINH adapted the BEA contract, which had been introduced in 1988, to produce the BEH. It was inspired from the UK PFI health experience.

MAINH is involved in the development of the legal, technical and financial frameworks for national programs in the healthcare sector, and also in its monitoring and evaluation. It then facilitates the execution and the use of it. Besides that, it also provides a methodological support system to the management of investments and associated costs linked to it.

In 2009, the merger of MAINH and two other agencies involved in public healthcare resulted in the creation of the ANAP. Its first mission consists in improving management and economic performance of healthcare entities by supporting 30 *établissements de santé* and the regional health agencies, *Agences Régionales de Santé*. The second one consists in promoting the sector's infrastructures and assets.

Finally, there exists an entity entirely dedicated to PPP in France: MAPPP. Its creation resulted from the wish of the French Government to create an assessor in the PPP process, independent from the procuring authority and the private firm. MAPPP was created in October 2004 and formally set up in 2005. Attached to the Ministry of Economy and Finance, its initial purpose was to realize a preliminary evaluation of PPP projects. MAPPP assumes three main missions. The first one is to validate ex ante evaluation realized by procuring authorities. The second one consists in providing support to the latter in the preparation, negotiation and monitoring of CPs. Finally, the last one lies in developing CPs.

Among the partnership contract, MAPPP mainly focuses on CPs. Now, CPs are one of the two mechanism often used in the healthcare sector infrastructure. Hence the important coordination set up between MAPPP, MAINH and ANAP.

In this context, how has hospital infrastructure investment under PPP evolved in France? As it was mainly inspired by PFI in the United Kingdom, the point is to know if PPP for hospital investment has been as criticized as it has been in the UK.

3 Evolution of PPP for Hospital Infrastructure in France

Thanks to the two active programs "*Plan Hôpital 2007*" and "*Plan Hôpital 2012*", PPPs for hospital investment have been used actively in France in the past few years. However, events like the failure of the biggest contract for hospital construction, the *Centre Hospitalier Sud Francilien (CHSF)* recently tarnished its image to the public.

3.1 Plan Hôpital 2007 and Plan Hôpital 2012

In 2003, the success of this new long-term contract was not assured. Professionals were very reluctant to accept it. In fact, they criticized the incomplete and imprecise nature of the texts and the difficulty to delegate the job of the project manager in a sector tied to construction. Hence the aggressive programme set up by the Government with the P*lan Hôpital 2007*. This Plan was created to reform the pricing of healthcare services, to change the governance of the sector and to encourage investment. At least 15 per cent of this investment had to be carried out through PPPs (Le Taillandier 2007). At the same time, the MAINH was created to develop and promote PPP.

The result was successful. On 15 January 2007, 37 projects in BEH were engaged, 2 in CP. They accounted for investments of 1.5 billion euros, an amount close to the target set at the beginning of the plan. Of these, 17 contracts were signed among which was the very important project of the University Hospital of Caen on the Mother Child Haematology wing of 100 million euros and the reconstruction of the CHSF, 330 million euros (Le Taillandier 2007).

It is divided between investments of various types: logistics, accommodation, a wing, or the entire hospital, with an average size of 10 to 30 million euros. However, this first generation of PPP hospital gave priority to investment property, with the exception of the two CPs relating to power plants and power grids. The contracts have mostly been driven by the *établissements publics de santé* with a private company. Decentralizing investment decisions to *établissements publics de santé* is seen as a factor of success, by permitting fast initiatives.

After such success, a second wave of projects was launched in 2006 under the "*Plan Hôpital 2012"*. Overall, over 40 BEHs and 10 CPs reached financial close under the two hospital plans. 35 hospitals have reached completion and are in operation today.

3.2 The Future of PPP for Hospital Investments Infrastructure

However, as it happened in the United Kingdom with PFI for hospital infrastructure, PPP's popularity fell a few years after an initial striking success. There are two main points that have raised important questions in France.

The first one lies in the fact that the major contractors were awarded all the PPP contracts (Epec 2012, 5.2.2). By doing so, the PPP market was not competitive and the state was in a way subsiding private entities. The second reason, which has provoked this general disillusion for PPP and raised a wave of contestation, is the failure of the CHSF (Epec 2012, 5.2.2). This project reached financial close in 2006. The BEH for the 343 million euros project was signed with the Eiffage Company. Throughout the construction period, the relationship between the public and the private partners deteriorated significantly (Hamel 2010). The project is now completed but opened with a one-year delay due to disputes between the parties. As a result, the project has attracted a lot of attention and criticisms. The bad management of the project was criticized. The resulting consequences, whose risks had been entrusted to the state, had to be accepted by the whole society. However, when the public sector transferred the risks to the private entity, did it measure the resulting risks for the whole society? In the end, the French people heavily rejected PPPs because they questioned the position of the Welfare State. By creating the former, the society charged the State for providing the services necessary for the welfare of the whole society. What if the state was not accepting the risks anymore?

Finally, while the analysis of the VFM mainly discredited PFI in United Kingdom for hospital infrastructure investment, in France this is the debate about the appropriate way to manage healthcare that has caused such a controversy. In fact, the critics rarely claim VFM arguments, cost of capital or discount rate. When they mention the amount of losses, it is to deplore the war it provokes between the parties by forcing them to renegotiate the terms of the contract. The resignation of the manager of the CHSF shocked the public further. They were even more outraged by the austerity politics set up by the *Agence Régionale de Santé* as the consequence of the failure of the project whereas Eiffage was paid an important amount (Hamel 2010).

As a consequence, PPPs are not likely to be featured significantly in the healthcare sector in the future, except for niche applications such as information systems, energy production and logistics.

4 Conclusions

This paper describes the current use of PPP for hospital infrastructure investment in France. Mainly inspired by the PFI contract, it demonstrates that PPP has experienced the same disillusion as in the other side of the English Channel, as a result of the failure of the CHSF project. The reasons turn out to be fundamentally different than in the UK. In France, the public criticized the fact that the private sector was permitted to make profits on healthcare while imposing private management and services. While the economic base of PPP has been contested in the UK, this is the form of privatization of healthcare that has been discussed in France.

5 References

Andersen 2000; *Value for Money Drivers in the Private Finance Initiative,* a report commissioned by the Treasury Task Force.

Davis P 2004**;** *The NHS in England 2004/05, a pocket guide,* The NHS Confederation.

Edwards P, Shaoul J, Stafford A, Arblaster L, 2004; *Evaluating the operation of PFI in roads and hospitals*, Research Report no.84, Association of Chartered Accountants (ACCA).

EPEC, May 2012; PPP Units and Related Institutional Framework.

Flinders M 2005; **"**The Politics of Public-Private Partnerships" *British Journal of Politics and International Relations,* Vol 7, 215-239.

Greenaway J, Salter B, Hart S 2004; "The Evolution of a 'Meta-Policy'; The Case of the Private Finance Initiative and the Health Sector".

Hamel P.J, march 2010 ; « Un hôpital en partenariat public-privé (PPP) : un pari trop risque».

Hellowell M and Pollock A, 2007; "Private finance, public deficits: a report on the cost of PFI and its impact on health services in England".

Le Taillandier, 2007, Le partenariat public-privé àl 'hôpital: quelques singularités».

Pollock A, Price D, Player S 2007; "An Examination of the UK Treasury's Evidence Base for Cost and Time Overrun Data in UK Value-for-Money Policy and Appraisal*"*.

Private Eye March-April 2004; *An Idiot's Guide to the Private Finance Initiative.*

Treasury 1998**; "**Statement by the Chancellor of the Exchequer on the Economic and Fiscal Strategy Report, in the House of Commons", 11 June 1998 (see Treasury website).

Predicted Thermal Sensation Patterns in Industrial Spaces: a practical study based on ergonomic approaches

Morgado M[1], Talaia M[4], Tavares I[2], Teixeira L[3]

Abstract: Nowadays thermal environment studies are gaining a great importance in workplaces design once individuals spend most of their time in these spaces. In this paper, the predicted pattern of workers thermal sensation was studied with the aim of identifying industrial spaces with critical thermal conditions. On the subject of Ergonomics and Occupational Health this study intends to aware the Safety and Health departments for the most uncomfortable areas in the industrial space and, as a consequence, avoid thermal environment work-related problems, improve performances and work conditions (safety and healthy). Thus, two opposite thermal scenarios were studied, one in an industry affected by hot thermal environment and other in an industry which regards cold thermal environment. In both cases, two thermal indexes were applied: the EsConTer to predict spaces thermal sensation pattern, and PPD index to predict the percentage of individuals dissatisfied in a space. The results suggested EsConTer index as a great thermal sensation predictor which easily identifies critical areas to thermal comfort. In this sense EsConTer index should be further valorised by industry to control thermal environments in order to satisfy most of the workers comfort needs.

Keywords: Occupational ergonomics, Thermal comfort, EsConTer, PPD, Cold thermal environment, hot thermal environment.

1 Introduction

Atmospheric conditions changes largely affect industrial thermal environments. In Portugal, with latitude nearly 40 degrees north and 8 degrees west, it is possible to experience in the same industrial chamber stressful (hot and cold) and comfortable environments. This is partly explained by solar radiation effect, which, due to the inclination of Earth's axis of rotation and solar diurnal cycle intersects a region in different ways.

Yao *et al.* (2009) and Teixeira *et al.* (2014) showed that air temperature inside a building is seriously influenced by outside environment conditions. As a result, the knowledge of the environment outside a building is a requirement while studying its inside environment parameters.

In an inner industrial chamber, regarding the solar diurnal cycle phenomena, a kind of greenhouse effect is created in the course of the day. Thus, warmer thermal environments are expected in the afternoon. A thermal environment is characterized as a set of thermal variables surrounding a person which may influence her directly or/and indirectly, such as air temperature, air velocity, air relative humidity, among others. Therefore, the entire thermal sources in the space, such as thermal machines (free thermal energy) should be taken into consideration when studying an inner thermal environment, once they have a high impact in thermal environment changes, increasing/decreasing inside air temperature when switched on/off.

1 **Mariana Morgado** (marianafmorgado@ua.pt)
2 **Isabel Tavares** (isabel.tavares@ua.pt)
3 **Leonor Teixeira** (lteixeira@ua.pt)
Dept. of Economics, Management and Industrial Engineering.
4 **Mário Talaia** (mart@ua.pt)
CIDTFF / Department of Physics
University of Aveiro.
Campus Universitário de Santiago, 3810-193 Aveiro, Portugal.

Furthermore, according to Cox (2005) a healthy environment can be found when the combination of physical, chemical and biological proprieties do not cause or aggravate none of the workers diseases and ensure high levels of comfort, contributing for workers best performances while they execute their functions/tasks.

Regarding workplaces, where individuals spend most of their time, Ergonomics is the science, associated to occupational health, that tries to adapt workplaces (machines, environment, displays) to workers welfare needs and it is crucial to guarantee workers comfort, safety and as a consequence performance (Teixeira *et al*. 2014; IEA 2014; Wisner 1992; Felix *et al*. 2010).

In this sense, the Safety and Hygiene Department (SHD) should care about the seasons of the year, solar diurnal cycle and free thermal sources in order to improve work conditions by using Ergonomics measures that increase workers' satisfaction, comfort, performance, and assure occupational health by minimizing work related accidents as well as fatigue symptoms.

The study of thermal environment, an Ergonomics research field, became popular since Fanger (1972)'s investigations with the purpose to promote a positive relation between individuals and the thermal environment surrounding. As a matter of fact, this positive relation is a key to workers' performance, health and comfort because individuals spend most of their time in workplaces (Bluyssen *et al*. 2011).

Individuals' thermal environment perception is performed by their thermal sensation which uses human body thermal sensors, such as skin, commanded by hypothalamus and regulated trough human body thermal regulation and behaviour. Thus, thermal sensation does not depend exclusively on thermal factors(such as air temperature and air relative humidity) but also on personal factors which greatly affect individuals' response to thermal environment surrounding, for example, metabolism, age, culture, eating habits and gender. Hence, occupants' thermal sensation arises as the biggest issue in thermal comfort study regarding its subjectivity, depending from person to person.

A comfortable thermal sensation is considered as the satisfaction state of an individual when exposed to a certain thermal environment. Contrarily, a stressful thermal sensation is defined as the dissatisfaction state of an individual when exposed to hot or cold thermal stress environments (ASHRAE 55 2004; Talaia *et al*. 2014). At workplaces, stressful thermal sensations triggered by extreme thermal stress which cause any health or safety problems are considered work-related accidents/diseases. Hot thermal stress is experienced by workers when environmental parameters (e.g: air temperature, radiant temperature, air relative humidity and air velocity), clotting insulation and individual's metabolic rate cause a stepwise internal body temperature increase. Regarding the *Associação Empresarial de Portugal* (AEP 2004), the symptoms caused by hot thermal environments are vasodilatation, perspiration, malaise, dizziness and fainting, breakdowns and under extreme conditions death. According to Lida (2005) cold thermal environments associated to air temperatures below 15°C cause lack of concentration and reduces the ability to think and judge. Additionally, affects muscles control reducing motor capacities such as dexterity and strength and causes shivering.

Accordingly, this paper intends to analyse industrial spaces by understanding their thermal sensation pattern in order to avoid thermal stress scenarios and implement improvement measures (ergonomics) which promote higher performances and safer and healthier work conditions. In order to study workers thermal sensation two thermal indexes were applied, the EsConTer index (Talaia & Simões 2009) and PPD index (Predicted Percentage of Dissatisfied) (ISO 7730 2006).

2 Research Methodology

This study was carried out in two different companies affected by opposite thermal environments: a company of the glass industry (industry 1) affected by hot thermal environments; and a company of the fish processing (industry 2) which regards cold thermal environments and intends to analyse the thermal workplaces conditions following a strict methodology orientated for studying occupants thermal sensation.

The first step to start developing this work was to interpret the layout of companies' shop floor in order to define the spaces' points of observation. Taking into account the layout of the companies studied, 35 points of observation in industry 1 and 25 in industry 2, were defined. In each observation point, data related to air temperature T (ºC), air relative humidity U (%) and wet bulb temperature (ºC), were collected using the measuring instruments 'Testo 435-4' and 'Center 317 – temperature humidity meter'. This set of data was collected during two shifts (in the morning shift and in the afternoon shift), inside and outside the industrial spaces in study. To authenticate the data collected, the measurements given by both instruments were compared to each other as well as to the weather charts and temperature and air relative humidity graphics downloaded from *Instituto Português do Mar e da Atmosfera*- IPMA (https://www.ipma.pt).

Then, the EsConTer and PPD indexes were applied in order to analyze collected data.

EsConTer (Es- colour scale; Con- comfort; Ter- thermal) is a thermal index created by Talaia and Simões (2009), which predicts the thermal sensation of spaces' occupants, valorising the ASHRAE seven-point (ASHRAE 55 2004) in its results. EsConTer index results follows the same scheme as ASHRAE seven-point thermal sensation scale, although represented by a colour scale from '-3' (dark blue colour - thermal sensation: very cold) to '+3' (dark red colour - thermal sensation: very hot), as shown in Figure 1.

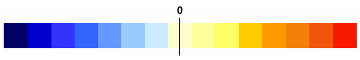


Fig.1
EsConTer thermal sensation colour scale.

The calculation equation of EsConTer index is:

$$\text{EsConTer}=-3.75+0.103(T+T_w) \qquad (2.1)$$

where, T corresponds to air temperature T(°C) and T_w to wet bulb temperature (ºC).

Concerning the Predicted Percentage Dissatisfied (PPD) index, it was created by Fanger (1972) and represents the percentage of individuals dissatisfied exposed to certain thermal conditions. This index valorises the human body thermal balance concepts and because of that reason is known as a PMV (Predicted Mean Vote) auxiliary, regarding the PMV-PPD model (ASHRAE 2001) and represented by:

$$\text{PPD} = 100 - 95e^{\left[-\left(0.03353\text{PMV}^4+0.2179\text{PMV}^2\right)\right]} \qquad (2.2)$$

Regarding an optimal scenario the PPD index should be equal to 0, which means that 100% of the occupants of a thermal environment are satisfied/feeling comfortable. Nevertheless it is impossible to experience such scenario due to occupants' thermal sensation subjectivity (Castilla *et al*. 2011; ISO 7730 2006; Liang & Du 2005).

Once PMV and EsConTer indexes valorize the same information scale (results)(ASHRAE 55 2004), the previous formula was modified, replacing PMV index by EsConTer index and then predict the workers dissatisfaction percentage regarding their the thermal environment surrounding.

$$\text{PPD} = 100 - 95e^{\left[-\left(0.03353\text{EsConTer}^4+0.2179\text{EsConTer}^2\right)\right]} \qquad (2.3)$$

The EsConTer index and PPD index were processed regarding an algorithm created in Matlab which aims to represent spatially both indexes. This algorithm generates colour maps which represent the industries layouts with respect to data collected by the measuring instrument.

3 Results and Discussion

From the algorithm created in MatLab for EsConTer index the colour maps shown in figure 2 were displayed. The axis of the colour maps regard the layout dimensions (meters) and the colour scale on the right side of the maps regard the variable in study, which have generated a colour patterns. Figure 2 represent the workers predicted thermal sensation pattern given by EsConTer index over industry 1 and industry 2, respectively.

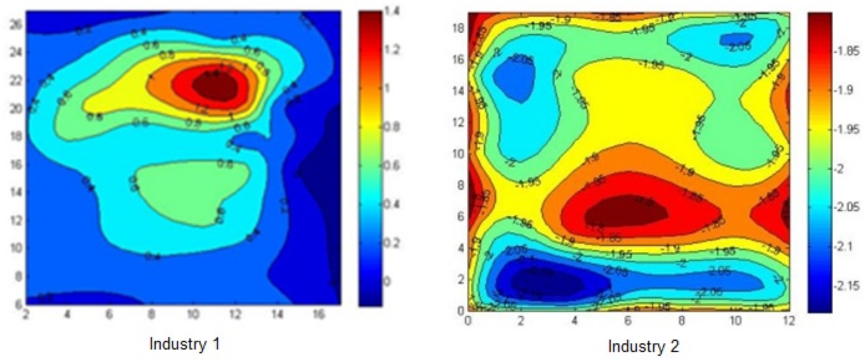


Fig.2
Thermal sensation pattern given by EsConTer
in the two companies studied.

Both pictures have very different thermal lines drawn in colour maps once each colour map represent each industry layout (space, machines, equipment and so on) and because of that reason each industry in study has its own thermal sensation pattern.

As shown in Figure 2 and regarding industry 1, the workers predicted thermal sensation varies between '-0.20' and '1.40', it means among a comfort and slightly warm thermal sensation. The area coloured by darker red, as expected, shows to be the most propitiated area to thermal discomfort. This area represents the most meaningful thermal source in the industry, the oven. Accordingly, the areas around this source seem to be the most critical areas regarding hot thermal stress, with results between '0.40' and '1.20'. The areas with results between '0.2' and '-0.2'are linked to comfort sensations, due to a slight breeze which enters in the chamber through windows and other openings.

Also in Figure 2 but considering industry 2, as expected, the range of the workers predicted thermal sensation is significantly lower, with values between '-1.70' and '-2.20', in other words, slightly cool and cool thermal sensations. The fish discharger to the machine that sorts and classifies the fish is considered the most uncomfortable area, represented by darker blue colour (-2.20). All industry 2 areas suggest cold thermal discomfort, however, taking into consideration that workplaces are positioned in the areas in the ranges between '-2.10' and '-1.95', the authors of this paper recommend a particular attention to those areas work conditions.

In Figure 3 workers thermal sensation patterns given by PPD are shown, in other words, the percentage of individuals dissatisfied with the thermal environment around.

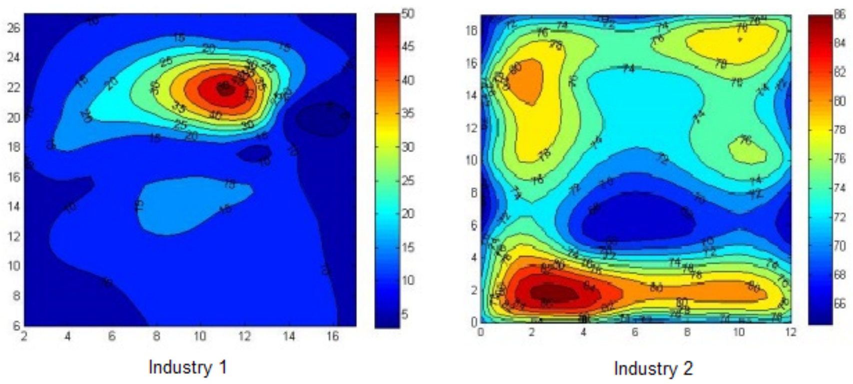


Fig.2
Dissatisfaction sensation pattern given
by PPD in the two companies studied.

Both pictures show that PPD index suggests being in agreement with EsConTer values, regarding thermal lines similarity and EsConTer-PPD relation, associated to PMV-PPD model (ASHRAE 2001).

Regarding Figure 3, in Industry 1, as expected, the highest percentage of dissatisfaction, 50%, is focused in the oven area. The area around this thermal source, previously mentioned as the most propitiated area to thermal discomfort, presents percentages between 10% and 30%.

According to Figure 3 and Industry 2, in agreement with previous results, the workplace which regards fish discharger is also classified by this index as the area which comprises a higher percentage of individuals dissatisfied, between 80% and 82%. The areas represented in the ranges between '-2.10' and '-1.95' in Figure 3 Industry 2, are represented by this image by the interval 72%-78%.

Thus, Industry 2 shows to be, through PPD index, linked to higher percentages of individuals dissatisfied PPD as well as higher (cold) discomfort thermal sensations regarding EsConTer index. Such fact suggests that Industry 2, is affected by more uncomfortable thermal environments and because of that reason is more critical to work- related accidents in a thermal context.

4 Conclusions

The methodology applied in this paper revealed the predicted workers thermal sensation pattern by EsConTer and PPD indexes application in industry 1 and industry 2.

The results showed that both indexes presented, as expected, the critical areas regarding workers thermal discomfort for both industrial contexts, it means, under hot thermal environments and cold thermal environments.

The results graphical representation through colour maps and the very suitable thermal lines drawn in the maps seemed to be a great method to facilitate results analysis over layout of companies' shop floor. Through it was easily identified in the layout, the areas which suggest higher discomfort in both companies.

EsConTer and PPD indexes suggested being in agreement in both industrial contexts taking into consideration PMV-PPD model. In this sense, it is suggested the EsConTer index as a great thermal sensation predictor.

Regarding Industry 1, it is highlighted the area between 10m and 25m on YY axis and between 2m and 15m on xx axis in order to aware the Health and Safety Department for potential thermal discomfort issues, which under extreme scenarios can cause work-related problems. As well and regarding the same purpose, for Industry 2 the areas under thermal lines with values between '-2.20' and '-1.95', concerning EsConTer scale, were underlined.

In a nutshell, EsConTer index and its colour scale were efficient to understand both companies workers thermal sensation pattern and because of that reason both industries thermal sensation patterns were identified. In this sense, EsConTer index should be further valorised by industry to control thermal environments in order to satisfy most of the workers comfort, health safety and performance needs.

5 References

AEP, 2004. Formação PME: Higiene e Segurança no trabalho.

ASHRAE, 2001. Thermal Comfort. In *American Society of Heating, Refrigerating and Air-Conditioning Engineers*. Colorado 80112-5776 USA: Englewood.

ASHRAE 55, 2004. *Thermal environmental conditions for human occupancy*, American Society of Heating, Refregerating and Air-Conditioning Engineers.

Bluyssen, P.M., Aries, M. & van Dommelen, P., 2011. Comfort of workers in office buildings: The European HOPE project. *Building and Environment*, 46(1), pp.280–288.

Castilla, M. et al., 2011. A comparison of thermal comfort predictive control strategies. *Energy and Buildings*, 43(10), pp.2737–2746.

Cox, C., 2005. *Health optimisation protocol for energy-efficient buildings*, Delft, The Netherlands: TNO.

Fanger, P., 1972. *Thermal Comfort* 2nd editio., New York: McGraw-Hill.

Felix, V.B. et al., 2010. Evaluation of thermal comfort in surgical environments using Fanger's method and equivalent temperatures. *Ambiente Construído*, 10, pp.69–78.

IEA, 2014. International Ergonomics Association. *What is Ergonomics- Definition*. Available at: http://www.iea.cc/whats/index.html.

ISO 7730, 2006. Ergonomics of thermal environment- Analytical determination and interpretation of thermal comfort using calculation of PMV and PPD indeces and local thermal comfort criteria.

Liang, J. & Du, R., 2005. Thermal Comfort Control Based on Neutral Network of HVAC Application. In *2005 IEE Conference on Control Applications*. Toronto, Canada.

Lida, I., 2005. *Ergonomia: projeto e produção* 2ªEd. ed., São Paulo: Blucher.

Talaia, M. & Simões, H., 2009. EsConTer: um índice de avaliação de ambiente térmico. In *V Congresso cubano de Meteorologia*. Somet-Cuba, Sociedade de Meteorologia de Cuba, pp. 1612–1626.

Talaia, M., Teixeira, L. & Morgado, M., 2014. Detection of the thermal sensation in a workplace applying a color scale and the PMV index. In P. Arezes et al., eds. *Proceedings of the International Symposium on Occupational Safety and Hygiene*. Guimarães, Portugal: Sociedade Portuguesa de Segurança e Higiene Ocupacional, pp. 438–440.

Teixeira, L., Talaia, M. & Morgado, M., 2014. Evaluation of indoor thermal environment of manufacturing industry. In M. P. Azeres et al., eds. *Occupational Safety and Hygiene II*. London, UK: CRC Press Taylor & Francis group, pp. 553–558.

Wisner, A., 1992. A antropotecnologia. *Estudos Avançados*, 6(16). Available at: http://www.scielo.br/scielo.php?script=sci_arttext&pid=S0103-40141992000300003&lng=pt&nrm=iso&tlng=pt.

Yao, R., Li, B. & Liu, J., 2009. A theoretical adaptive model of thermal comfort – Adaptive Predicted Mean Vote (aPMV). *Building and Environment*, 44(10), pp.2089–2096.

The Cycle of Competitive Intelligence as a tool to strengthen the Cooperation in the Spanish Pharmaceutical Industry

Fernández-Arias M P[1], Hidalgo A[2], Quevedo P[3]

Abstract: It is common to find Competitive Intelligence activities within the high-tech enterprises in particular in the pharmaceutical industry. These companies not only use the process of Competitive Intelligence (CI) to act against competitors, traditional aim of the CI. It is increasingly used to enhance cooperation. The cycle of CI is used both to extract offensive, defensive and cooperative intelligence. The paper presents the results of a sample study of 186 Spanish pharmaceutical companies that were asked about the purpose of cooperation in their CI activities. The results confirm that these are used in the development of business relationships, search for partners, joint research, etc. and that companies bet on these relationships for the future within the CI.

Keywords: Competitive Intelligence; Cycle of Competitive Intelligence; Knowledge Management; Pharmaceutical Sector; Cooperation.

1 Introduction

Competitive intelligence (CI) is one of the most useful tools for strategic analysis because it provides, analyses and distributes information, the knowledge and intelligence throughout the organization. The importance given to CI has been based on offensive and defensive activities implemented in the company. However, some authors have opened another research line that creates tools to make decisions in other directions. Thus, sometimes the company launches its CI to research the environment and competition in particular with the aim to enhance internal improvements or collaborations with companies (e.g. for open innovation lines).

The Medical College Organisation report (OMC) on the pharmaceutical sector (OMC, 2014) some actions are recommended to increase the competitiveness of the sector. The OMC says that it would be reasonable to expect a process of concentration and restructuring that promotes partnerships, joint ventures or mergers to create solvent and innovative pharmaceutical companies. It is noteworthy that the research model of the pharmaceutical industry continues to evolve over the last decade, from the classic pattern of R&D to prototype called R&D (cooperation and / or collaboration).

In this sense, the goal of the study is to analyse the behaviour of pharmaceutical companies integrated in the Farmaindustria association with the possibility to improve the cooperation amongst them by using CI cycle activities. Five phases are suggested in the process of CI generation of to study in each of them the importance of cooperation. The aim is to determine whether cooperation is a purpose in using the CI in a company and, if so, we can expect CI processes to evolve and enhance the relationship networks between companies in the sector.

1 **M. Paula Fernández-Arias** (pfarias@etsisi.upm.es)
2 **Antonio Hidalgo** (ahidalgo@etsii.upm.es)
3 **Pilar Quevedo** (pquevedo@etsisi.upm.es)
Dept. Business Administration. Universidad Politécnica de Madrid.
Campus Sur. Ctra. Valencia, Km 7. 28031 Madrid. Spain

2 Theoretical Considerations

The Strategic and Competitive Intelligence Professionals (SCIP) describes competitive intelligence as "the process of gathering ethically, analysis and disseminate reliable, relevant, specific intelligence, timely, foresighted and actionable, regarding the implications of the business environment the competitors and the organization itself " (SCIP, 1999). However, there are many CI definitions provided by different authors remarking the strategic aspect and the variety of targets with their activities (Cohen, 1997; McGonagle, 1998; Bernhardt, 1994; Hockman, 1999). The information provided to the organization by the CI, properly treated, generates intelligence on which to base strategic planning and decision making and with an impact on organizational performance (Prescot, 1999; Herring, 1999 Ortoll and others, 2010; Antia and Hesford, 2007, Tena and Comai, 2003).

There is currently no data in literature on the number of companies carrying out competitive intelligence as a systemic process. Studies in Spain (Postigo, 2001; Infoact, 2001; Cetisme, 2003; Tena and Comai, 2003) cannot detail the spread of practice in companies due to the heterogeneity of the analysed organizations.

2.1. CI Cicle

Despite the virtual unanimity on the scientific method being the precedent of the intelligence cycle (Vignettes, 2010), we can say that there has never been agreement on the number, name and specific content of the phases comprising it. However, when analysing the mentioned characteristics and phases, we find in literature some common trends in different authors and communities as well as important differences between them. It is noteworthy that the positions are not contradictory but complementary (Bernhardt, 1994; Ortoll et al, 2010; Prescott, 1999; Choo, 2002; Lesca, 2006; Arroyo, 2005; Martinet and Marti, 1995; Escorsa and Maspons, 2001; Ashton and Stacey, 1995).

On this basis, the proposed CI is formed by five phases (Figure 1): Planning of resources and activities; Collection and validation of information; Analysis and dissemination of intelligence; Using the results; and Evaluation of process performance.

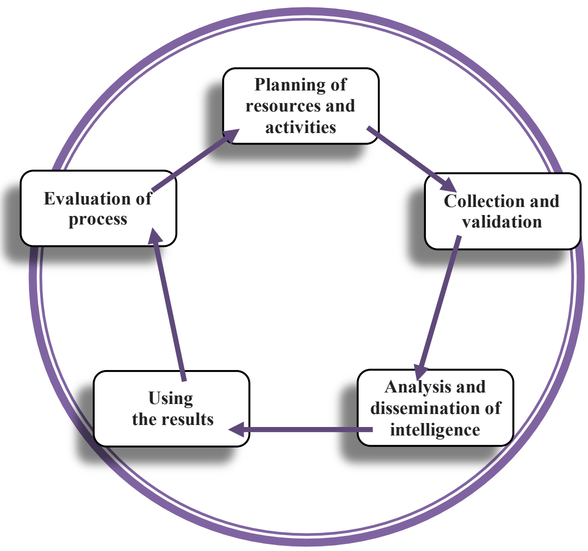


Fig.1
Competitive Intelligence Cycle of five phases.

2.1.1 Planning of resources and activities

Companies need to plan the CI activities bearing in mind the final aim. Sometimes planning needs legal information, tax rate, etc; further information from competitors to know what they are and their activities in the sector. In other occasions the priority is information on market changes, products and processes, etc.

2.1.2 Collection and validation of information

At this stage of CI companies evaluate where and under what conditions gather the necessary information to fulfil their need. Therefore, it is mandatory to know the sources of such information (internal, external, private, public, structured, unstructured, etc.) It is also important to know the existence of controls, validation and verification of sources and information.

2.1.3 Analysis and dissemination of intelligence

At this stage of the process the tools used for data analysis, analysis and control of both the information storage and the needed and generated, are of great importance. The different ways to broadcast or disseminate the intelligence generated in the organization can be carried out by taking into account individuals or specific group departments (marketing, R&D&I, sales network, general management, etc.), users subsidiaries or from within the organization. It is also important to know the kind of dissemination that is carried out from the media's point of view (meetings, intranet or other).

2.1.4 Using the results

At this stage it is important to remark the activities focused to sort out problems and analyse whether the company is aware that the CI has managed to solve risky situations in departments, subsidiaries, projects, etc., and if it is expected that the results of the CI serve to sort out different issues.

2.1.5 Evaluation of process performance

Companies should evaluate the results of the CI cycle to enable process improvement and the necessary adjustments on the planned targets. It is necessary to evaluate activities flexibility, CI user's satisfaction, improvements in the strategic areas of the organization, etc.

2.2 Cooperation and CI

Information has a first magnitude strategic dimension, either as active means of defense -knowing to prevent- or reactive -knowing to attack (Kahn, 2001). However, authors like Ortoll et al (2010) confirm that the impact of social networks on both information sources and the efficiency of the whole process of competitive intelligence is significant. Thus, several authors have explored the importance of social networks in the process of competitive intelligence (Palop and Vicente, 1999; Escorsa and Maspons 2001; Trim, 2004; Michaeli, 2006), especially the importance of networks as sources of information for their members. Some researchers also relate the involvement of network structure on the efficiency of the process of competitive intelligence (Jaworski and Kohli Macinnis, 2002).

This job has planned a model that, just as others (Tena and Comai, 2001; Hussey and Jenster, 1999) takes into account the purpose of the CI in the company. Two objectives are proposed in the activities of the CI cycle. The company may determine that part or the whole of the CI activity pursue the so called competitor intelligence (for defensive and offensive actions) and can determine how much of the CI is intended for a cooperative intelligence. There is wide reference of competitor intelligence in literature due to the CI's own nature, but is harder to find evidence of the second, competitive intelligence for cooperation, partner search, agreements, etc. However, activities taking place in the CI cycle of can be used in a broad spectrum of fundamental issues for the development of a partnership (finance, marketing, R&D&I, etc.)

3 Method

This job applies a descriptive and explanatory method based on a questionnaire addressed to analyse the CI phases, the targets pursued by the company and the impact on some business results. A sample of the sector to the National Business Association of the Pharmaceutical Industry (Farmaindustria) established in Spain was taken to carry out this study. The group has the vast majority of pharmaceutical laboratories (186 members representing 84% of the prescription market and 42% of the holders of marketing authorizations for medicines). The final questionnaire was obtained after several meetings with industry experts (managers, laboratory owners) area doctors of the company organisation and the sub-department of Farmaindustria. After validating the questionnaire it was sent to all partners in Farmaindustria guaranteeing the confidentiality of responses

It is important to remark the existing difficulty to draw information from these companies. You have to go through many different filters in order that pharmaceutical companies consider it innocuous to answer questions on the information they use. In most cases legal departments should approve the questionnaires and this may take weeks.

The five CI phases compiling the theory bases of the different authors were laid out. At each stage of the CI cycle, were asked laboratories for different aspects of the interest in cooperation. With the answers to the questionnaire a descriptive analysis of the use of competitive intelligence for cooperation activities and expectations of pharmaceutical companies was carried out.

4 Results

The results are divided according to the five phases of the CI cycle. In the planning phase 65 % of companies stated that they commonly use CI consulting when cooperation activities are intended. Given the competitive nature of the CI it seems that, as stated by Tena and Comai (2001), the cooperative intelligence has significant purposes for the process.

During the second stage, information collection phase, over 50 % of companies answer that they commonly use sources of information from their partners in research projects which shows the level of relationship that come to have companies so protective towards the security of their information when it comes to investigate with other companies. There are also a high percentage of companies using information from. other subsidiaries of the group at times or on many occasions. Bearing in mind they were asked in the context of competitive intelligence, it is noteworthy that the percentages of consultation between partners and between subsidiaries of the same group are not far.

In the third phase of the CI cycle, companies declared that 40% send relevant information to the project partners, while only 6.4 % do so to their own subsidiaries. It is remarkable the importance given to the management of information between partners when having a common project. It should be noted that they were not asked for a specific project, but for their usual performance in the context of competitive intelligence

The fourth phase, referring to the use of the results, it is noted that 66 % of cases frequently use the reports generated in CI in other companies of the same group, but not a regular system as only 10% do so. In both situations described usage decreases when asked for external companies in the same group. Using CI reports between project partners is also important (4 % of respondents), whilst almost 39% never or almost never used them.

The last phase, performance evaluation, reveals that pharmaceutical companies consider that CI encourages collaboration with other organisations (over 60 % agree or strongly agree with this). Regarding the detection of new financial partners approximately 30% said that the IC was not relevant or had minor importance, but 50% said it was somewhat or very important.

Finally, as to the intention to increase IC resources, willingness was shown to increase resources in the pharmaceutical sector, regardless the current economic situation.

5 Conclusions

Farmaindustria's pharmaceutical companies show that they commonly use other companies' sources of information, they share the knowledge gained in the CI process with project partners and consider that the CI encourages collaboration with other entities. It should be noted that they were not asked for a specific project but by the usual action for cooperation in the framework of CI.

The main conclusion is that most pharmaceutical companies are committed to sharing knowledge generated during the CI process with other companies, subsidiaries or partners despite such tight controls imposed in the sector when it comes to extracting information in their organizations.

In general, there was a willingness to increase the resources invested in CI in the pharmaceutical sector. It seems that if we bet for cooperation, companies will find in the intelligence process a valuable ally to advance towards their research objectives and growth.

6 References

Antia, K.; Hesford, J. (2007) "A process-oriented view of competitive intelligence and its impact on organizational performance". *Journal of Competitive Intelligence and Management*, 4/1:5-33.

Arroyo, S. (2005): *Inteligencia competitiva. Una herramienta clave en la estrategia empresarial*. Ed. Pirámide, Madrid

Ashton, W.; Stacey, G. (1995) Technical intelligence in business: understanding technology threats and opportunities. *Journal of Technology Management*, Vol. 10 nº 1

Bernhardt, D.C. (1994): "I want it fast, factual, actionable: Tailoring competitive intelligence to executives needs", *Lond Range Planning*, vol. 27, núm. 1, pp 12-24

CETISME (2003): "Inteligencia Económica y Tecnológica. Guía para principiantes y profesionales". Dirección General de Investigación. Cetisme. Comunidad de Madrid.

Choo, C.W.(2002): *Information Management for the Intelligent Organization: The art of scanning the environment*. Medford, NJ: Information Today.

Cohen, S. (1997): "Digital Detective", *Training & Development*, vol.51, issue 6, pp.16-19

COMISIÓN EUROPEA (2010): *EU Industrial R&D Investment Scoreboard 2010* en http: //publications.jrc.ec.europa.eu/repository/bitstream/JRC61230/jrc61230.pdf Cited 8/01/15

EFPIA (2011): The Pharmaceutical Industry in Figures. European Federation at Pharmaceutical Industries and Associations. en http://www.efpia.eu/documents/52/61/The-Pharmaceutical-Industry-in-figures-Edition-2011 cited 26/12/14

Escorsa, P.; Maspons, R. (2001) *De la vigilancia tecnológica a la inteligencia competitiva*. Prentice Hall. Madrid.

Herring, J.P. (1999): "Key Intelligence Topics: A Process to Identify and Define Intelligence Needs" *Competitive Intelligence Review*, Vol. 10, Nº2, pp.4-10

Hidalgo-Nuchera, A.; Iglesias-Pradas, S.; Hernández García, A. (2009): "Utilización de las bases de datos de patentes como instrumento de vigilancia tecnológica", *El profesional de la información*, v.18, n. 5, sep-oct, pág. 511-518

Hockman, D (1999): "What is Competitive Intelligence?", *Grand Rapids Business Journal*, vol. 17, issue 33, pp. 3-5.

Hussey, D.; Per V. Jenster, P.V. (1999): Competitor Intelligence: Turning Analysis into Success (Wiley Series in Practical Strategy) Ed. Wiley.

INFOACT (2001): InfoAct- Información para la Acción. European Comisión.

Informe sobre el Sector Farmacéutico (2014). Organización Médica Colegial de España. Consejo General de Colegios Oficiales de Médicos de España.

Jaworski, BJ; Macinnis, D; Kohli, A. (2002): "Generating Competitive Intelligence in Organizations". *Journal of Market-Focused Management*, 2002, 5: 279-307.

Kahn, David.(2001): "An historical theory of intelligence". *Intelligence and national security,* v. 16, n. 3, Autumn, pp. 79-92.

Lesca, N, Caron-Fasan, M. (2006): *Veille anticipative: une autre approche de l'intelligence économique*. Paris: Hermes science publications.

LIBRO VERDE DE LA INNOVACIÓN (1995) Comisión Europea.

Martinet, B.; Marti, Y-M. (1995) L´intelligence économique. Les yeux et les oreilles de l´entreprise. Les Editions d´Organisation, Paris.

McGonagle, J. (1998): *Protecting Your Company Against Competitive Intelligence in the Digital Age.* New Jersey.

Memoria Anual (2013) FARMAINDUSTRIA. Consultado el 16/1/2015

Michaeli, R. (2006): *Competitive intelligence: strategische Wettbewerbsvorteile erzielen durch systematische Konkurrenz-, Markt-und Technologieanalysen.* Berlin, Heidelberg: Springer, 2006.

Ortoll Espinet, E.; López Borrull, A. ; Canals A.; García Alsina, M.; Cobarsi Moraes,J. (2010): "El papel del capital social en la inteligencia competitiva". *Revista General de Información y Documentación.* Vol. 20, pp. 213-223

Palop, F.; Vicente, J.M. (1999): Vigilancia Tecnológica e inteligencia Competitiva. Su potencial para la Empresa Española. Fundación Cotec. en: http://www.navactiva.com/web/ es/descargas/pdf/avtec/potencial_vtec.pdf

Postigo, J. (2001): "La inteligencia competitiva en España: una encuesta sobre su utilización por parte de las empresas exportadoras". *El profesional de la información*, Vol.10, Nº 10, oct., pp.4-11

Prescott, J.E. (1999): "The Evolution of Competitive Intelligence: designing a process for action". *Proposal Management,* Spring*, pp.*37-52.

SOCIETY OF COMPETITIVE INTELLIGENCE PROFESSIONALS (SCIP) (1999): "List of the CI cycle as published". en http://www.scip.org. cited 10/11/2005 cited 10/11/2005

Tena, J.; Comai, A. (2001): "Los propósitos de la inteligencia en la empresa: competidora, cooperativa, neutral e individual". El profesional de la información, Vol. 10, Nº 5, pp. 4-10.

Tena, J.; Comai, A. (2003): "La inteligencia competitiva en la planificación estratégica y financiera" Harvard Deusto Finanzas y Contabilidad, nº 56, pp. 30-37

Trim, P. (2004): "The strategic corporate intelligence and transformational marketing model". *Marketing Intelligence & Planning,* 22/2: 240-256.

Vignettes, M. (2010). El Ciclo de Inteligencia: naturaleza y alternativas. Inteligencia y Seguridad, 8, 113-136.

Kalman Filter application in the correction of forecasts by floods HYMOD model

Pereira Neto AV[1]

Abstract: Floods are the most devastating natural disasters, striking numerous regions in the world each year, causing a huge loss in the industry. This is a consequence of the increasing frequency of heavy rain and changes in upstream land-use. In general, less developed countries are the most vulnerable to floods, causing damages that significantly affect the industry and the national GDP**.** Rainfall-runoff models play a very important role in flood forecasting. However, these models contain large uncertainties caused by errors in both the model itself and the input data. The objective of this paper is to present data assimilation techniques to reduce these uncertainties and to analyze the deviations between flood observations and forecasts from HYMOD model. A preliminary study revealed that there are systematic errors in the flood forecasts, which vary with the day, throughout the year and from station to station. The methodology consists in applying Kalman Filter to correct the flood forecasts. When compared to other statistical methods, the Kalman Filter approach is more efficient since it benefits from updating the regression coefficients recursively, allowing the filter to adapt to the frequent changes in the numerical weather prediction model, and to different weather conditions. The Kalman Filter has also the advantage of not requiring large database for its design and application. As a result, the Kalman Filter model presented in this work has proved to be a good alternative for operational implementation, showing improvements in the root mean square errors of the order of 30% to 45%. The applicability is self-evident, since this is an important tool to improve accuracy in forecasting, so reducing vulnerabilities, flood risk, and forming an important ingredient of the strategy to reduce loss in the industry, thereby contributing to national sustainable development.

Keywords: Rainfall-runoff models, HYMOD model, Kalman Filter.

1 Introduction

A flood forecasting comprises an important element of integrated water resources management. The benefits of river forecasts for power generation, navigation, irrigated agriculture and the operation of industries make implementation of such a system more cost effective and sustainable. Rigorous analysis would call for statistical analysis of flood peaks and the calculation of the present value of costs and benefits of flood forecasting and warning. The benefits of flood forecasting, warning and response for the industry are virtually self-evident. Hydrological models are defined by parameters and states, parameters being the physical description and time-invariant characteristics usually superficial and sub-surface and states being the streams and storages of water and energy that are propagated in time for physical models. In hydrological modeling, the exact prediction of significant hydrological variables is very complex due to various sources of uncertainties like persistent errors in initial states, calibration of the model and the structure of the model. The structure of hydrological models creates uncertainty, because a model cannot accurately model the physics of the basin. In addition to uncertainties in quantitative prediction of hydrological model, the observation of these quantities is also difficult. Problems due to errors in the sensors, complex topography, among others, create uncertainties in the hydrological observation. Due to the un-certainty of the forecast and observational data, hydrological surveys are focused on statistical combination of forecasts and observations in a framework that com-bines the knowledge of both datasets to produce a unique dataset, which is more and quantifies the uncertainty of prediction. This process is

1 **Antonio V P Neto** (cristone42@gmail.com)
Programa de Pós graduação em Tecnologia Ambiental e Recursos Hídricos,
Universidade de Brasília (UNB), Campus Univ. Darcy Ribeiro,
Brasília, DF, Brasil, 70910-900.

called data assimilation, forecasting in real time or updating, whose basic objective is to characterize the State of the system in the future from the knowledge of the initial state. The success of data assimilation depends directly on the prediction of the model, which depends on the estimated parameter. During the past two decades, much effort has been placed on estimating correctly the model parameters (calibration) and improving hydrologic forecast. The increase in computing power makes valid the computational routine of many models that are candidates for such correction. So far, none of the existing methods of update is considered better than others for every hydro meteorological situation.

2 Objective

The objective of this paper is to present data assimilation techniques to reduce un-certainties, to analyze the deviations between flood observations and forecasts from HYMOD model. Hypothesis: The use of Kalman filter in daily average flows update using the hydrological model HYMOD can reduce uncertainties.

3 Method

The methodology consists in applying Kalman Filter to correct the flood forecasts. The nonlinear rain-flow rate hydrological model used for this study is the HYMOD daily simulation, which is relatively simple and correlates the average precipitation and potential evapotranspiration, to a basin, with the flow. The Kalman filter consists of a prediction and correction scheme. Initially the prediction is made with the dynamic model of State. Afterwards the correction uses an observation model to minimize the covariance error.

4 Results

Initially the assimilation of data flow has been evaluated. The results of flow simulations using or not data assimilation were compared with observations on pluvial stations. On average, the RMSE values increase, causing the simulated flow rates get too closer to those observed in the posts used for assimilation.

5 Conclusion

The development and evaluation of a data assimilation scheme of flows in a hydrological model rain flow is presented. In General, a good performance of the Kalman Filter technique for data assimilation is observed. In case of assimilation of flows, the model estimates improve in the stations used in the assimilation, as well as in validation points, showing possibility of transferring information for non-monitored sites.

6 References

Abebe, A. J.; Price, R. K. 2003. Managing uncertainty in hydrological models using comple-mentary models. *Hydrological Sciences*, v. 48, n. 5, p. 679-692.

Broersen, P. M. T.; Weerts., 2005. A. H. Automatic error correction of rainfall–runoff models in flood forecasting systems. In: PROCEEDINGS IEEE/IMTC CONFERENCE, 2005, Ottawa, Canada. *Proceedings...* Ottawa, Canada. p. 1531-1536.

Collischonn, W.; Haas, R.; Andreolli, I.; Tucci., 2005. C. E. M. Forecasting River Uruguay flow using rainfall forecasts from a regional weather-prediction model. *Journal of Hydrology*, Am-sterdan, v. 305, n. 1-4, p. 87-98.

Divac, D.; Milivojević, N.; Grujović, N.; Stojanović, B.; Simić, Z., 2009. A Procedure for State Updating of SWAT-Based Distributed Hydrological Model for Operational Runoff Fore-casting. *Journal of the Serbian Society for Computational Mechanics*, v. 3, n. 1, p. 298-326.

Gomes, J.; Mine, M. R. M.., 1998. Estimativa de parâmetros de modelos hidrológicos utilizando o filtro de Kalman. *Revista Brasileira de Recursos Hídricos*, Porto Alegre, v. 3, n. 2, p. 67-86.

Goswami, M.; O'connor, K. M.; Bhattarai, K. P.; Shamseldin, 2005. A. Y. Assessing the per-formance of eight real-time updating models and procedures for Brosna River. *Hydro-logy and Earth System Sciences*, v. 9, n. 4, p. 394-411.

Kafle, T. P.; Hazarika, M. K.; Samarakoon, L. Development of flood forecasting models for the Bagmati basin in Nepal. In:, 28., 2007, Kuala Lumpur, Malaysia. *Proceedings*... [S.l.]: Asian Conference on Remote Sensing 2007.

Kahl, B.; Nachtnebel, H. B. Online updating procedures for a real-time hydrological forecasting system. In: CONFERENCE OF THE DANUBIAN COUNTRIES, 24., 2008, Bled, Slovenia. *Proceedings*... Bled Slovenia: IOP Publishing, 2008. 8 p.

Madsen, H.; Skotner, C , 2005. Adaptive state updating in real-time river flow forecasting - A combined filtering and error forecasting procedure. *Journal of Hydrology*, Amsterdan, v. 308, n. 1-4, p. 302-312.

Meller, A.; Bravo, J.M. & Collischonn, W. 2012. "Assimilação de dados de vazão na previsão de cheias em tempo-real com o modelo hidrológico MGB-IPH". Revista Brasileira de Recursos Hídricos: RBRH.

Moore, R. J., 2007. The PDM rainfall-runoff model. *Hydrology and Earth System Sciences*, v. 11, n. 1, p. 483-499.

Nash, J. E. and Sutcliffe, J. V., 1970. River flow forecasting through conceptual models, Part I - A discussion of principles, J. Hydrol., V.10, 282–290.

Paz, A. R.; Collischonn, W.; Tucci, C. E. M.; Clarke, R. T.; Allasia, D. Data Assimilation in a large-scale distributed hydrological model for medium-range flow forecasts. In: PROCEEDINGS OF SYMPOSIUM HS2004 AT IUGG2007, 2007, Perugia. Perugia: IAHS, 2007. p. 471-478. (IAHS Publication, 313).

Technological and Industrial Mapping of Pharmaceutical Sector: a Comparison with Emerging Countries

Akkari A[1], Munhoz I, Santos N, Santos R, Santos F, Knupp J

Abstract: The main aim of this work was to perform a technological and industrial mapping of the pharmaceutical sector, based on a survey from international patent database (WIPO and Derwent). Among the results, while the dominant position in the market belongs to the European and U.S. pharmaceutical industries, there is an increasing importance of emerging countries, specially China, but also India and, even in a smaller magnitude, of Brazil, bringing hope to the technological and scientific dissemination and increased competition against pharmaceutical multinationals.

Keywords: Patents; Pharmaceutical Industry; Emerging Countries.

1 Introduction

The main driver force in pharmaceutical industry growth is innovation and the protection of new products /processes is a stimulus factor for high investments in R&D, which involves costly activities, low success rate and requiring a long time. Moreover, patent ensures the exclusive right to temporary marketing of pharmaceuticals, yielding extraordinary profits and competitive advantages. There is consensus that future growth in the pharma industry will mainly come from emerging markets, specially China, India and Brazil. From this perspective, the monitoring of patent database becomes an auxiliary process for decision-making and allow the analysis of the technological innovation of a region, including emerging countries and to compare them with European and U.S. companies.

2 Objectives

The aim of this work was to perform a technological and industrial mapping of the pharmaceutical sector, based on a survey from international patent database.

3 Methods

This study based on the information obtained from the World Intellectual Property Organization (WIPO) and the DerwentInnovations Index, from 1996 to 2012. Numerical analysis for scenarios prediction was carried out, using least squares method and an algorithm were implemented in MATLAB.

1 **Alessandra Cristina Santos Akkari** (alessandra.akkari@ufabc.edu.br)
Centro de Engenharia, Modelagem e Ciências Sociais Aplicadas,
Universidade Federal do ABC,
Av. dos Estados 5001, 09210-580, Santo André, SP, Brasil.

4 Results

Almost all patents originated in the world for pharma products/processes is concentrated in Europe (40.43%) and U.S. (31.01%), followed by China (8.59%) and Japan (8.05%), according to WIPO. The index of Brazil (0.07%) is lower than that observed in India (0.67%) and almost equal to South Africa. The prediction until 2016 showed a decreasing (-17%) in U.S. patents. China (22%) and Brazil (16%) demonstrate get a higher growth in the number of patents, followed by India (12%) and Europe (10%). Furthermore, prediction indicated an increasing trend in the number of granted pharmaceutical patents in Brazil (90%), reflecting the large foreign interest in emerging markets. Derwent data showed that Novartis, AstraZeneca, Boehringer, and Bayer, in this order, are the companies with more pharma patents in the world, followed by the University of California and La Roche. In seventh place, there is a Chinese research institute (Beijing Guanwuzhou Bio. Sci. Inst.), indicating the prominent position that China has gained in drug industry.

5 Conclusion

First, it can be seen that the data of the Derwent corroborated and complemented the survey in this paper based on WIPO, showing that the pharmaceutical sector is still dominated by European and U.S. industries, which hold a large part of patents, enabling the maintenance of its competitive advantages and demonstrating its high innovation capacity. However, until 2016 the forecasts showed a decrease in the number of U.S. patents in the pharma industry, while it is expected a stronger growth in the number of protections of China and Brazil, suggesting that Chinese pharma patent indices tend to equate with the numbers from the U.S. and Europe. This fact indicates the beginning of a possible technological and scientific dissemination and an increase in pharmaceutical sector competition due to the advancement of emerging countries, mainly China.

References

Bunnage, ME (2011) Getting pharmaceutical R&D back on target. Nature Chemical Biology, doi: 10.1038/nchembio.581.

Masiakowski P, Wang S (2013) Integration of software tools in patent analysis. World Patent Information, doi:10.1016/j.wpi.2012.12.010.

Understanding the human role in Cyber-Physical Systems

Frazzon E[1], **Hurtado P**[2]

Abstract: Recently the concept of Cyber-Physical Systems (CPS) and its applications have become a popular research topic. By speeding up the interaction between the flow of material and information, those systems are capable of dealing with dynamic environments and perturbations. They are useful in many fields, such as: production and transport scheduling and control; aeronautic industry; medical training, among others. With the evolution of technologies and related researches, a future with a more intense human-machine interaction is imminent. This research attempts to understand the different roles that a human decision maker might play in relation to a CPS. Thus, a literature review was developed, followed by the proposition of a classification for the human-CPS interaction.

Keywords: Cyber-Physical Systems (CPS); Human-CPS interaction.

1 Introduction

The Cyber-Physical System (CPS) concept refers to a physical system that has embedded technologies for data capture; information management, processing, communication, analysis and storage. In order to deal with uncertainty a decision maker agent requires skills as flexible thinking, perception, and intuitive control, to use properly the information available. Those skills will be hardly reached by machines. Therefore, the human presence is mandatory in CPS (Berglund and Karltun, 2007; Schirner et al., 2013). A classification of the roles played by the human might guide to a wider comprehension of the system as a whole.

2 Objectives

This research aims the understanding of the role of the human in the CPS. In this way, is necessary to determinate and characterize the human aspects that are involved in the application of CPS.

3 Methods

In order to accomplish the objective, a literature review was implemented as follows: (i) research in science direct using key words related to each research axis and the conjunction of them; (ii) filter by title; (iii) analysis of abstracts; and (iv) definition of a literature portfolio (50 Papers).

1 **Enzo Morosini Frazzon** (enzo.frazzon@ufsc.br)
2 **Paula Andrea Hurtado** (paula.hurtado@grad.ufsc.br)
Industrial and Systems engineering Department,
Federal University of Santa Catarina, Florianópolis,
SC, 88.040-001, Brazil, (Tel: +55-48-3721-7076).

4 Results

In the literature review were found: 55.588 papers for CPS; 15.193 papers for decision making levels and 2.283 papers for human competences. Using a combination of keywords in the three axes, 777 papers were selected. It was possible to identify that the social component has an important responsibility in CPS performance (Inagaki and Sheridan, 2012; Li et al., 2011). In addition, three important levels regarding decision making related to CPS were identified: strategic, tactical and operational level (Schmidt and Wilhelm, 2000).

5 Conclusion

There are three domains related to the research on human behaviour in CPS: the individual, organisational and contextual (Frazzon et al., 2013).

In relation to the activities realized by humans in a CPS, two distinguished kinds of relation emerge: (i) the human actor as one that only interacts with the system, i.e. a strategic or tactical level relation that does not have a direct interaction with the core of the CPS, but a high-level of decision making is required; (ii) the human actor as part of system operational level were the human role is influenced and bounded by task expertise.

6 References

Berglund M and Karltun J (2007) Human, technological and organizational aspects influencing the production scheduling process. International Journal of Production Economics, 110(1):160-174.

Frazzon EM, Hartmann J, Makuschewitz T, & Scholz-Reiter B (2013). Towards socio-cyber-physical systems in production networks. Procedia CIRP,7, 49-54.

Li X, Yu X, Wagh A, & Qiao C (2011). Human factors-aware service scheduling in vehicular cyber-physical systems. In: INFOCOM, 2011 Proceedings IEEE (pp. 2174-2182). IEEE.

Inagaki T and Sheridan TB (2012) Authority and responsibility in human–machine systems: probability theoretic validation of machine-initiated trading of authority. Cognition, technology & work, 14(1):29-37.

Schirner G, Erdogmus D, Chowdhury K and Padir T (2013). The future of human-in-the-loop cyber-physical systems. Computer, (1), 36-45.

Schmidt G and Wilhelm WE (2000). Strategic, tactical and operational decisions in multi-national logistics networks: a review and discussion of modelling issues. International Journal of Production Research, 38(7), 1501-1523.

EDUCATION

Problem-Based Learning Method use in the civil construction organizational environment

Martins V[1], Neves R[2], Bastos L[1], Melo A[1], Nunes D[1]

Abstract: The changes in the civil construction context, and consequently the production management of constructions, require a different profile engineer, which demands more refined skills from those professionals, such as innovation, focus on customer, production planning and control, quality management systems knowledge, sustainability and a humanist vision. The main objective of this paper is to show the efficiency of using the Problem Based Learning methodology adapted to the organizational context. The research strategy adopted was the Research-Action, in which the research team aimed the improvement of the way professionals understand and solve problems. The results involved the development of abilities related to the organizational context, as well as the individual, collective and organizational learning skills, highlighting problems and possible solutions for the company. Through increasing these skills, it was possible to stimulate a humanistic and sustainable vision, customer-focused, and a better quality management system. In addition, problems in this system were presented, which stated the necessity of creating an environment which enables the exchange of information among its sectors.

Keywords: Problem-Based Learning method; Learning Skills; Organizational management; Construction Environment.

1 Introduction

The emphasis in a wider work and academic background and the increase practical experience possibilities throughout higher education are evaluated as options to satisfy the demand of a multiprofessional profile and provide the personal maturity and the professional identity needed to act in situations of unpredictability, in which companies can be presented. In addition, the investment in developing abilities for management become indispensable for companies that intend to maintain their competitiveness in the current marketplace. Therefore, this paper aims to show the efficiency in using the Problem-Based Learning (PBL) methodology in the civil construction organizational environment. The research was proposed and performed in a company which went through the process of reallocating the roles of its civil engineers that also managed the construction sites. The use of the suggested method was used in order to increment the development of the management skills of the workers.

1 **Vitor Martins** (vitor.martins @uepa.br)
Leonardo Bastos (lslbastos@hotmail.com)
André Melo (acsmelo@yahoo.com.br)
Denilson Nunes (denilson.lucena@gmail.com)
Departament of Engineering. State University of Pará.
Trav. Dr. Eneas Pinheiro 2626, Belém, Pará, Brazil.

2 **Renato Neves** (neves@ufpa.br)
Institute of Technology Federal University of Pará.
Av. Augusto Corrêa S/N, Belém, Pará, Brazil.

2 Literature Research

2.1 Problem-Based Learning in the Organizational Context

Mamede et al. (2001) conceptualize PBL as an educational strategy and a philosophy approach to the work background, which conceives a learning process in which self-directed students can build their knowledge actively. From problems and collaborative working, students learn in a contextual manner, they set their own learning objectives and acquire knowledge with a personal meaning following the inner disposal of each one. Kalatziz (2008) says PBL, being an instructional model itself, presents definitions, attributes and objectives that make it a method. The same author states that PBL uses real-life problems to stimulate the development of critical thinking, problem-solving abilities and the learning of concepts presented in syllabus.

The PBL is a method that emphasizes the development of essential abilities such as the effective problem (BARROWS; TAMBLYN, 1976; WOODS, 1996; ENGEL, 1997) and the self-directed study. The approach centered on the student also increases the abilities of listening, summarize information and teach others. (BARROWS; TAMBLYN, 1976). Teaching classmates or workmates is an ability required by many professionals, jointly to the capacity of working as a part of the team. (BARROWS; TAMBLYN, 1976; WOODS, 1996).

The adapted model studied in this paper was developed by Neves (2006) in its Doctorate thesis, and states that the learning process initiates with the sharing of the individual knowledge. Later, this process becomes social, shared to the group, and generates both individual and collective learning. After the group comprehends and seeks the solution of the problem, the results are discussed one more time with the company staff, which motivates the final solution proposition to present rules and procedures that guarantee good conditions for the organizational learning process.

The use of the PBL method adapted to the organizational context is justified by the will of the company to invest in the qualification of their engineers that manage construction sites in the context of their own workplace, sharing experiences among each other, in a way they can discuss the means of performing activities. Thus, they are able to identify the concepts studied and relate then to the company's reality. The Fig.1 shows the adapted model's structure.

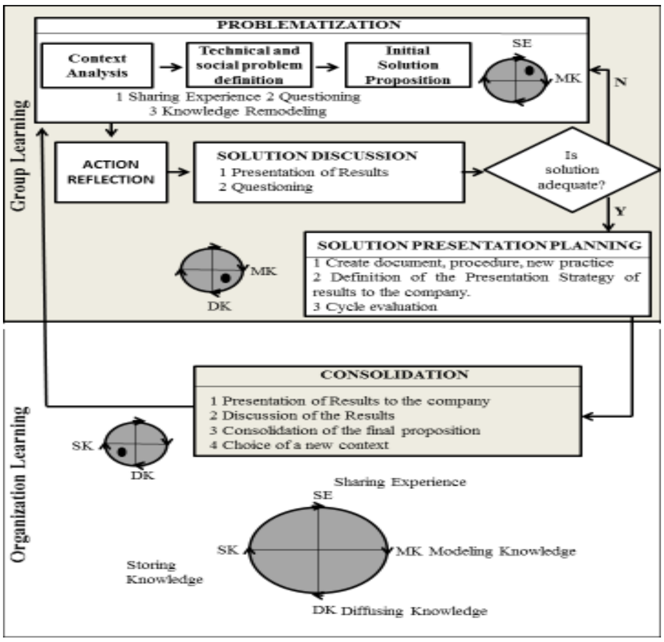


Fig.1
Capacitation Model (NEVES, 2006).

3 Research Methodology

The strategy of Research-Action was used as it was developed with the interest in changing and participation of everyone involved. Thiollent (2007) states that for a research to be marked as Research-Action it is essential the implementation of an action by the people involved in the problem. Additionally, it is necessary the action to not be trivial, which means an action that needs to be investigated scientifically, in order to be elaborated and performed. In the Research-Action, the researchers fill an active role of adjusting the problems found, in the accompaniment and in the in the evaluation of the actions generated from the problems.

The research process was performed in a participative way which involved the researcher and the engineers of the site. Facing the context of a problem, the engineers developed an action, which was followed by a reflection and the planning of new actions for the next cycle. The research assumed the role of an enabler who provided orientations about the didactic resources aiming for the theoretical restructuration and the seeking for knowledge by the engineers that participated in this research through their own initiative.

The researcher was also responsible for organizing the group dynamics and the meeting topics. Besides, throughout the meetings, he presented a questioning attitude, asking constantly the engineers about the reasons for the problems listed in each cycle.

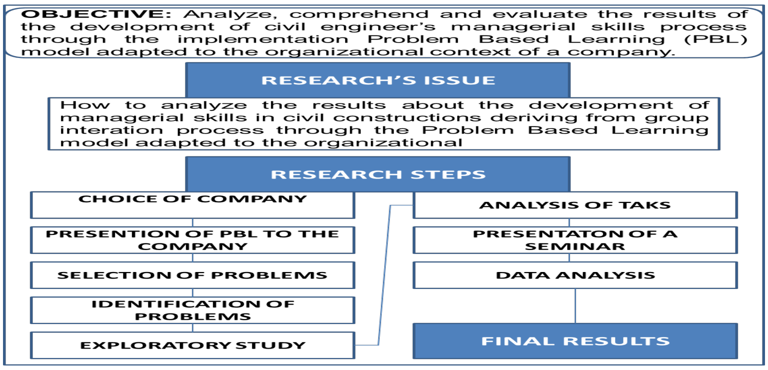


Fig.2
Research Outline.

The data analysis process began with the reading of the meeting notes. Periods from those notes, interviews with members and documents from company such as organogram, procedures and indicators were used in order to intersect the evidences. The group meeting story was told in a sequential and chronological way, presenting factors that were considered important by the research with the objective of analyzing the organizational learning process, the development of the managerial ability and aspects of the company's organizational management.

In order to facilitate the data analysis, the following constructs were defined: analysis of the organizational context; analysis of the individual learning, analysis of the collective learning, analysis of the organizational learning; and analysis of the company's management system. These definitions were bases in the literature review and the source of evidences were the meeting notes, the interviews with directors, employees and the engineers (managers of the sites), the in loco observation, the researcher's personal notes and the analysis of company's internal documents. The evidences were elaborated during the process of transcription the meetings and the reading of them, and aimed to identify expressions and words used by the engineers as they spoke in the meeting. This was important since it assisted the researcher in the analysis of the interviews.

4 Results Analysis

In order to identify the managerial abilities, the personal characteristics and specific work abilities were considered, as well as additional information collected in the interviews to engineers and their employees. The Fig. 3 presents the mean of the results for the engineers that managed the construction sites. It can be seen that the managers (ME) view their own expertise differently from the opinions of their team (OTHERS), which was more critical over the abilities of the engineers.

It observes that the great divergences in the results are presented in the abilities Leadership, Teamwork, Decision Making, and Critical Analysis, hence they need more attention in their development process. Throughout the exploratory study through the researcher's in loco perception in the meetings, it was identified that engineers presented high technical capacity, however the difficulties in managing people were evident.

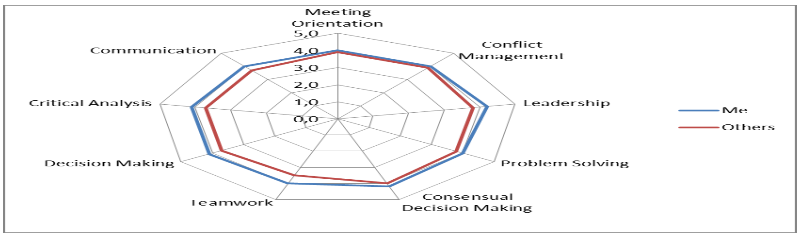


Fig.3
Chart of Evaluation of the Management Abilities – Mean.

4.1 Cycle #1 – Construction Sites Planning and Control

The engineers spoke about the lack of meeting with the sites' administration in order to define the execution strategies of the services. The researcher observed that only four engineers presented a more active attitude as he expressed his understanding and opinion about the topic discussed. According to the answers, the research asked for a flowchart of the planning system for the next meeting, aiming to identify who are the people involved and the components of this process in the company. Thus, the meeting ended with the responsibilities set for each one for the next session and the definitions of data, place, and time of it. It was also deciced that a reference term about planning would be sent to the engineers so they could read it and assist them as a theoretical basis about this topic.

In the second meeting, nine engineers participated and it began by presenting the flowchart of the company's main current planning stages. At this moment, the researcher could identify and analyze all the stages and members involved in the planning process and he asked to the engineers: "In your opinion, what are the relevant indicators in a planning system?"; "Why do you think the planning is not going well?"

In a general way, the engineers alleged they believe the planning should be presented in a more objective manner.

[...] Some tools that don't increase value to the process must be eliminated from the planning [...] there is a large variety of indicators today that has no use for many services [...]. (Engineer 1).

It was identified certain discomfort by the engineers on the tools used in the planning process. Most of them did not know how to transform the indicators into relevant information for a better management.

Next, the researcher asked for who had read the reference term about planning that was provided in the first meeting.

[...] I didn't find the time to do the reading (Engineer 1).

[...] I started reading it, but it's large, it has many pages [...]. (Engineer 3).

[...] The term should be more objective, it's too "academic". (Engineer 7).

The third meeting was attended by only five engineers, i.e. only 50% of all group members, which showed certain disinterest/resistance in the PBL program. The conference began with the presentation of the reference term by the group's coordinator, who discussed concepts, definitions and tools for long term (strategic level), medium term (tactical level) and short term (operational level) planning.

At the end of the presentation, the coordinator asked the group how to introduce the reference term into the current flowchart of the company. Then, it was initiated a discussion about the relevant tools and indicators for the company's planning process. Some practices were cited such as service order programming (SO), Service Execution Planning (SEP), evaluation indicators of constructors and the introduction of the commitment meeting practice.

This meeting ended by defining the date, time and place of the next session and the group took the responsibility of search and bring schedule models to be used in the commitment meeting practice.

The fourth meeting was attended by eight engineers. The group coordinator initiated this session by asking why planning is important and if the group was in the percentage categories of engineers that believe or do not believe in planning.

[...] It is important to give us a horizon [...] without planning, we would not be able to know if we're late or not site's course. (Engineer 4).

Schedule models were also presented by the group and it was decided the creation of a procedure to attend the planning's needs expressed by each participant, in order to minimize the difficulties in following the company's current planning. The conference ended by defining the data, place and time of the next session as well as the member's deliberation for the next meeting. The researcher and the coordinator were in charge of sending a procedure model for planning and the group should search and define the better practices to be inserted in the procedure.

The fifth meeting was attended by nine engineers and aimed the elaboration of the planning procedure, with the participation of all members jointly. The coordinator began by asking if someone read the procedure sent and if there was any insertion/modification in it.

[...] I did some observations and took notes, but I haven't modified anything. I brought it here so we can do it along our own procedure (Engineer 1).

The meeting advanced with the process of elaboration of the procedure, in which the group members presented their suggestions and understandings about each item to be included, modified or excluded from the procedure. The researcher noticed that some engineers did not opine in the generation of the document. The procedure intended to establish the planning stages and the control of the construction site's physical advance. The meeting ended with the procedure written and formatted, however it was necessary to attach tools that would follow what was described in the procedure. This was a task to be presented in the next session. Each engineer was in charge of bringing tools that attended to the necessity of what was in the procedure.

Finally, the sixth meeting was attended by eight engineers. The group coordinator was absent, and then the meeting was conducted by the researcher. This session aimed to complete the planning procedure by attaching tools that would attend the defined guidelines. This meeting began with the group questioning about the advance of the program, its real objectives and where it would like to reach through its implementation in the company.

[...] I confess that I didn't identify the company in the procedure we wrote in the last meeting (Engineer 6).

[...] I think you must agree that we're already in the sixth meeting and still couldn't leave one point, the planning. [...] We need to see a goal that we still don't have today. (Engineer 1).

It was possible to notice that the group still had not understood the real meaning of the PBL program implementation. The company's high administration, when asked, would have informed that the objective would be the raise of the site's physical advance from 1.5% to 3% per month, which caused certain misunderstanding about what was being done related to objectives defined by the company's administration.

[...] We are waiting for something that isn't coming. It starts to discourage, and frustrate, as we have no expectation of an immediate feedback. (Engineer 3).

[...] If this objective was set in the first meeting, which was to increase the productivity, I think that the production/execution item would never be sixth in priority. Certainly, it would have to be among the first three. [...]. (Engineer 1).

The meeting finished with the definition of a new set of topics to be analyzed, which were: Projects, HR & Supplies, Production/Execution, Costs and safety. It was defined that planning was a topic related to all the others, then, the next meeting would discuss about Projects. The procedure that was being elaborated about planning was not completed.

5 Conclusion

The group presented issues in acting towards to the problems. Those issues were always in other sectors of the company. The managers had obstacles not resist to admit the responsibilities for the problems (afraid of showing weaknesses), what strained the decision making and, consequently, compromised the development process of the managerial skills and the group learning process. They had difficulties in evolving the self-knowledge, reflecting on their actions and experience.

The company must create an environment that enables the exchange of information among its sectors, aiming the engagement of the people involved. It is also necessary to be certified that every member is aware about the purpose of their work and how it contributes to the organization to achieve their goals. Recognize and appreciate the work performed by the collaborators is also valid. It is highlighted that clear feedbacks provide the development of a good work, however to do this, people need clear and in time information. It is not necessary only to evaluate the behavior or the results is necessary, but also to make people notice their importance to the company's success.

Regarding to the model, it is important to state that the discussed problem has to be aligned to the company's objectives and to the interests of the group (collective); preferably real and happening at the moment (related to the daily routine); and associated to the managerial process; relevant to the professional exercise. In addition, the decision about the set of actions to be performed for the solution and implementation must be the responsibility of the production manager; and also consider the human, social and technical aspects. Then, the problem stimulates the individual, group and organizational learning. It is necessary that all group members understand the need of changes and improvements.

6 References

BARROWS, H. S.; TAMBLYN, R. An Evaluation of Problem-Based Learning in Small Groups Using a Simulated Patient. Journal of Medical Education, v. 51, p. 52-54, 1976Slifka MK, Whitton JL (2000) Clinical implications of dysregulated cytokine production. J Mol Med, doi: 10.1007/s001090000086

ENGEL, C. E. Not Just a Method But a Way of Learning. In: BOUD, D.; FELETTI, G. I. The Challenge of Problem-Based Learning. London: Kogan Page, 1997

KALATZIS, A. C. Aprendizagem Baseada em Problemas em Uma Plataforma de Ensino a Distância Com o Apoio dos Estilos de Aprendizagem: uma análise do aproveitamento dos estudantes de engenharia. São Carlos, 2008. Dissertação (Mestrado em Engenharia de Produção) – Escola de Engenharia, Universidade Federal de São Carlos, São Carlos, 2008.

MAMEDE, S. et al. Aprendizagem Baseada em Problemas: anatomia de uma nova abordagem organizacional. Fortaleza: Hucitec, 2001BOMFIM, R. Competência profissional: uma revisão bibliográfica. Revista Organização Sistêmica, vol. 1, nº 1, 2012.South J, Blass B (2001) The future of modern genomics. Blackwell, London

NEVES, R. M. Desenvolvimento de Competências de Gerentes Intermediários Através da Adaptação da Aprendizagem Baseada em Problemas – ABP. Porto Alegre, 2006. Tese (Doutorado em Engenharia Civil) – Programa de Pós-Graduação em Engenharia Civil, Universidade Federal do Rio Grande do Sul, Porto Alegre, 2006

SCHMIDT, H. G. Foundations of Problem-Based Learning: some explanatory notes. Medical Education, v. 27, n. 5, p. 422-432, 1993

THIOLLENT, M. Metodologia da Pesquisa-Ação. 15. ed. São Paulo: Cortez, 2007

WOODS, D. R. Problem-Based Learning: how to gain the most from ABP. Hamilton, Canada: Griffin Printing, 1996

Using LEGO® Serious Play® in Marketing Classes

Estelles-Miguel S, Palmer Gato ME, Albarracín Guillem JM, Santandreu Mascarell Cristina[1]

Abstract: This paper focuses on exposing the educational innovation process that has been launched in the 2013-2014 academic year in Services Business Marketing belonging to the 5th degree course in the Faculty of Business Administration (FBA) of the Universitat Politècnica de València (UPV). On that subject, and during classroom practices we have used the "LEGO® Serious Play®" tool known as "gamification tools" for developing a SWOT (Weaknesses, Threats, Strenghs and Opportunities), this tool helps in the develop-ments of students' creatitivy and serves as a link in the development of the activity as you can see in this paper.

Keywords: Gamification, Educational Innovation, LEGO® Serious Play®, SWOT.

1 Introduction

Adaption to the European Higher Education Area (EHEA) implies subject design based on competencies and learning objectives, whic affect teaching-learning methodology. This has forced academics to rethink their use of new teaching methods, which must undergo a major renovation. They must be adapted to prioritize student work, promote both autonomuous and collaborative learning, and encourage the development of a range of skills and competencies, both specific and generic. It is in this line of work where the authors of this paper design this experience.

This paper explains the use of a gamification tool in Marketing classes in UPV. For this purpose design experience will be described, which are considered: what is sought with such practice, problems that may occur in performing experience, and how to fiw them as they arise, and other features to consider. Also defined objectives to be achieved by means of this tool. Information gathered by teacher while performing experience is collected. Finally the results obtained in carrying out the experience, which was very interesting when used as a tool to define part of the SWOT of the Faculty of business Administration in which the experience took place.

Note that this experiment was performed in two distinct groups with a very uneven number of students (in the morning were 50 students while in the evening only 12 students participated). It also explains problems obtained with one and anothez due to group size.

This paper is organized as follows in Section 2 the goal of this experiences are explained, in the Section 3 experience and its develop is defined, in the Section 4 the results of this experience are included and finally Section 5 when the conclusions are presented.

1 **Sofía Estellés Miguel** (soesmi@omp.upv.es)
Marta Elena Palmer Gato (marpalga@doe.upv.es)
José Miguel Albarracín Guillem (jmalbarr@omp.upv.es)
Cristina Santandreu Mascarell (crisanma@omp.upv.es)
Dpto. de Organización de Empresas.
Universitat Politècnica de València.
Edificio 7D, Camino de Vera S/N, 46022 Valencia.

2 Experience Goals

This experience was conducted with the following objectives:

- Proposing an workgroups experience different.
- Identity Streghs and Weaknesses of the Faculty of Business Administration from the students point of view.
- Encourage students creativity when developing a SWOT.
- Increase student participation in a group work.
- Identify how team can improve individual performance.

3 Learning through Play or Gamification

The term Gamification not appear until 2008 and its use did not begin to generalize until 2010 (Paharia, 2010). Gamification is an emerging concept in the field of academic disciplines. This term is understood as "the integration of game dynamics in no recreational environments" (Deterding et al, 2011). One of the goals of gamification is converting non playful environments more fun and appealing (Huotari and Hamari, 2012). The intention thereby exploit the essence of games:fun, participation and passion (Deloitte, 2012). The gamificis also defined as an attitude, a learning strategy and a movement (Kapp, 2012).

Gamification is attracting increasing interest in different areas. In fact, there are several studies that suggest that due to the expansion of mobile technology, gamification will become a significant trend in the coming years (BBVA, 2012 and Deloitte, 2012), estimated that in 2015 over 50% of organizations that manage innovation processes are going to do with gamification (Gartner, 2011).

All games have four common traits: a goal, rules, a feedback and voluntary participation (Mc. Gonigal, 2011). The game mechanics are different actions, behaviors, techniques and control mechanisms that are used to convert into play activity (Kapp, 2012). With them it is possible to create an attractive and easy accession to the player. Includes: points, prizes, rankings, challenges, missions and and gifts.

Dynamics ot the game are the effect, motivation and desire to pursue users and are based in turn on fundamental human needs (Maslow, 1943 and Reiss, 2004).

During the game people are allowed to flow, which is a spontaneous pleasure state during which the person is fully engaged in a task through a deep motivation (Csikszentmihalyi, 1996). A state where the individual is at the perfect level of skills: or not enough challenges (boring) or nor too challenges (anxiete and frustation). Linked to this concept are extrinsic and intrinsic motivations. The first is determined by the environment and aims to achieve an external goal (recognition or reward) while the second is the one that leads the individual to perform an activity for its own pleasure, because it is in itself interesting and satisfying (Amabille, 1999). The most importan in the gamification activities is the intrinsic motivation because it´s getting the participant hooked. That engagement or commitment refers to the involvement. Three types of commitment may appear: cognitive, emotional and physical (May et al., 2004).

In terms of marketing, it is considered that the gamification helps companies increase user involvement, loyalty and brand recognition, and train employees (Meloni, 2012). There are titles dedicated to marketing gamification (Hamari and Lehdonvirta, 2010; Huotari and Hamari, 2012 and Oliver Perez, 2012).

3.1 LEGO® Serious Play®

Term Gamification not appear until 2008 and its use did not begin to generalize until 2010 (Paharia, 2010). Gamification is an emerging concept in the field of academic disciplines. This term is understood as "the integration of game dynamics in no recreational environments" (Deterding et al, 2011).

Ten year ago, the Danish toymaker LEGO, famous worldwide for its colorful and versatile pieces, was posed the next internal management challenge: How to make the planning corporate strategies processes were a more effective team exercise, in which all workers would undertake to implement the outcome. Kjeld Kirk Kristiansen conceived the idea of what today is known as LEGO® Serious Play®**,** a method of problem solving and communication tool based on the use of best-selling games of construction: LEGO®.

The game brigs togheter some of the most important features to learn: the first thing that appeals to the motivation of people; the second is that you learn doing, nobody can play for you but it is a personal and non transferrable experience and the third is that the error is inherent part of the game, and knowing how to live and learn from it is critical. Additionally, the game is innovative, is playful, promotes creativity, facilitates spontaneous communication, is a positive dynamic, is eminently collaborative, generates conmitment, everyone participates, delivery areas of freedom, is democratic (nobody has privileges over others) and we play can play simulate and anticipate the reality before it happens.

A target is marked, and the student mus leap into action to solve the challege posed. Among the advantages to organizations LEGO**®** Serious Play® are:

- Enables participants to become personally involved building permanent and positive, avoiding catharsis and disqualifying review as part of a real team.

- Promotes discovery itself generating commitment and trust with the team, the problem the project or company.

- Facilitates the treatment of real situations in specific scenarios, learning to priorize, make decisions and discover the basic principles that guide us.

- This methodology allows the simple and fast way integration of diverse and complex factors from an environment that is dynamic and complex, what other methodologies requires much longer transactions to get a complete picture.

3.2 Development of Innovation Activity

At the experience beginning, we sill explain to students the objectives of the activity and how they should perform it.

- Objectives: Find the weaknesses and strenghts of their Faculty.
- Perform:
  1. Students were divided into two groups and were put in a large wortable (3x3 meters) and were given lots of LEGO**®** bricks in the middle of it.

  2. Each student had to make a model with LEGO**®** bricks to represent the idea they want to convey, depending on the table at which pose weaknesses or stregths are. Every can use colors, sizes and shapes as it deems necessary.

  3. Once students have completed their models, they should explain to the rest of their group, no one could criticeze the ideas.

  4. When all students have finished explaining their models, the whole group must decide how to integrate the different models into one, putting the most important or critical ideas in the center and adding all the ideas in concentric circles, depending on its relationship or importance. One the model is completed, each group explain their model to another group, without criticism.

  5. Once completed students may decide to spend part of their model to another model if they feel it is appropriate.

For the above explained activity students had two hours of class. The teacher cound not advise or explain or help, just give the rules and then observes and records. Finally is who make the lists of strenghs and weaknesses that indicate the students and takes pictures of the finished models.

4 Results

LEGO bricks offer huge opportunities for imaginative play, which is what children normally do with them, and can be used to build cool or complex models of things – vehicles, buildings, or whatever – or they can form the basis for machines and robots, which is often the adult domain. In this way, externally displayed thoughts can be assembled into complex arguments much more easily than they can in biological memory. Images displayed in this field are vivid and enduring, unlike the fleeting ghosts of imagination. This enables us to see them clearly, play with them, and craft them into finished products, to a level of refinement that is impossible for an unaided brain. (Donald, 2001: 309). It was this idea, that abstract meanings, feelings or concepts could be physically represented, and then manipulated and tinkered with, that was embraced within LEGO Serious Play. Here, though, our focus is on using LEGO bricks to support the representation of ideas, and the organisation of thinking. The central idea of LEGO Serious Play is not uniquely tied to business consultancy. It can be used to represent all kinds of experiences and feelings, and responses to things (Gauntlett, 2014).

Fig.1
One of the models photograh.
Source: Own.

In the explained methodology sessions a lot of contributions from students were obtained, with them we carry list of strengths and weaknesses.

Table 1
Strengths.
Source: Authors from students data.

Teacher-student ratio	Remunerated trainees
Pretige of teachers	Relevant to finding work
Buildings architecture	Relationship with companies
Good Facilities (library, parks, sports, etc.)	Importance of Environment and recycling
Groundwork for future employment	Public University
Practical application	Internal sport leagues
Integration of people (races and cultures)	FADE takes advantages of UPV technologies
Parking	Foster creativity
Prestige	RED (Riunet, PoliformaT, politube)
Good WIFI	Innovation
Centralization of Services	Own degrees
Individuals (Teacher, personal, students)	Tools that gives you

As you can see many of them we never had imagined, even to people who have long been working here, however students got above all using this technique which helps in creating ideas. It is important to note that one of the main reasons for using active teaching methods like this, is to provide students with a deeper understanding of the subject. Teachers are very satisfaied with student behaviour. Students actively participated int the learning process. Importantly, introducing these methods was a complex process, and caused some overburdening of lectures.

Table 2
Weaknesses.
Source: Authors from students data.

Loneliness, it is the only non-technical Faculty, is rounded by technical schools.	Lack of organization of the Faculty in terms of Erasmus students.
Little individual attention to students regarding his/her learning needs.	Obligation to attend all classes, no sense in many cases .
Slow computes	Classrooms with little natural light.
High prices in VENDING machinesand are almost always empty or lack of replenishment.	Teachers give students little flexibility (eg. When working and have to make it compatible).
Eternal queue in the nearest lunch.	Long time between test and the results thereof.
FBA parking has few places for students.	Little attention to students by beadles
No photocopying service in FBA.	Odor that comes from farms.
Little foresight in the works (ie. Parking works)	Little involvement of some teachers
High enrollment rates	To have to pay sports departament.
Deanery is very detached from reality.	Highly saturated.

5 Conclusions

After making the whole experience, the conclusions that can be obtained from it is that all new activities are interesting, and arouse the interest of students, provided they are well planned and conducted.
We have met all the objectives in desingning this activity, i.e.:

- Students have made a group work experience differently.
- We have identified the weaknesses and strengths of the Faculty of Business Administration from the subject students point of view.
- Teachers have fostered students creativity when developing a SWOT, as you can check to see the long list of proposed ideas (at other times when we have done diferenly way, ideas have been scarce).
- Increased the participation of student. Students with these dynamics are more involved.
- Students feel as part of a whole.
- Students have realized that with the ideas of others could improve his/her ideas and viceversa.

All students have valued highly this activity, that they had never done before and liked them a lot. For teachers, it has been very nice. We have checket that really is more participatory and work grows best. Students will better understand the ideas. Also indicate as for teachers require a great deal having to design new activities and carry them out. The authors of thiw paper will continue working on these and in the following expericence we will pass a questionnaire to students to collect more direcly and orderly impressions from them.

The scientific contributions are in their application in the area of marketing. There are many jobs in other areas especially in computer science programming.

References

Amabile, T. (1996). Creativity in Context: Update to the Social Psychology of Creativity. Boulder, CO, US. Westview Press.

BBVA (2012). Gamificación. El Negocio de la Diversión. Innovation Edge.

Csikszentmihalty, I.S. (1992). Optimal Experience: Psychological Studies of Flow in Consciousness. Cambridge University Press.

Deterding, S., Dixon, D., Khaled, R. & Nacke, L. (2011, September). From Game Design Elements to Gamefulness: Defining Gamification. En Proceding of the 15th International Academic MindTrek Conference. Envisioning Future Media Environments. ACM. pp. 9-15.

DELOITTE (2012). Tech Trends 2012. Elevate IT for Digital Business. Technology Trends.

Donald, M. (2001). A Mind So Rare: The Evolution of Human Consciousness, New York. W.W. Norton.

GARTNER (2011). Gartner Gamification Report 2011

<http://www.gamification.org/wiki/Gartner_Gamification_Report_2011> [Retrieved 16/12/2014].

Gauntlett, D. (2014), 'The LEGO System as a tool for thinking, creativity, and changing the world', in Mark J. P. Wolf, ed., LEGO Studies: Examining the Building Blocks of a Transmedial Phenomenon, New York: Routledge. Available at http://davidgauntlett.com/complete-list-of-publications/

Hamari, J. & Lehdonvirta, V. (2010). «Game Desing as Marketing: How Game Mechanics Create Demand for Virtual Goods» en Journal of Business Science & Applied Management (2010, Vol. 5, nº1, pp.14-29).

Huotari, K. & Hamari, J. (2012, October). Defining Gamification: A Service marketing Perspective. En Proceding of the 16th International Academic MindTrek Conference. Tampere, Finlandia. pp. 17-22.

Kapp, K.M. (2012). The Gamification of Learning and Instruction: Game-Based Methods and Strategies for Training and Education. San Franscisco: Pfeiffer.

Maslow, A.H. (1943). «A Theory of Human Motivation» en Psychological Review (1943, Vol. 50, nº4, pp. 370-396).

May, D.R.; Gilson, R.L. & Harter, L.M. (2004). «The Psycological Conditions of Meaningfulness, Safety and Availability and the Engagement of the Human Spirit at Work» en Journal of Occupational and Organizational Psychology (2004, Vol. 77, nº1, pp. 11-37).

Mc.Gonigal, J. (2011). Reality is Broken. Why Games Make us Better and How the Can Change the World. London. Penguin Press, H.C.

Meloni, W. & Hirmrt. W.M.R. (2012). Gamification in 2012. Market Update. Consumer and Enterprise Market Trends. http://goo.gl/75Ph5. [Consulta: 29 de abril de 2014].

Pérez, O. (2012). «El Valor del Juego. Ludificación en la Narrativa Audiovisual Contemporánea» en TELOS Revista de Pensamiento sobre Comunicación, Tecnología y Sociedad (2012, Diciembre, nº93, pp. 23-33).

Reiss, S. (2004). «Multifaceted Nature of Intrinsic Motivation: The Theory of 16 Basic Desires» en Review of General Psychology (2004, Vol. 8, nº3, pp. 179-193).

Entrepreneurship in engineering students – developing a scale

Silvério JV[1], Fonte JT[1], Leão BFS[1], Soares JCV[2], McGowan P[3], Carvalho PS[1]

Abstract: The literature affirms that the identification and study of students' entrepreneurial characteristics has a special relevance for the development of adequate educational programmes related with entrepreneurship and business creation among other consequences. In this sense, the objective of this paper is describe the creation process of an entrepreneurship scale in engineering academic contexts and analyse the preliminary results obtained by the scale application in two universities, one from Brazil and one from Northern Ireland, and compare the entrepreneurial profile. The results shown that values referent to variation coefficients conform each reality are relatively low. And we can conclude also that Brazilian students show an entrepreneurial profile a little bit superior than Northern Irish students.

Keywords: entrepreneurship, scale, engineering, students.

1 Introduction

In the last decades of the 20th century, the importance of entrepreneurship has been recognized by economists as one of the drivers of social welfare. Around the world, governments are recognizing the importance of their role in motivating individuals in the company and other stakeholders in developing opportunities, thereby targeting a positive change in society and economic growth (Blenker et al., 2008).

Kabongo & Okpara (2010) said that the study of entrepreneurship in higher education institutions is one of the more interesting and challenging areas of research for universities, governments, and industrial sectors. These kinds of studies and researches about entrepreneurship have increased in the last three decades. So, this phenomenon also has happened, being considered an important research area. Recently, entrepreneurship is established as an academic class but, it's also study programmers and courses that can be found in several educational levels (Kostoglou & Siakas, 2012).

To understand the entrepreneurial behaviour, Maciel (2007), supported by a set of their previous research, says that in some studies, that personality traits of the humans are seen as variables that predict certain behaviour, especially the notion of locus control. The author indicates Boydston, Hopper and Wright (2007) to suggest that the locus control is defined as the belief that the individual has in relation to portion control your own destiny. Being that this concept can also be extended to the observation of two of its main constituent dimensions: internal locus of control and external locus of control.

1 **José Victor Silvério** (josevictor-silverio@hotmail.com)
Jakson Trindade Fonte (k22.jak@gmail.com)
Bruna Fernanda Silva Leão (brunafsleao@gmail.com)
Paula Soares Carvalho (paulinha_soares15@hotmail.com)
Curso de Engenharia de Produção. Universidade Federal de Goiás – Regional Catalão. Av. Dr. Lamartine P. de Avelar 1120, Setor Universitário, Catalão, Goiás, Brasil.

2 **Júlio Cesar Valandro Soares Carlos** (j-cvs@hotmail.com)
Curso de Engenharia de Produção Unidade Acadêmica Especial de Ciências e Tecnologia – Câmpus Aparecida de Goiânia Regional Goiânia - Universidade Federal de Goiás.
Rua Mucuri, s/n, Área 3, (Campus da UEG/UFG),
Setor Conde dos Arcos, Aparecida de Goiânia - GO, 74968-755.

3 **Pauric McGowan** (p.mcgowan@ulster.ac.uk)
Dep. of Marketing, Entrepreneurship and Strategy
University of Ulster - Jordanstown campus - Shore Road
Newtownabbey Co. Antrim - Belfast BT37 0QB – Northern Ireland/UK.

As a definition, researchers associate the construct: "internal locus of control as the personal belief that the subject itself has an influence on their results through their skills or efforts. Locus of external control, on the other hand, is the belief that external forces control their results" (Kaufmann; Welsh; Bushmarin, 1995). However, according to Maciel (2007), external locus of control is associated with greater effectiveness of leaders, indicating as an example the individuals who hold the belief that their success is more related to external factors rather than internal factors.

In this study, the constructs initiative, need for achievement, propensity to risk/assuming, take advantage of opportunities, self-assurance, leadership, planning, proactivity, persistence, searching information, creativity, self-efficacy and passion, were used with the purpose of enabling the characterization of the entrepreneurial profile of engineering students in Northern Ireland and Brazil, to make a correlation between the results obtained at both locations.

The objective of this paper is describe the creation process of an entrepreneurship scale in engineering academic contexts and analyse the preliminary results obtained by the scale application in two universities, one from Brazil and another from Northern Ireland, and compare entrepreneurial profile. In this way this paper tries answer the questions: How to build a scale to evaluate the entrepreneurial profile in engineering students? Have differences between the entrepreneurial profile of engineering students from Brazil and Northern Ireland?

2 Methodological Procedures

Firstly, it is important to say that happened meetings in order to outline the constructs referent to entrepreneurial profile and to structure the scale (research in-strument) inherent this work. In this sense, we surveyed documents (minutes) which describe the construction process this scale written in order to register these meetings. Additionally we interviewed the researchers who have participated this process. So, we got information to relate the process referent the construction of the scale (research instrument) to identify the entrepreneurial profile.

After that, the research instrument was applied in a non-probabilistic sample of Brazilian and a Northern Irish students in order to get possible improves in this one. Then we did such improves and obtained de the final version of the scale, according to related in topic 3.1.

Finally we collected data (survey) using the final version of the scale. Especially in Brazil we interviewed 200 students from Civil Engineering, Mine Engineering and Production Engineering. Relative to Northern Ireland, it was interviewed 100 students from Engineering Management, Electronic Engineering, Mechanical Engineering, Mechatronic Engineering and Biomedical Engineering.

Then, having these data, we did descriptive statistics analyses like mean, standard deviation and variation coefficient. Furthermore, it was possible establish some comparisons between Brazilian and Northern Irish realities. For that we used one statics software. So it was possible to classify the level of entrepreneurship as a result of each construct in the reality of each country.

3 Results and Discussions

3.1 The Entrepreneurship Scale Development Process

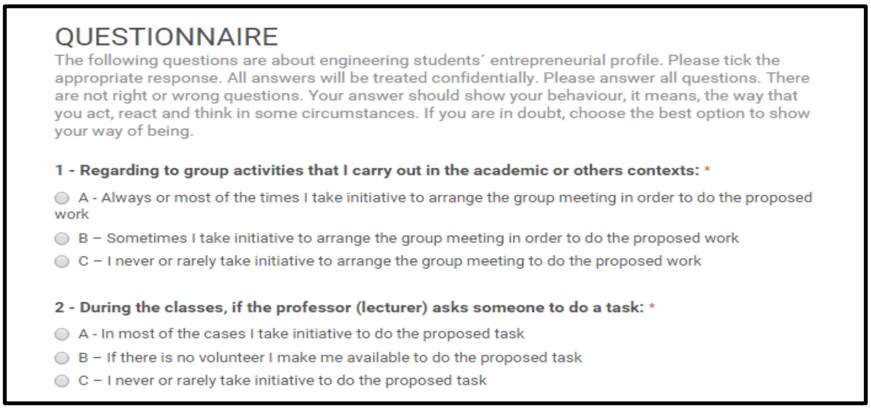
To build the scale (research instrument) used to collect data was necessary follow some steps. At first was necessary study about the entrepreneurship profile and now betters what are the personality traits who the entrepreneurs have, and how to measure the intensity of these traits. In this sense, was started one bibliography review taking the mainly authors about the theme as McClelland (1961).

So, based on the bibliographic review it was possible note that the personality traits is joined in groups called constructs, which defines a part of the entrepreneur's behaviour and skills. According to the same author cited above the mainly constructs were selected. How the bibliographies were to evaluate the general entrepreneurship profile become necessary adapt the constructs to the engineering students context and determine one scale to measure the intensity.

With each construct was made statements about the skills and abilities applied to situations who the students experiences during the university. To each statement is possible agree completely, disagree completely or stay on the middle, and for each option is attributed different points.

With the statements one research tool was build, mixing the different constructs, enabling to the first application to validate the scale (pre-test). At first it was applied to some production engineering students of Federal University of Goiás (UFG) in Brazil (BR) studying in different years on the college (32 students answered the scale between 22/4/2013 and 30/04/2013) and it was applied to some students of "Entrepreneurship" module referent to "Business Development and Innovation" master course of Department of Marketing, Entrepreneurship and Strategy of University of Ulster in Northern Ireland (NI) (11 students answered the scale between 11/4/2013 and 19/04/2013).

After the first application (pre-test) the scale passed for some modifications based in two points: the opinion of the students who answered this test phase, and in the results found. In other words, the research instrument was applied in a non-probabilistic sample of Brazilian and a Northern Irish student in order to get possible improves. Then we did such improves and obtained de the final version of the scale with 47 statements with the follow constructs: initiative, need for achievement, propensity to risk/assuming risks/, take advantage of opportunities, self-assurance, leadership, planning, proactivity, persistence, searching information, creativity, self-efficacy and passion. A part of the scale is shown on the Figure 1, and the full scale can be accessed following the electronic address goo.gl/ot8bEh.


QUESTIONNAIRE

The following questions are about engineering students´ entrepreneurial profile. Please tick the appropriate response. All answers will be treated confidentially. Please answer all questions. There are not right or wrong questions. Your answer should show your behaviour, it means, the way that you act, react and think in some circumstances. If you are in doubt, choose the best option to show your way of being.

1 - Regarding to group activities that I carry out in the academic or others contexts: *

- A - Always or most of the times I take initiative to arrange the group meeting in order to do the proposed work
- B – Sometimes I take initiative to arrange the group meeting in order to do the proposed work
- C – I never or rarely take initiative to arrange the group meeting to do the proposed work

2 - During the classes, if the professor (lecturer) asks someone to do a task: *

- A - In most of the cases I take initiative to do the proposed task
- B – If there is no volunteer I make me available to do the proposed task
- C – I never or rarely take initiative to do the proposed task

Fig.1
Part of the scale to evaluate the entrepreneurial profile of engineering students.

3.2 Preliminary Results

The final version of the scale was applied to 300 students divided between the universities and engineering courses.

In Brazil the scale was applied to 200 students from Federal University of Goiás (UFG) divided in three courses: Civil Engineering, Mine Engineering and Production Engineering.

In Northern Ireland it was applied to 100 students from University of Ulster divided in follow courses: Engineering Management, Electronic Engineering, Mechanical Engineering, Mechatronic Engineering and Biomedical Engineering.

To show and discuss the preliminary results it was structured the Table 1, in the sequence:

Table 1
Preliminary results referent to entrepreneurship constructs – Brazil (UFG) and Northern Ireland (Ulster) lease use the "Table Title" style for figure legends.

	BR´s mean	NI´s mean	BR´s standard deviation	NI´s standard deviation	BR´s variation coefficient (%)	NI´s variation coefficient (%)
Initiative	1,78	1,74	0,23	0,05	13,00	2,88
Need for achievement	1,69	1,67	0,135	0,1	7,99	5,99
Propensity to risk/assuming risks/	1,47	1,58	0,045	0,05	3,06	3,17

Take advantage of opportunities	1,42	1,60	0,14	0,07	9,86	4,38
Self-assurance	1,65	1,62	0,06	0,28	3,58	17,33
Leadership	1,56	1,65	0,25	0,12	16,02	7,29
Planning	1,54	1,69	0,15	0,06	9,74	3,55
Proactivity	1,58	1,54	0,25	0,11	15,82	7,15
Persistence	1,42	1,54	0,06	0,15	4,23	9,75
Searching information	1,64	1,60	0,22	0,07	13,41	4,38
Creativity	1,92	1,71	0,12	0,04	6,25	2,34
Self-efficacy	1,52	1,55	0,13	0,09	8,55	5,82
Passion	1,98	1,75	0,19	0,09	9,60	5,13
Variation coefficient (%) mean					**9,29**	**6,09**

According to Table 1 we can observe values referent each entrepreneurship construct in Brazilian and Northern Irish contexts. As referred in the Methodological Procedures, to lower values in each construct, we have higher levels of entrepreneurial behaviour, and so on. In this sense it is possible compare the values referent each reality.

So, we can verify that there are some values referents each entrepreneurship construct which show that Brazilian students (UFG) have entrepreneurial behaviour higher than Northern Irish students (Ulster). For instance, to follow constructs it is possible observe this situation: propensity to risk/assuming risks, take advantage of opportunities, leadership, planning and persistence.

On the other hand, there are some values referents each entrepreneurship construct which show that Ulster students have entrepreneurial behaviour higher than UFG students. To follow constructs it is possible to see this circumstance: initiative, creativity, searching information and proactivity.

Furthermore, it is possible note similar values between Brazilian and Northern Irish contexts especially referent to need for achievement and self-assurance constructs.

However if we observe the values referent the difference between Brazilian and Northern Irish entrepreneurship constructs it is possible to say that Brazilian students show an entrepreneurial profile a little bit superior than Northern Irish students.

The Table 1 also shows that values referents to variation coefficient (VC) are relatively low. In relation to the VC, it is important to emphasize that this information is a statistic unit that corresponds to the standard deviation in average's percentage, being the statistic parameter mostly used by researches in relation to the accuracy quality of experiments (AMARAL; MUNIZ; SOUZA, 2007). Conform Pimentel Gomes (2000), in the field experiments, if the coefficient of variation is less than ten percent, the same is low, between ten and twenty percent is median, between twenty and thirty is high and above thirty is considered too much high.

Shimakura (2011) underlines that if we have low levels of VC this means that is more homogeneous data set. The VC is low when it is lower or equal twenty-five percent. However, this standard can be different according to application. It is hard to classify a variation coefficient as low, median or high, according to Shimakura (2011), but this can be good when you compare two variables or two groups which are impossible to establish comparisons.

Then, considering this references and the Brazilian reality, we can observe that only the constructs "Initiative", "Leadership", "Proactivity" and "Searching in-formation" have values referent to variation coefficient above 10%, but lower than 20%. This mean that these values can be considered moderated. However the values referent the other constructs can be considered low, because their variation coefficient values are lower than 10%.

In relation to Northern Irish reality all values referent to variation coefficient are lower than 10%, except the value relative to "Self-assurance" (17.33%). So, the other values can be considered low. Then, according to these values referent both realities, the behaviour's students are relatively homogeneous. In other words, these values show low levels of variability.

We can analyse the mean considering all values referent to variation coefficients conform each reality. So we can compare these values between Brazilian and Northern Irish realities. In this sense we can observe that Northern Irish reality shows a value lower than Brazilian reality. It means that the Northern

Irish behaviours' students are less variable (less variability) than Brazilian behaviours' students, considering these preliminary data.

Finally referent to the scale reliability analysis were calculated the Cronbach's Alpha coefficient. The value found was equal to 0,851. It means that the reliability of the scale is acceptable. According to Malhotra (2001) the value to be considered for this parameter is 0.60, for values lowers than it the reliability is considered weak.

4 Conclusions

The objectives of this paper is describe the creation process of an entrepreneurship scale in engineering academic contexts and analyse the preliminary results obtained by the scale application in two universities, one from Brazil and another from Northern Ireland, and compare entrepreneurial profile were achieved.

So, to achieve the scale (research instrument) proposed for this paper it was necessary follow some steps as development a first version, form literatures knowledge, apply a pre-test and to do some alterations. Then we did such improves and obtained de the final version of the scale with 47 statements and the follow constructs: initiative, need for achievement, propensity to risk/assuming risks/, take advantage of opportunities, self-assurance, leadership, planning, proactivity, persistence, searching information, creativity, self-efficacy and passion.

Then we collected data (survey) using the final version of the scale in students from Brazilian and Northern Irish realities. In this sense, can conclude that Brazilian students show an entrepreneurial profile a little bit superior than Northern Irish students.

Finally, referents to future studies we intend establish correlations between entrepreneurial profile and academic performance. In this sense, probably we will use de multiple linear correlation.

5 References

Amaral, A. M. do, Muniz, J. A., and Souza, M. de. 2007. Avaliação do coeficiente de variação como medida da precisão na experimentação com citros. Available: www.webnotes.sct.embrapa.br/pab/pab.nsf/.../$FILE/pAB04796.doc [Accessed 23 March 2014].

Blenker, P., Dreisler P., and Kjeldsen J. 2008. A Framework for Developing Entrepreneurship Education in a University Context. International Journal of Entrepreneurship and Small Business, 5(1), 45–63.

Boydston, M., Hopper, L., and Wright, A. 2007. Locus of control and entrepreneurs in a small town. Small Business Advancement National Center [Online]. Available: http://www.sbaer.uca.edu/research/asbe. [Acessed 27 March 2014].

Kabongo, J. D., and Okpara, J. O. 2010. Entrepreneurship education in sub-Saharan African universities. International Journal of Entrepreneurial Behaviour & Research [Online], 16 (4), 296-308. Available: http://www.emeraldinsight.com/journals.htm?issn=1355-2554&volume=16&issue=4. [Accessed 25 March 2014].

Kaufmann, P., Welsh, D., and Bushmarin, N. V. 1995. Locus of control and entrepreneurship in the Russian Republic. Entrepreneurship: Theory and Practice, v .20, n. 1, p. 43-56.

Kostoglou, V.; Siakas, E. 2012. Investigating higher education graduates entrepreneurship in Greece. Annals of Innovation & Entrepreneurship.

Maciel, C. de O. 2007. Comportamento empreendedor, lócus de controle e desempenho: proposta e teste de um modelo de equações estruturais. Anais do XXXI ENANPAD- Encontro da Associação Nacional dos Programas de Pós-Graduação em Administração. Brasília/DF, de 17 a 21 de Setembro de 2007.

MALHOTRA, N. K. 2001. Pesquisa de mercado: uma orientação aplicada. Trad. de Nivaldo Montingelli Jr. e Alfredo Alves de Farias. 3. ed. Porto Alegre: Bookman.

McClelland, D.C.; Winter, D.C.1961. Motivating: Economic Achievement. New York, Free Press.

Pimentel Gomes, F. 2000. Curso de Estatística Experimental. 14.ed. Piracicaba, Degaspari, 477p.

Shimakura, S. 2011, Bioestatística. Available: http://leg.ufpr.br/~shimakur/CE055/ce055.html, [Accessed 25 March 2014].

Brand Identity Applied Research: the case of Brazil's Educational Public Organization (EPO)

Devonish IMS[1], Quelhas OLG[2], França SLB[3], Meiriño MJ[4]

Abstract: Research conducted in order to analyze factors that contribute to the brand identity of Brazil's EPOs individually. Brand identity provides new management paradigm for POs, aimed at updating the communication mechanisms and protection of organizational cohesion. The research conducts a case study in a Brazilian EPO, being held interviews with the managers of the organization, following a structured script. The results indicate the need to adapt concepts of business management for public organizations and the lack of evidence of brand management or construction of identity in them. In addition, the research showed problems in motivation, identification with the institution and perception of self-worth from the public server.

Keywords: brand identity; public management; educational organization.

1 Introduction

Public services have the duty to mediate the relationship between government and citizens, which include the main social commitment to EPOs: to promote systematized knowledge exchange. Thus, the society claims the assurance that public offices provides accessible, fair and equitable services and has effective administration in problem solving and efficient use of public resources (Neves, 2001). In response and in order to regain credibility, incentives both to provide transparency, as to modernize public services through new practices seek to update organizational values, through the adoption of new management tools and processes. What helps to define their identity and the consequent adaptation of their image, both external - improving the public interface -, as internal - raising levels of satisfaction and motivation among servers.

2 Objectives

Identify the relevant factors of branding in EPOs. The research focused mainly to infer the identity of the brand - how managers want it to be perceived.

1 **Isabela Menezes da Silva Devonish** (Isabela.menezes@gmail.com)
Lab. de Tecnologia, Gestão de Negócios e Meio Ambiente.
Escola de Engenharia. Universidade Federal Fluminense.
Niterói, RJ, Brasil.
Divisão de Programação Visual. Centro Federal de Educação Tecnológica Celso Suckow da Fonseca. Rio de Janeiro, RJ, Brasil
2 **Osvaldo Luiz Gonçalves Quelhas**, D.Sc (quelhas@latec.uff.br)
3 **Sérgio Luiz Braga França**, D.Sc. (sfranca@latec.uff.br)
4 **Marcelo Jasmin Meiriño**, D.Sc. (marcelo@latec.uff.br)
Lab. de Tecnologia, Gestão de Negócios e Meio Ambiente.
Escola de Engenharia. Universidade Federal Fluminense.
Niterói, RJ, Brasil.

3 Methods

The research adopts an exploratory approach to obtain insight into an area where studies are scarce: brand identity in EPOs. Based on theory relating branding/public management/the education area, the empirical study investigates - through confrontation data and structured interviews - a representative case of EPO - one of a network in the same model throughout Brazil - to understand how identity is perceived. Considering the objective as in-depth analysis, it was chosen a qualitative treatment.

4 Results

There is a clear concern about the bad reputation of public servers, since it was mentioned by all interviewed. The need to publicize the institution was most often cited as the means of gain a good image. The results also presented unconformity in the discourse of managers, showing no evidence of brand management. At last, factors related to servers were ordered last, showing they do not see their connection and importance for the brand.

5 Conclusion

Despite evident in theory the importance of internal branding, the relation between server/public satisfaction is clearly ignored. The survey revealed actions used do not meet the institution needs, as there is an urge to recover communication tools. It also showed how EPOs are still conservative in the appropriation of business mechanisms, there is no consensus on a brand identity, conscious management or even a responsible for it.

References

AAKER, D., (1991). Managing Brand Equity - Capitalizing on the value of a brand name, New York: The Free Press.

CHAPLEO, C. (2010). What defines successful university brands? *International Journal of Public Sector Management*, 23 (2), 169-183.

DE CHERNATONY, L.. (1999). Brand management through narrowing the gap between brand identity and brand reputation**.** *Journal of Marketing Management*, 15 (1-3), p. 157-179.

FOSTER, C.; PUNJAISRI, K.; CHENG, R. (2010). Exploring the relationship between corporate, internal and employer branding. *Journal of Product & Brand Management*, 19 (6), 401 -409.

NEVES, A. (2001). *Serviço público: para um a cultura de gestão na administração pública*.

PATTON, M. (1990). *Qualitative evaluation and research methods*. United States. SAGE Publications.

YIN, R. K. (2010). *Estudo de Caso: planejamento e métodos* (4a ed.). Porto Alegre: Bookman.

Preparing Engineers with Strong Management and Communication Skills

Santi CE[1]

Abstract: The seek for engineers that meet the companies needs for technically qualified professionals and well developed interpersonal and communicational competences was the trigger for the development of this work. Based on data from alumni of our Computer Engineering program regarding the current position and recommendations collected in LinkedIn, one can demonstrate that the new project-based pedagogical proposal implemented in 2008 made possible the development of managerial and interpersonal relationship competences in the students. The projects are the motivational element for the students and are of main importance for achieving these results.

Keywords: new engineer; pedagogical practices; management.

1 Introduction

The set of competences that companies are seeking in the engineers has been significantly changed in the last years and the attributes and abilities searched in these professionals are even more focused on "*how to be*" than in the technical "*how to do*" (NOSE & RABELATTO, 2001). There is a search for professionals that can adequately communicate, lead teams, manage conflicts, and additionally to all that, find solutions to the technical problems that are presented to them.

Preparing engineers that meet these requirements is a very hard task for the 21st century institutions and educators that must continuously rethink the professional profile of their alumni (TIBÉRIO & TONINI, 2013). Brazilian traditional curricula of engineering programs, besides all specifically and strong technical courses, present disciplines with goals, such as, "*how to be an entrepreneur*" or "*how to adequately express yourself written and orally*". In general, they have no clear context for the students, demotivating them and hardly meting these objectives.

To develop personal and managerial competencies, one need to put the students in a learning situation (PERRENOUD, 2000) bringing to the classroom, problems from the "real work world" and giving opportunities to the students to practice the work in teams, to written and orally communicate, to manage projects and conflicts. These ingredients help to preparing the engineers that companies need.

2 Objectives

This work aims at presenting the results obtained by changing pedagogical practices in a Computer Engineer program started in 2008 and point out competences observed in the profile of this program's alumni, especially those regarding the abilities to manage projects and lead teams, as well the capability to develop human resources and to prepare reference documents.

1 **Carlos Eduardo Santi** (carlos.santi@metodista.br)
Faculdade de Exatas e Tecnologia da Universidade Metodista de São Paulo.
Rua do Sacramento, 230, CEP 09640-000 São Bernardo do Campo/SP, Brasil.

3 Methods

Data from these alumni were mined in LinkedIn a business-oriented professional network service and were considered information about their professional occupation and recommendations from company colleagues. Recommendations from classmates and teachers were disregarded to avoid polarization of results.

4 Results

From the analysis of the data mined is possible to confirm that alumni from this program are in job positions that demand management and leading skills developed during their under graduation. One can also find in the recommendations the recurrence of terms like “leadership”, “team”, and “organized”, that are close related to the objectives of the methodology used since 2008 to prepare them.

5 Conclusion

According to data mined the students are occupying positions that demand strong personal and project management skills, communication and team leadership, what can show that we are in the right way to form 21th century engineers. The organization of the courses in a project-oriented program is fine tuning the alumni from this Engineering program to meet the needs of companies that hire them.

References

Nose MM, Rabelatto DAN 2001 O perfil do engenheiro segundo as empresas. IN: Anais do XXIX Congresso Brasileiro de Educação em Engenharia, Porto Alegre.

Perrenoud P. 2000 Dez novas competências para ensinar: convite à viagem. Porto Alegre: Artes Médicas Editora.

Tibério JR, Tonini AM 2013 Os saberes profissionais do engenheiro gestor. IN: Anais do XLI Congresso Brasileiro de Educação em Engenharia, Gramado.

Development of DL for the training of the Business Game Bom Burguer's tutors

Marinho MT[1], Rodrigues JS[2], ZambonKL[3]

Abstract: Previous experience of training teachers of public schools as tutors for the business game Bom Burguer showed that entrepreneurship content has limiting factors. As a strategy to overcome this limitation, we propose the development of aDistance Learning (DL) Course using the Moodle platform. The game creates the conditions for learning with experiences of the process of running a business, during which the entrepreneurship content and business management are demanded. The DL course was made in a content environment that will support tutors, allowing new forms of interaction between students and teachers, as well as introducing new evaluative forms in the process that will provide feedback to students and teachers. A preliminary test was performed and after there will be a new test for analysis the user's perception to validate the environment.

Keywords: Entrepreneurship, Business Game, Distance Learning Course.

1 Introduction

This paper is the result of previous research that showed that although the Business Game (BG) Bom Burguer (www.bomburguer.net) is an innovation, teachers in the public school system presented difficulties in using it due to deficiencies related to entrepreneurship, because this topic is not part of the curriculum of undergraduate courses of most ofthem. Thus, we tried to create subsidies for the use of the Bom Burguer to support the learning process with DL using the Moodle platform. To achieve this goal, the work was structured from the content to be implemented in distance education environment and the study and analysis of the Moodle tools.

2 Objectives

In this paper, it is proposed to develop a Moodle learning environment to train Bom Burguer's tutors, with the specific objectives:

a) Create the teaching materials with activities in various tools (quiz, crossword, chat, forum, briefing, video, reporting, COLLES and ATTLS questionnaire) in Moodle environment;

b) Improve the environment with resources byuser's feedback, using features Juwah et al. (2004);

c) The activities must involve the contents of how to use the game, entrepreneurship and identity learning, as proposed by Kolb and Kolb (2009).

1 **Mariana de Toledo Marinho** (mariana.tmarinho@gmail.com)
2 **José de Souza Rodrigues** (jsrod@feb.unesp.br)
3 **Kátia Livia zambon** (katia@feb.unesp.br)
Dept. de Engenharia de Produção.
Universidade Estadual Paulista "Júlio de Mesquita Filho".
Bauru 17033-360, Brazil.

3 Methods

The platform Moodle was used for the development of the course, it is an open source support for distance learning, which allows the creation of online courses, disciplines pages, working groups and learning communities. Universidade Estadual Paulista (UNESP), through the Núcleo de Ensino à Distância (NEaD), is responsible for providing academic Moodle.

The course in question is in format of topics aimed to increase the educational flexibility and to achieve better balance between individual reflection and the online discussion (ALVES, BARROS and OKADA, 2009).

From a methodological point of view, this research is applied, it involves the development of DL course. The evaluation of this environment will be made by means of an activity with volunteer teachers from the public school system, analyzing the facilities of its use and the content of the supplied material.

4 Results

The course covers the topics learning, entrepreneurship and BG Bom Burguer to achieve the goal of training tutors of the game. The first, aims to take the student and/or tutor to reflect on how he/she deals with the challenges faced in his/her life in other words, on how he/she deals with his/her own learning. With this reflection the intention is to lead the student to think about how his/her posture influences on the results he/she gets. The second objective is to generate learning about entrepreneurship, including reflection from two points of view, the work world and the creation and business management. The third topic, aims to eliminate, as much as possible, the interference of the game on entrepreneurship learning, minimizing the effects of the field of technology used (game and its structure).

5 Conclusion

The development of a DL course requires the trainer a greater preparedness to take advantage of all the features available in Moodle environment, dedication and planning than in developing a presence course.

After the construction of the DL course in Moodle, it was possible to notice the enrichment of the environment in terms of learning support to the students, helping them in self-assess and learning contents useful to perform activities that require mastery of the game and the concepts used in it, learning and improving their written and expression, interacting in the Forum and using materials to support learning in the web environment. However, a new experimental test will be performed later with computer technicians and teachers for validation and refinement of the environment.

References

ALVES, L.; BARROS, D.; OKADA, A. Moodle: estratégias pedagógicas e estudos de caso.
1. ed. Bahia: EDUNEB, 2009.

KOLB, A.; KOLB, D. A.On becoming a learning: the concept of learning identify. CAEL Forum and News, 2009.

JUWAH, C et al., Enhancing student learning through effective formative feedback. The Higher Education Academy, 2004.

Creation of a Mentoring Program for improving the Education of Industrial Engineers

Almeida M[1]**, Salgado A**[2]

Abstract: This paper aims to present the creation of a mentoring program to be applied in developing future junior industrial engineers acting professionally. Its objective is to contribute to a better professional performance as engineers. It is a case-study for the RIP region (including the cities of Resende, Itatiaia and Porto Real), which is located in an industrial area in Rio de Janeiro State, in Brazil, better preparing the new junior engineers for the labor market. As a result, 87% of mentors and mentees approved the program as efficient, based on the initial targets. The young engineers are still college students and company interns.

Keywords: mentoring program; young engineers education; mentors and mentees.

1 Introduction

The idea of the program started based on the feedback of supervisors of internship programs and interns of industrial engineering. These are still students at the University of State of Rio de Janeiro. Industrial Engineering is commonly called Production Engineering in Brazil.

In Brazil, it is common that the student in the 2 last years of studies at university has the possibility to practice the role as intern. The obligation of practice to get his undergraduate degree is 60 working hours, but usually they extend this period from 6 months to 2 years of practice, what is called internship.

Aiming to support these internships, the university offers in its minimum curriculum the subject of supervising internship classes. They are offered for 2 semesters (consecutives or not) and are named Supervising internship Classes I and II. First of all, these classes aim to check if the companies are providing learning environment for the student as engineers, and no other kind of activities that would help the company, but not provide engineering knowledge. Secondly, they support the student with other subjects related to the internship. The aim of the period of internship is to train the students as engineers. Despite some problems that are found, they have what is expected. A proof of it is that most of the students, in the last 20 years, were hired as junior engineers by these industries of the RIP region just after concluding their undergraduate studies.

Some difficulties while practicing the internship period were detected by feedback from supervisors to interns during the supervising internship classes. The main difficulties faced by the young engineers were not only technical issues, but also behaviors at the beginning of their professional careers. This condition is comprehensible as the focus of the Industrial Engineering Undergraduate Course at UERJ is to provide knowledge and skill to future engineers, but little attention is done regarding the attitude of students while industrial engineers practitioners.

1 **Maria da Glória Diniz de Almeida** (gloria_uerj@yahoo.com.br)
Dep. de Engenharia de Produção. Faculdade de Tecnologia.
Universidade do Estado do Rio de Janeiro.
Resende, CEP 27.537-000, Brazil.
Departamento de Engenharia de Produção Mecânica.
Faculdade de Engenharia de Guaratinguetá.
Universidade do Estado de São Paulo. Guaratinguetá, CEP 12518-010, Brazil.

2 **Andreia Maria Pedro Salgado** (andreia@feg.unesp.br)
Dep. de Engenharia de Produção Mecânica.
Faculdade de Engenharia de Guaratinguetá.
Universidade do Estado de São Paulo. Guaratinguetá, CEP 12518-010, Brazil.

2 Objectives of the case-study

This case-study aims to present the creation of a mentoring program to be applied in order to develop future junior industrial engineers acting professionally, whose objective is to contribute in better professional performance as engineers.

Regarding the objectives, the program aims to:

- Develop the industrial engineer intern, improving his chances to enter the labor market.
- Support the intern to get better performance results on his job at industry.
- Make mandatory feedback to be done from a full or senior engineer to an intern while his training at industry and also that he can learn how to handle it since the beginning of his professsional career. Feedback is one the key “tool” of management for developing people.
- Make the difference for the industrial engineering undergraduate course at UERJ and for other universities in this region that may be interested in the program.

The perimeter of this case-study is focused on the industries and on the industrial engineering undergraduate courses of the RIP region (cities of Resende, Itatiaia and Porto Real, which are located in Rio de Janeiro state, Brazil).

3 Mentoring: definition in some words

Based on CAPES[3] data-base, more than 5.000 publications support mentoring definition, studies and practices, in which more than 4.000 were published in the last 10 years and 96% in English language.

During the research for mentoring definition, no other publication, article or practice was found about application of mentoring for industrial engineers undergraduate student education. Publications were found for:

- Guiding the career of young professionals who have already concluded undergraduate course.
- Areas such as Medicine, Nursing, Professor and Teachers training and Athletes in early career years.
- Mentoring from senior students to peer ones at early university years.

One of the definitions for mentoring it is a trial for transferring experience and expertise from more experienced professional (mentor) to a less one (mentee) inside an organization. It works as a kind of “shortcut” where the mentor supervises the activities and performance of a younger colleague who should learn quickly (STEWART, 2003).

Some good mentoring programs have some good practices in common. One of them is the commitment, confidentiality and transparency from both sides. Another good practice is that the program involves an action plan and results evaluation.

Mentoring can provide benefits not only for mentees, but also for mentors. Some of the advantages for mentees are the support for professional development as engineers (better technical and behavior performances), the opportunity to show skills and potential for future advanced activities and improvement of self-confidence. On the other hand, mentors can develop their leadership in developing people and feedback practice. Stewart (2003) stills complements that the role of mentoring is to allow the mentor to review, make a reflexion and even modify future actions as a result of the program.

[3] CAPES - Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (Coordination for Undergraduate Education Improvement), Brazil

4 Methods

The PDCA (Plan – Do – Check – Act) is the base method used to create the program. It was developed through 4 semesters, integrated in the supervising internship classes I and II. Every semester the PDCA was applied in order to improve the program for the following one, as shown on Figure 1.

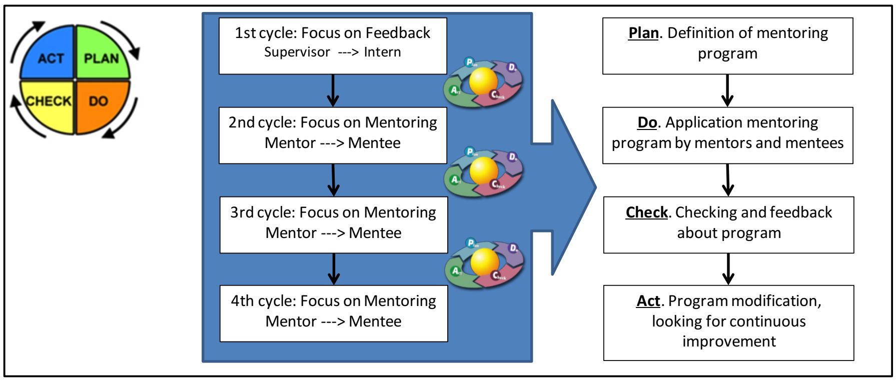


Fig.1
PDCA method applied in 4 semesters
for the mentoring program improvement

4.1 1st PDCA Cycle: Focus on Feedback

During this 1st semester, the students at supervising internship classes I and II had:

- Plan: creation of a feedback exercise / practice between supervisor – intern.
- Do: discussions among professors and students about general competencies and behaviors at work.
- Do: questionnaire application to get feedback from supervisor to intern, focusing on points to be improved.
- Do: individual meetings with professors to provide orientation regarding these points.
- Check: discussion among professors about the practice / exercise and the need of support to improve these "weak" points detected on feedback from supervisors.
- Act: research about methods of mentoring program inside the academy and good practices in companies. This step was repeated in all the cycles.
- Act: proposal of a first version for the mentoring program applied for interns at industries.

4.2 2nd PDCA Cycle: Focus on Mentoring 1st Version

During this 2nd semester, a 1st trial of mentoring was implemented, followed by PDCA cycle. The main activities were:

- Plan: creation of a first version of mentoring program applied for interns at industries.
- Do: orientation and guidance for mentors, mentees and company human

resources departments.

- Do: application of a self-evaluation of general competencies for the mentees about points to be improved.

- Do: practice of mentoring between mentors and mentees in 4 meetings along 4 months (2-hour-meeting per month). During these meetings, mentor and mentee needed to define 2 points of improvement for the mentee and discuss how to make it better. Being the main content of these meetings the improvement of these 2 chosen points. The mentor needs to be an engineer with at least 4 years of experience and chosen by the mentee.

- Do: follow up the mentoring program development during the semester in the specific subject supervising internship classes I and II at university by the professors.

- Do: creation of an optional activity for students who were not under internship programs due to the fact that just 60 hours are mandatory.

- Check: application of 2 different questionnaires –mentor and mentee - in order to get feedbacks from the program and "feed" PDCA cycle.

- Act: proposal of modifications for the mentoring program next cycle.

4.3 3rd PDCA Cycle: Focus on Mentoring 2nd Version

During this 3rd semester, a 2nd trial of mentoring was implemented to continuously improve the PDCA cycle. The main additional activities from the previous version were:

- Plan: creation of the 1st standard version for the mentoring program to be applied for industrial engineers students / interns, based on the feedback received from previous cycle mentors and mentees.

- Do: practice of mentoring between mentors and mentees in 3 meetings during 3 months
(2-hour-meeting per month). These 3 meetings were defined based on the time of the supervising internship classes I and II at university in each semester. This schedule is being repeated from that day on.

- Do: follow up of the mentoring program development during the semester inside the subject of supervising internship classes at university by the professors.

- Do: creation of a formal presentation of the activities developed by the mentees for the professors at the end of the semester to check the practice of mentoring.

- Check: application of 2 different questionnaires from the mentors and the mentees to get feedback about the program and "feed" PDCA cycle.

- Check: application of a questionnaire about the relevant competencies and skills of industrial engineering considered by ABEPRO[4]. The research output was a list of the most relevant ones for the RIP region industries from the mentor's point of view.

- Act: proposal of modifications for the mentoring program.

Souza (2014) discusses in her dissertation about the competencies more relevant by students and professors points of view, based on ABEPRO list, which was an input for this case-study.

[4] ABEPRO – Associação Brasileira de Engenharia de Produção (or Production Engineering Brazilian Association), Brazil.

4.4 4th PDCA Cycle: Focus on Mentoring 3rd Version

During this 4th semester, a 3rd version of mentoring was implemented in order to continuously improve the program. The main additional activities from the previous version were:

- Plan: creation of the 2nd standard version for the program to be applied for industrial engineers students / interns, based on the feedback received from mentors and mentees on the previous cycle. In this standard, the following steps needed to be practiced:

  – Identification of 2 points of improvement for the mentee based on the list of the most relevant competencies and skills for industrial engineers of the RIP region industries under this case-study.

  – Definition of a short project in which the mentee would have the opportunity to practice these 2 points of improvement.

  – Definition by the mentor how to check the results of the program at the end of the semester. It means which 2 targets should be reached by the mentee in order to prove the program's results.

  – Evaluation of these 2 targets and the results by the mentor at the 3rd mentoring meeting.

  – Presentation of the short project at the end of the semester at university at the subject supervising internship classes I and II for professors.

- Plan: creation the 2-semesters-scenario for mentoring program. As the students have 2 semesters for the subjects (I and II), the possibility (not mandatory) of practicing the program with the same mentor and points of improvement.

- Plan: creation of the standard documentation to guide mentors and mentees to guarantee standardization for positive results on the program.

- Check: in the last feedback questionnaire, qualitative performance evaluation was included to check the program results.

- Act: make the last changes on the standard mentoring program applied for interns at industries.

It is important to emphasize that the professors, in this program, have no interference which mentee performance aspects should be improved. They should be defined and followed by mentor and mentee. The professor supports the method in the program.

The commitment between mentor and mentee is the mindset for the mentoring program success.

5 Results

By a questionnaire formalized applied to mentors and mentees, the program is validated with 87% of efficiency compared to the initial targets defined by mentors and mentees at the beginning of the program.

It is important to make it clear that the efficiency is measured in a qualitative way, not a quantitative one.

Next steps are under development regarding the program to guarantee its academical validity and efficiency.

6 Conclusion

The feedbacks from mentors, mentees and professors consider that the program is valid for improving education of industrial engineers students as future professionals.

This program is supported by the Director of the University of the State of Rio de Janeiro (UERJ) and its professors and students committee. The subject of supervising internship classes I and II allows the development of this case-study due to the value that the mentoring program is expected to add to the Industrial Engineering Undergraduate Course at UERJ and its students as future engineers.

7 References

Clutterbuck DC (2006) Organising mentoring programmes: how to be a great programme coordinator. Development and Learning in Organizations: An International Journal

Cohen-Scali V (2008) Accompagnement en entreprise et intentions liées à la carrière chez des apprentis du bâtiment. Pratiques psychologiques

Eller LS, Lev EL, Feurer A (2014) Key components of an effective mentoring relationship: A qualitative study. Nurse Education Today

Ensher EA, Thomas C, Murphy SE (2001) Comparison of traditional, step ahead and peer mentoring on protege's support, satisfaction and perceptions of career success: a social exchance perspective. JOURNAL OF BUSINESS AND PSYCHOLOGY

Gibb S (2003) What do we talk about when we talk about mentoring? Blooms and thorns. British Journal of Guidance & Counselling

Gibb S (1994) Evaluating Mentoring. Education + Training

Sanfey HS, Hollands CH, Gantt NLG (2013) Strategies for building an effective mentoring relationship. The American Journal of Surgery

Savoie A et al (2008) La relation mentorale formelle en milieu de travail : apports de la recherche à la pratique. Pratiques psychologiques

Stewart J (2003) Mentoring in undergraduate business management programes. Journal of european industrial training

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