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FOSTERING THE LEAN APPROACH AS A SUSTAINABLE STRATEGY: CHALLENGES FROM PORTUGUESE COMPANIES

Abstract: *Over the last years the sustainability of current manufacturing processes adopted by industries have been drawn attention worldwide. In response to this challenging, Lean Manufacturing has appeared as an alternative to support companies creating strategies towards sustainable practices. This research aims to evaluate the Lean tools as sustainable strategies implemented in companies located in the North of Portugal. The work was developed mainly based on an online survey applied to 102 Portuguese companies. From the research conducted, results showed that 5S and TPM methods were the tools which have higher progress of implementation by the consulted companies. Regarding the dimension of the consulted companies, results showed that micro and small were the ones with the lowest levels of implementation of lean procedures. The study allowed to suggest some implication regarding key Lean tools adopted by companies operating in the region and a set of barriers faced were also pointed out.*

Keywords: *Lean manufacturing; Sustainable performance, Portugal*

1. Introduction

The instability of the business market and the growth of companies' supply chain have been calling attention to organization's performance to become more efficient, flexible and faster to answer fast growing changes in the business environments.
Strategies which focus on supporting companies to overcome economic and environmental barriers have rapidly gained importance in the industrial arena. In this sense, Lean Manufacturing plays an important role in supporting companies to overcome environmental, social and economic impacts originated by the industrial production processes, since these impacts have been a major concern of the industrial sector. The study developed by Lewis (Lewis, 2000) combines normative and critical theory with empirical material drawn from three case studies, the obtained results showed that lean production can underpin competitive advantage if the firm is able to appropriate the productivity savings it creates. Similarly, the ambiguity of lean production in practice means that the implementation process can create strategic resources to underpin sustainable competitive advantage.

As a philosophy, lean thinking promotes efficiency and elimination of waste, focusing on a high customer service level. Based on that, Lean tools have been also adopted by many companies from different sector aiming to improve their operations. The implementation of Lean Manufacturing tools in any type of organizations (services or industry) can bring many benefits, such as waste reduction and improving operating efficiency.

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Cardoso *et al.*, (2017) have analyzed the external consultation and internment services in a hospital from Northern Portugal and have studied the patient and hospital technical assistant's flows at these services applying principles of Lean HealthCare, i.e., principles of Lean Thinking adapted to the health care services. They found several wastes, such as lacking information and signage, long queues, lengthy waiting times resulting from various service inefficiencies. To solve these problems, some proposals for improvement were made, for instance, the use of Lean tools such as kanban systems, Visual Management and other tools like simulation using Arena software.

Also, a work developed by Resende *et al.*, (2014) presents the results of a Lean Production project implementation developed in a plastic injection company. The main objective of the project was to apply Lean principles and tools involving the stakeholders of the company. For this case, the Value Stream Mapping (VSM) was used to analyse the production system and to identify the wastes and the main issues for improvement, after that, some proposals were presented and implemented using Lean tools such as 5S, PDCA cycle, Kanban, SMED and Kaizen. As results of this application, some tangible and financial results obtained were an increase of productivity of the assembly lines by 12%, of the operating income by 6%, a reduction of the cycle time of six dies to 10%, a reduction by 15% of tool changeover time and an increase of total incomes estimated in €360,000.00. Intangible results were also obtained, namely the operators' engagement and involvement with continuous improvement and Lean implementation.

The cases outlined above, show that Lean is not limited to one type or size of the organization, but rather all types, sizes and industries that attempt to increase their competitive advantages, operations and profits in the regional and global markets (Alkhoraif et al., 2018). Nevertheless, some literature recommends that the lean aspects must be different and adapted according to the company's dimension and characteristics.

Having in mind the economic and environmental gains of lean practices, this research aim is to evaluate the level of implementation of Lean tools in different types and dimension companies, resorting to an online survey with a set of companies from the North of Portugal.

Then, Lean practices such as Kaizen philosophy, 5S (Sort/Set in order/Shine/Standardize/Sustain), Total Productive Maintenance (TPM), Kanban, Just in time (JIT), stock reduction, Kaizen circles and collaboration with suppliers, were analysed.

The research is organized as follows: first, a literature review underpinning the concept of lean manufacturing tools and its application is presented. Then, the methodological approach selected for gathering data is provided. The main results are then presented and discussed. After this, conclusions and direction for future works are presented.

2. Background literature on Lean Approach

Lean Manufacturing focus on the reduction of waste and improvement of operational efficiency using a set of different tools to get these objectives (Al-Zuheri et al., 2021). Many of these tools can be successfully used in isolation, which makes it much easier to get started, but on the other hand, the benefits of the implementation can be found as far as different tools are used, as they do support and reinforce each other (Rodrigues et al., 2020).

In the literature, studies highlighting the influence of the application of the Lean methods and tools in different performance indicators can be easily found. For instance, Belekoukias, Garza-Reyes and Kumar, (2014) and Garza-Reyes *et al.*, (2018) investigated the impact of five essential lean

methods, i.e. JIT, autonomation, kaizen/continuous improvement, total productive maintenance (TPM) and value stream mapping (VSM)on a group of companies (140 and 250 respectively) around the world, on four commonly used measures for the compliance of environmental performance, i.e. material use, energy consumption, non-product output, and pollutant releases. The results indicate that JIT and automation have the strongest significance on operational performance while kaizen, TPM and VSM seem to have a lesser, or even negative, effect on it.

This research provides further evidence regarding the effects that lean practices have on the performance of organizations, supporting companies and managers to a better understanding of the relationship between lean strategy as well the performance of their operations.

Möldner, Garza-Reyes and Kumar (2018) studied the effects of lean manufacturing practices on the process innovation performance of manufacturing organizations. Findings suggested that both technical and human lean practices have a moderate to a strong positive impact on the input and occurrence of incremental and radical process innovation in manufacturing companies.

Based on the consulted literature, the studies have shown that the implementation of the Lean tools based on the companies' dimension is not equally applicable to large and small companies. The concept of lean thinking was successfully introduced in large and medium-sized enterprises belonging to the automotive sector, but the small enterprises were ignored for a long time and specific investigations about this topic were rarely (Matt & Rauch, 2013).

However, research on Lean concepts applications in Small, Medium Enterprises (SME) have been increasing due to the existence of a large number of these organization worldwide.

For instance, in India, a study aiming to identify the reasons, advantages and barriers on Implementation Lean Integrated Management System in Micro, Small, Medium Enterprises (MSME) was developed (see Mohan Sharma & Lata, 2018), the results summarized a set of the benefits of 5S as a Lean Management tool, benefits such as cleaner and safer work environment, reduction in non-value-added time, effective work and the visual workplace vision were highlighted. This provides support for the synergistic effects of implementing practices, representing multiple aspects of Lean Management (Jewalikar & Shelke, 2017).

Despite the barriers to the implementation of lean tools, Pearce, Pons and Neitzert, (2018) have identified critical success factors for lean implementation following two first-time implementations of lean in small to medium-sized enterprises (SMEs). Case studies collectively spanned over four years were observed and showed that the real problem with achieving lean success was not management commitment, but their ignorance of what they should commit to, hence a knowledge problem.

Following the interest and the advantages for MSME in the Lean tools applications, some authors (Almanei et al., 2017, 2018) developed frameworks under the prism of the needs of SMEs, showing that unsuccessful implementation can have a great impact on organization's resources, but even more importantly, affect employees and their confidence in lean philosophy.

Summing up the pieces of evidence presented in this section, the lean methods and tools can be used as an attempt to improve the organization's performance. An illustration can be drawn through the use of JIT method. JIT plays a significant role to achieve a high service level at a minimum cost. As mentioned, the TPM and Kaizen/continuous improvement methods also have a great impact on the organization's performance (Abdul et al., 2017).

Also, as a lean tool, 5S can be used as a simple tool which supports companies towards the development of discipline and

cleanliness at the workplace, maximizing efficiency and productivity, and could be implemented in all types of companies and services (Abu et al., 2019; Jiménez et al., 2015; Mohan Sharma & Lata, 2018; Monteiro et al., 2017; Omogbai & Salonitis, 2017; Resende et al., 2014; Roriz et al., 2017; Veres et al., 2018). The 5S tool is a Japanese method of organizing the workspace, in a clean, efficient and safe manner, to achieve a productive work environment and consists in five steps of implementation: Sort, Set in order, Shine, Standardize and Sustain (Veres et al., 2018).

Another important aspect related to Lean implementation is related to the close relationship between human resources and all the supply chain elements such as suppliers, partners, and clients (Rudnichenko et al., 2021). The involvement of the top managers and the engagement of the workers in the implementation process is very important to get the performance objectives intended (Larteb et al., 2014).

Under such background and considering the positive benefits of the implementation of lean tools, this research aims to analyse the level of implementation of Lean tools in different companies' dimension, in the North of Portugal.

3. Methodological approach

Aiming to study the implementation level of lean procedures, a survey was conducted in a set of Portuguese companies. The questionnaire was inspired by the work developed by Jabbour *et al.*, (2013), focusing on a specific group of 9 methods and tools identified as Engagement of workers, Continuous Improvement, 5S, TPM, Kanban, JIT, Stock Reduction, Kaizen Circles, and Suppliers Relationship.

The sample taken is a convenient one due to time and budget constraints. Companies were asked about their willingness to fill out the questionnaire, published online through Google Docs forms, and 102 answers were obtained from multisector companies.

The questionnaire consisted of two parts; the first one contains general questions about the characterization of the companies, such as dimension, number of employees related to logistics, and turnover. The second one consists of nine Lean attributes (Table 1), where companies were asked to rate their level of implementation of lean practices, with each item on a five-level Likert scale ranging from 1 (Not implemented) to 5 (fully implemented).

Table 1. Measures of the Level of Implementation of Lean Practices

Item	Description
LM1	Engagement of workers
LM2	Continuous improvement
LM3	5S (Sort/Set in order/Shine/Standardize/Sustain)
LM4	Total productive maintenance (TPM)
LM5	Kanban (pull system)
LM6	Just in Time (JIT)
LM7	Stock reduction
LM8	Kaizen Circle (discussion groups to improve processes)
LM9	Collaboration with suppliers

4. Main findings

The results and discussion presented in this section are based on a developed analysis using a statistical approach through the software IBM SPSS version 24.

4.1 Preliminary analysis

As summarized in Table 2, the preliminary results showed that the consulted companies had a large spectre of characteristics. The results also showed that the dimension of the companies related to the number of workers is very heterogeneous. More than 50% of the consulted companies had a micro or small dimension, meeting the Portuguese business fabric.

Regarding the number of employees associated with the logistics area, it was possible to observe that a large number of companies had up to three workers associated with this field. It should be noted that the consulted companies are multisector, so this value is within the expected. Besides, a great number of companies had a turnover, by year, more than five million euros (36.3%).

To understand the level of Lean procedures by the consulted companies, based on the literature review nine questions were selected and pointed out.

Table 3 shows the descriptive analysis – N, minimum, maximum, mean, standard deviation, skewness, and kurtosis – for each item, as well the reliability coefficient, calculates (α -Cronbach's alpha) for each dimension of the questionnaire.

Descriptive statistics for each item revealed that the answers to almost items ranged between the minimum and maximum allowed, indicating a reasonable existence of response variety.

The analysis also showed that practices such as 5S (LM3) and TPM (LM4) present the higher means values, meaning more progress of their implementation. On the other hand, the lowest means values are related to the procedures of Kanban (LM5) and Engagement of workers (LM1). This could be explained by the fact that 5S tool and the TPM method are considered hard lean practices that are more extensively used than soft Lean practices (Engagement) (Larteb et al., 2014).

Also, the 5S is a simple implementation tool which allows rapid results with high visual impacts, consisting of the first tool to use to clean and straighten the workplace (further details about these items can be found in Silva et. al (Silva et al., 2019).

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Table 2. Technical record of participating companies

Dimension of the company	(%)	Number of employees associated with logistics	(%)	Turnover (in euros)	(%)
Micro	32.35	[0;3)	34.31	[0;100k)	13.7
Small	25.49	[3;6)	20.59	[100k; 250k)	10.8
Medium	16.67	[6;9)	5.88	[250k 500k)	9.8
Large	25.49	[9;12)	9.80	[500k; 1M)	10.8
		[12;15)	1.96	[1M; 5M)	18.6
		15 or more	27.45	5M or more	36.3

Table 3. Descriptive Statistics and Reliability

	Min	Max	Mean	St. Dev.	Sk	Kurt	Alpha
LM1	1	5	2.49	1.481	0.262	-1.528	
LM2	1	5	3.12	1.381	-0.422	-1.144	
LM3	1	5	3.20	1.328	-0.472	-0.946	
LM4	1	5	3.42	1.238	-0.822	-0.244	
LM5	1	5	2.25	1.369	0.423	-1,477	**0.915**
LM6	1	5	2.65	1.426	-0.001	-1.558	
LM7	1	5	3.16	1.241	-0.526	-0.779	
LM8	1	5	2.63	1.400	0.053	-1.496	
LM9	1	5	3.06	1.296	-0.278	-0.989	

Concerning the reliability of the scales, an alpha analysis of Cronbach was conducted, the results showed that constituent items of the lean dimension represent values greater than 0.7, which performs good internal reliability of the questionnaire.

Figure 1 shows the boxplots for all questions, giving information about the use of the entire scale. Besides, 50% of inquired companies, partially implemented (level 3), for the case of practices Just in Time (JIT) (LM6) to Collaboration with suppliers (LM9). All these practices are related to the Production Pull System which requires collaborations with the suppliers and the implementation of JIT, getting a stock reduction and continuous flow.

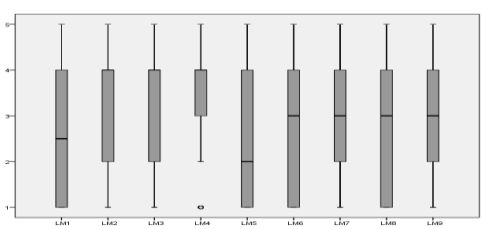

Figure 1. Boxplots of Lean management practices

Companies that are trying to implement the Pull System should also implement all these methods and tools at the same time, on the same level. In contrast, practice Kanban (LM5) has a lower level of implementation, where 50% of companies selected levels 1 (not implemented) or 2 (starting to implement). Tools such as Kanban and JIT are mainly implemented by large companies and international groups generating a certain fear and barrier, it can be justified due to these companies have financial resources to invest and training of their employees and are also opened to testing new methodologies and tools (Matt and Rauch, 2013). For this research, the analysis showed that only 25% of the companies have selected the full achievement/implementation of these practices.

4.2 Correlation and Principal Component Analysis (PCA)

Aiming to understand how these practices are correlated, a Principal Component Analysis was carried out. In Table 4, is possible to observe that the correlations between items are not very high. However, the item TPM (LM4) stands out to the correlation with Continuous improvement (LM2) and 5S (LM3). Regarding TPM, this approach supports predictive, preventive and corrective maintenance activities to achieve efficient production in the equipment. Relies on tools such as 5S, Single Minute Exchange of Die (SMED), Overall Equipment Effectiveness (OEE), Planned, autonomous and quality maintenance and initial control before starting production (Garza-Reyes et al., 2018).

Another important result achieved through the analysis carried out is related to the level of implementation of Lean practices according to the numbers of workers. According to Matt and Rauch (Matt & Rauch, 2013), the Lean production methods and

instruments are not equally applicable to large and small companies, which can be influenced by the number of workers.

To understand the most relevant aspect of this dimension, confirmatory factor analysis was conducted. For this analysis, it was necessary to evaluate the Kaiser-Meyer-Olkin (KMO) sampling adequacy measure and the Bartlett sphericity test. Both indicate the adequacy of the data for the accomplishment of the factorial analysis (Kline, 2011).

Table 4 shows the main results, for all items, the results showed that the achieved factor loadings were greater than 0.5, implying that they represent relevant attributes. The results of the factorial weights also showed that all the items present a positive correlation with the latent variables.

Table 4. Correlation

Item	LM1	LM2	LM3	LM4	LM5	LM6	LM7	LM8	LM9
LM1	1								
LM2	0.591	1							
LM3	0.625	0.576	1						
LM4	0.572	0.671	0.696	1					
LM5	0.558	0.518	0.555	0.491	1				
LM6	0.660	0.464	0.675	0.489	0.655	1			
LM7	0.572	0.532	0.600	0.607	0.454	0.586	1		
LM8	0.528	0.633	0.530	0.537	0.587	0.385	0.581	1	
LM9	0.398	0.560	0.505	0.435	0.388	0.338	0.407	0.695	1

Regarding the suitability measure of the KMO sample, the result obtained is close to 1, meaning that an average degree of adequacy of the PCA. The calculated chi-square statistic was significant at the level of 0.000 (<0.05), which indicate the presence of correlation between the various items.

Resorting the Principal Component method for extraction, an eigenvalue higher than 1was considered and, only one component was achieved. Regarding the commonalities (after extraction), the analysis showed that the lowest values are related to Collaboration with suppliers (LM9), which is a small value than the one recommended by Field (Field, 2005).

4.3 Company's dimension

Regarding the companies' dimension, Figure 2 shows that micro and small companies have the lowest levels of implementation of lean procedures. It can be justified by the fact that these companies are not aware of the benefits of the tools and do not implement it. Another explanation is related to the challenges faced by those companies to implement some integrated Lean production systems, for instance, lack of training of the employees, specific knowledge about the lean tools and financial support.

To ensure the impact of these measures, a Kruskal Wallis test was conducted, aiming to examine the differences of practices according to the dimension of consulted companies. The test showed a significant statistical difference in all the measures except in Just in Time (LM6), with $p<0.05$. It means that there are significant differences in the stages of companies.

For the case of Just in Time implementation, considering the results presented in Table 5, the results showed that there is a need to improve these measures for all the consulted companies.

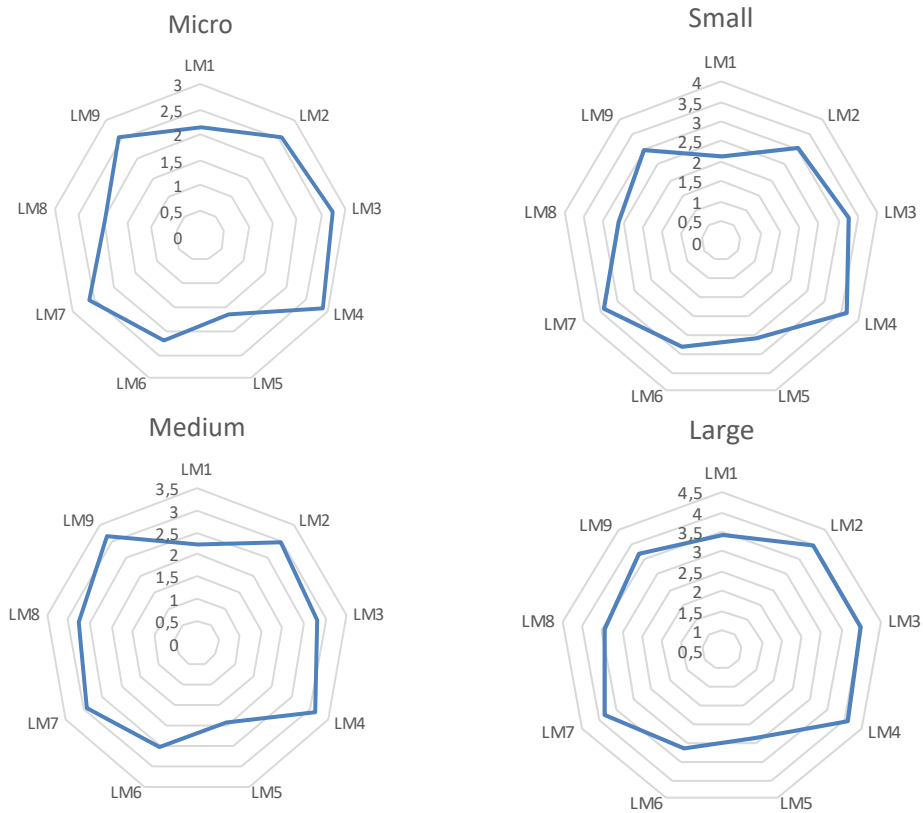

Figure 2. Average level of environmental management practices, by companies' dimension

Table 5. Principal Component Analysis

Item	Communalities	Loadings	KMO Measure	Bartlett's test
LM1	0.632	0.795	0.857	0.000
LM2	0.639	0.799		
LM3	0.694	0.833		
LM4	0.633	0.796		
LM5	0.558	0.747		
LM6	0.572	0.756		
LM7	0.592	0.770		
LM8	0.615	0.784		
LM9	0.448	0.669		

The analysis of the level performance progress was conducted in two stages: firstly, Kruskal Wallis was performed aiming to analyse if there are differences between measures. Secondly, the hypothesis was analysed, and for items where the hypothesis H0 was rejected in the previous test (sig < 0.05), a Dunn-Bonferroni test was performed (see Table 6). This posts hoc test reports the results among multiple pairwise comparisons. As expected, there is no difference between micro and small companies. The major differences between companies arise in the pairs micro-large and small-large companies,

meeting the results which showed that for most measures, the level between small and medium companies are also similar.

Finally, for all consulted companies, the calculation of average for their answers was conducted aiming to analyse the level of implementation of lean management practices. Figure 3 shows the achieved results confirming that large companies present an average higher level than micro and small companies (listed at the left side of the graphic).

Table 6. Kruskal Wallis Test and Post hoc Dunn-Bonferroni test for lean measures (group variable: the dimension of the company)

Item	LM1	LM2	LM3	LM4	LM5	LM6	LM7	LM8	LM9
Kruskal-Wallis test (sig.)	0.004	0.000	0.002	0.002	0.003	0.054	0.000	0.001	0.006
Dunn-Bonferroni test (sig.)									
Micro-Small	0.939	0.284	0.642	0.763	0.511	---	0.389	0.082	0.208
Micro-Medium	0.850	0.325	0.187	0.059	0.009	---	0.018	0.048	0.131
Micro-Large	0.001	0.000	0.000	0.000	0.001	---	0.000	0.000	0.000
Small-Medium	0.807	0.968	0.506	0.194	0.114	---	0.248	0.667	0.699
Small-Large	0.002	0.003	0.009	0.006	0.032	---	0.007	0.031	0.035
Medium-Large	0.012	0.008	0.028	0.106	0.528	---	0.083	0.136	0.137

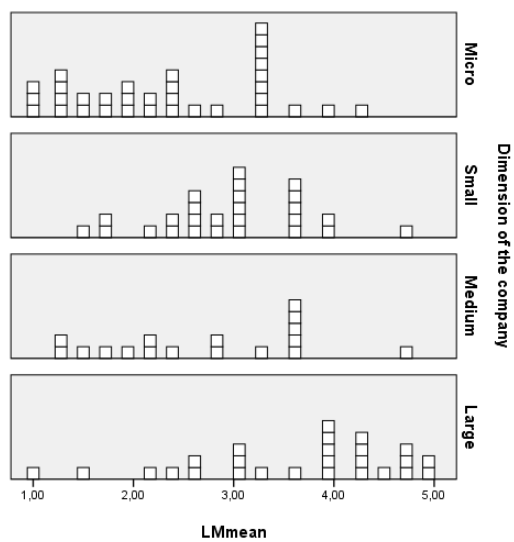

Figure 3. Level of lean management practices, by companies' dimension

5. Conclusion

In this work, an attempt to analyse the implementation level of Lean practices in the North of Portugal was conducted. Companies operating in this region was chosen due to the economic importance of this region for the country. Due to synergies between lean tools and sustainability, this research highlights the contribution of lean tools to support companies in achieving sustainable production. The results showed the 5S and TPM strategies were considered as tools well-established and with higher progress of implementation by the consulted companies, these tools have supported companies to

eliminate waste and improve the productivity of their production process. Yet, despite being a well-known tool in the industrial context, Kanban was considered as a tool with a lower level of implementation. As a simple and easy tool to implement, when considered, Kanban tool can support companies in improving efficiency in managing the production process, finding production bottlenecks and implementing necessary changes.

This research also identifies a set of lean tools which have been moderately implemented by the consulted companies, namely JIT, Stock reduction, Kaizen circles and Collaboration with suppliers. For these tools, the results showed about 50% of the consulted companies, have moderately implemented lean practices, which means that the tools are not fully implemented, but some concepts of these tools have been used.

The statistical analysis applied in this research also allows us to point out some implications, such as the correlations between the selected tools, which results indicates that the correlations between them are not very high. However, is important to highlight that TPM stands out to the correlation with continuous improvement and the 5S tool. It can be explained due to TPM is mandatory for most of the consulted companies.

It is also clear that the differences in the dimension of the consulted companies have a great significance on the actual level of implementation of lean tools. As for the case of micro and small companies which presents the lowest level of implemented tools. The major differences between companies arise in the pairs micro-large and small-large companies, the results indicate remarkable differences in perceptions and practices between large and small companies, which confirms that for these companies, there is still a long path to go on implementing lean manufacturing tools.

The findings presented here showed that the level of implementation of lean tools between small and medium companies are quite similar. For the case of large companies, it was possible to confirm that they present a higher level when compared with micro and small companies.

Although being an initial stage, research's findings contribute to a better understanding of the use of lean manufacturing tools by companies operating in an important economic region in Portugal. In summary, the results showed that for most of the consulted companies, implement lean tools persist as a challenging task. Also, the impact of lean tools on the sustainable performance of companies are not well perceived by the consulted companies.

For the case of companies operating in the Northern region in Portugal, this research sheds light on two important topics, firstly the need to disseminate between companies the importance of lean tools to support efficiency, and the contribution of these tools for achieving sustainability. Furthermore, the development of joint initiatives with local government and industrial association towards dissemination of positive benefits of lean tools are recommended, and even research projects involving universities and companies in the region.

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