Universidade de Aveiro Departamento de Economia, Gestão, Engenharia Industrial e Turismo
2019

RICARDO AUGUSTO ZIMMERMANN

INOVAÇÃO E GESTÃO DA CADEIA DE ABASTECIMENTO

Estratégias, capacidades e o efeito do alinhamento sobre o desempenho das empresas

INNOVATION AND SUPPLY CHAIN MANAGEMENT

Strategies, capabilities, and the effect of fit on business performance

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Thesis submitted at the University of Aveiro to fulfil the requirements for the degree of PhD in Industrial Engineering and Management, performed under the scientific supervision of Professor Luís Miguel Domingues Fernandes Ferreira, Assistant Professor of the Department of Mechanical Engineering of University of Coimbra, and Professor António Carrizo Moreira, Associate Professor of the Department of Economics, Management, Industrial Engineering and Tourism of the University of Aveiro.

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palavras-chave

inovação, gestão da cadeia de abastecimento, capacidades de inovação, estratégias de gestão da cadeia de abastecimento, fit, alinhamento, desempenho organizacional.

resumo

Inovação e gestão da cadeia de abastecimento são temas de grande importância e que apresentam elevado potencial para geração de diferencial competitivo sustentável para as empresas. Se, por um lado, a inovação permite a criação de novos produtos ou serviços e o alcance de novos mercados, uma gestão adequada da cadeia de abastecimento revela-se fundamental para a entrega dos produtos e serviços prestados aos clientes e para a obtenção de melhores resultados operacionais e financeiros pelas empresas. A relação entre inovação e gestão da cadeia de abastecimento, que ganhou muita importância nos meios acadêmico e empresarial nos últimos anos, tem sido estudada com dois diferentes enfoques: a relação das empresas com os seus parceiros de cadeia de abastecimento com vista à inovação; e a relação entre os dois processos ou áreas dentro das empresas, sendo este último o menos explorado e o alvo da presente investigação. De forma a contribuir para o desenvolvimento do conhecimento relativamente à relação entre inovação e gestão das cadeias de abastecimento, esta investigação tem como principal objetivo, usando como base o conceito de fit, estudar como as estratégias de gestão das cadeias de abastecimento afetam a relação entre as capacidades de inovação e o desempenho dos negócios das empresas. O estudo segue um paradigma positivista e utiliza a visão baseada em recursos (RBV) como principal teoria de base. Para testar as hipóteses da investigação, formuladas a partir do modelo teórico desenvolvido, um questionário foi aplicado a empresas de Portugal e do Brasil, tendo sido obtidas 329 respostas, e os dados foram analisados com recurso a métodos estatísticos, com destaque para a aplicação de análise de clusters, análise de variância (ANOVA), regressão linear, regressão hierárquica e análise de equações estruturais. As análises realizadas demonstram as diferenças na aplicação e nos resultados relativamente à adoção das estratégias de gestão da cadeia de abastecimento; confirmam o impacto das capacidades de inovação sobre o desempenho das empresas; e comprovam o efeito moderador das estratégias de gestão das cadeias de abastecimento sobre esta relação. O estudo apresenta contribuições para o meio académico, por meio da criação de uma modelo teórico sobre o impacto das estratégias de gestão das cadeias de abastecimento na relação entre as capacidades de inovação e o desempenho das empresas; e para a prática, fornecendo referências para a tomada de decisão relativamente à definição de estratégias e capacidades a desenvolver.

keywords

innovation, supply chain management, innovation capabilities, supply chain strategies, fit, business performance.

abstract

Innovation and supply chain management are two topics of great importance in the academic world and present great potential to generate sustainable competitive advantage for firms. If, on one hand, innovation allow the creation of new products and services and the improvement of business processes, helping to achieve new markets, an adequate management of the supply chain is fundamental for the improvement of the services provided to clients and for the achievement of better operational and financial performance. The relationship between innovation and supply chain management has gained importance in the last years and has been addressed in two different approaches: the importance of collaboration among supply chain partners to innovation; and the relationship between the two processes or areas within firms, which is the least explored and is the target of the present research. As a way to contribute to the development of knowledge regarding the relationship between innovation and supply chain management, the main objective of this thesis is, using the concept of fit as a basis, examine how supply chain strategies affect the relationship between innovation capabilities and business performance. The study is developed under a positivist paradigm and under the lens of the Resource-based View (RBV). To test the research hypotheses, formulated from the developed theoretical model, a survey was conduct on firms from Portugal and Brazil, with a total of 329 responses, and data were analysed by means of statistical methods, especially cluster analysis, one-way analysis of variance (ANOVA), linear regression, hierarchical regression and structural equation modelling. Results show differences in the antecedents of the adoption of the different supply chain strategies; confirm the impact of innovation capabilities on business performance; and indicates the moderator effect of supply chain strategies on the relationship between innovation capabilities and business performance. The study contributes in a variety of ways to theory, especially by means of the creation of a theory regarding the impact of supply chain strategies on the relationship between innovation capabilities and business performance and on the antecedents and consequences of the adoption of different supply chain strategies. The results also contribute to practice, providing references to decision making regarding the choice of the right capacities and strategies to be developed and adopted by firms according to internal and external requirements.

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INTRODUCTION

Innovation is everywhere. From managers and researchers to politicians, innovation is a "buzzword" that has been used widely and in different contexts. In a complex and dynamic world where novelty is the "rule", innovation has become a global phenomenon, affecting all sectors of the economy (Cornell University, INSEAD, & WIPO, 2017) and is recognized as one of the most important sources of competitive advantage for firms (Anderson, Potocnik, & Zhou, 2014; Birkinshaw, Hamel, & Mol, 2008; Cohen & Levinthal, 1990).

But innovation is not new. Joseph Schumpeter, recognized as one of the most important economists of the twentieth century, is known as a pioneer when it comes to innovation (Godin, 2006). In his book "The theory of economic development", originally published in 1911, Schumpeter considered innovation – or the occurrence of discontinuous and revolutionary change – as the core of economic development. More than a century ago, Schumpeter already argued that any firm seeking profit had to innovate (Godin, 2006; Schumpeter, 1997).

Even though the complexity of current times is certainly much bigger than in Schumpeter's time, the core definitions and ideas behind the term have not changed in its essence. Following Schumpeter's principles, the Oslo Manual (OECD & Eurostat, 2005) – a reference widely used by scholars and managers, as it succeeds in aggregating an academic view of the topic and a practical structure and application – highlights the existence of four types of innovation: (1) product innovations: involve significant changes in the capabilities of goods or services – both entirely new goods and services and significant improvements to existing products are included; (2) process innovations: represent significant changes in production and delivery methods; (3) organisational innovations: refer to the implementation of new organisational methods; and (4) marketing innovations: involve the implementation of new marketing methods.

The definition of innovation adopted in this study is the one proposed by the Oslo Manual, to which innovation is understood as "*the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations*"

(OECD & Eurostat, 2005, p. 46). This definition is widely accepted and used in academic research (Gronum, Verreynne, & Kastelle, 2012).

The motivation to study innovation came from the perception of its importance, not only for the competitiveness of firms, but for the development of countries and regions as well (Paunov, 2012; Todtling & Trippl, 2005). A simple look at the competitiveness of countries and their capacity to generate innovation shows that a well-structured innovation system produces effects well beyond the borders of companies (Archibugi, Filippetti, & Frenz, 2013; Godin, 2006). Wealth generation, job creation and increasing of quality of life are just some of the benefits that innovation can bring for a country and its population.

The first steps toward the final result presented in this thesis aimed to understand the characteristics that favour or undermine innovation within firms. It is clear that differentiation through innovation has an important role for companies and territories (countries or regions) in the recovery or even in the growing during and after times of crisis (Filippetti & Archibugi, 2011; Hausman & Johnston, 2014; Naidoo, 2010). Popular wisdom says that crisis brings great opportunities and innovation is certainly an important tool to take advantage of them.

But if innovation is a key to success, why firms often do not innovate (or do not benefit from innovation)? What makes it so difficult? What are the main barriers? The answer to these questions (or the attempt to do so) shows that the increasing intricacy of current days make innovation – particularly the persistence of innovation – even more complex (Chesbrough & Brunswicker, 2014; Damanpour, 1996). Innovation no longer depends on individuals (or firms in isolation) but involves the participation of many different actors, within and outside companies (Arlbjorn & Paulraj, 2013; Berghman, Matthyssens, & Vandenbempt, 2012; Chesbrough, 2003; Ozman, 2009; Roy & Sivakumar, 2010). It is in this context of cooperation and integration that the relationship between innovation and supply chain management emerges, a topic that has attracted attention from managers and researchers in recent years (Ageron, Lavastre, & Spalanzani, 2013; Golgeci & Ponomarov, 2013; Narasimhan & Narayanan, 2013; Oke, Prajogo, & Jayaram, 2013; Roy et al., 2004).

As well as innovation, supply chain management is recognized as an important source of competitive advantage for firms (Qi, Boyer, & Zhao, 2009; Qrunfleh & Tarafdar, 2014) and is an increasingly popular theme. This phenomenon can be understood as the result of the growing importance of the field to society – as a consequence of new technologies and new consumption habits – but also of a kind of "rebranding" of the theme. Kevin O'Marah[1] highlighted in a recent article for Forbes (O'Marah, 2018) that the perception of the term supply chain is dramatically more favourable among young (until 25 years-old) than among older people. According to O'Marah (2018), the undeniable proof of the increasing importance of supply chain includes the "*massive shareholder value created by supply-chain-intensive businesses like Walmart, Apple and Amazon, and the sustainability leadership of supply chain organizations like Unilever, Nike and Schneider Electric*".

The importance of supply chain to value creation can be explained by the following flow: while marketing stokes customer desire or demand and innovation/R&D creates things to satisfy that demand, supply chain makes it happen profitably, reliably and as fast as possible (O'Marah, 2018). Thus, supply chain management is understood as the management of supply chain activities aiming to maximize customer value and achieve a sustainable competitive advantage (Chen & Paulraj, 2004; Lambert & Cooper, 2000; Lee, Padmanabhan, & Whang, 1997; Li, Ragu-Nathan, Ragu-Nathan, & Rao, 2006). Supply chain refers to the flow of goods, money, information and knowledge across individuals, organizations, resources and activities (linked directly or indirectly) with the goal to deliver value to the end consumer (Chen & Paulraj, 2004).

Although the functions or processes related to supply chain management exist for many years, the term as an area of academic study, research, and business practice, has its origins in the 1980s (Halldórsson, Hsuan, & Kotzab, 2015). Purchasing and logistics, two areas traditionally related to operations management – which, in turn, grew historically out of production management and factory management – have evolved into a broader strategic approach to materials and distribution management, known as supply chain management (Burgess, Grimshaw, Huatuco, & Shaw, 2017; Charvet et al., 2008). In the

[1] Chief Content Officer SCMWorld, former CSO AMR Research/GVP Gartner, Creator of Supply Chain Top25.

editorial of the special issue on the 20th anniversary of the Supply Chain Management: An International Journal, Wagner and Fearne (2015) discussed the evolution of supply chain management theory and application, analysing its achievements and challenges on the way to become a recognized and well stablished research field or domain. Wagner and Fearne (2015) highlighted some topics to future research, including: theory building in supply chain management, collaboration (and the possible variations – partnership, coordination, alignment, relationship, etc.); service supply chain management; and sustainability and socially responsible supply chain practices (including green supply chain). The importance of adopting different and mixed methods is also highlighted. Other topics that have received great attention from academics in the last years include: supply chain risk, supply chain innovation, supply chain strategies, new technologies and their effects on SCM, omnichannel, global supply chain networks, among others.

Looking to the literature on the relationship between innovation and supply chain management, two different approaches stand out: (1) the relationship between a firm and its supply chain partners; and (2) the internal relationship between the two processes or areas (Zimmermann, Ferreira, & Moreira, 2016). As discussed in the part one of the thesis (literature review), most of the published studies on this relationship focus on the first approach. The second approach, and its possible variations, is a subject that has not been broadly explored in the literature yet. In a recent call for papers to the Supply Chain Forum: An International Journal, the editors Jan Stentoft and Christopher Rajkumar highlight this gap in the literature, especially the importance of the strategies adopted by firms to manage supply chain and innovation. Considering this gap, this study aims to contribute mainly for the second approach.

It is important to differentiate the study on the relationship between innovation and supply chain management, the topic under study in this thesis, from the term "supply chain innovation", which addresses the antecedents to adoption of an innovation by individual firms and the diffusion of an innovation throughout industry (Hazen, Overstreet, & Cegielski, 2012; Tan, Zhan, Ji, Ye, & Chang, 2015). Supply chain innovation deals with innovation in the supply chain management process and its propagation through supply chain partners, aiming to improve the performance of the supply chain (Hazen et al., 2012;

Stentoft & Rajkumar, 2018; Tan et al., 2015). Stentoft and Rajkumar (2018) divide the management of supply chain innovation in three components: business processes, network structure and technology. The first component encompasses processes such as customer relationship management, supplier relationship management, customer service management and product development. Network structure is related to the extent that the firm innovates together with other supply chain actors and the last component deals with the use in the supply chains of different technologies, such as enterprise resource planning systems, material requirements systems, radio frequency identification, business intelligence, statistics and analytics software, advanced robotics, 3D-printing, big data, among others (Stentoft & Rajkumar, 2018).

From the study of the relationship between innovation and supply chain management and based on both their relevance and the gaps identified in the literature (specially in part 1 of this document), three important concepts stood out, due to their impact on performance: innovation capabilities, innovation strategies and supply chain strategies (explored in parts 2 and 3). Innovation capabilities result from the abilities to develop and explore new ideas successfully (Francis & Bessant, 2005) and are determinant factors in generating competitive advantages (Adler & Shenhar, 1990; Guan & Ma, 2003). Following Guan and Ma (2003), seven types of innovation capabilities were considered in this thesis: research and development (R&D) capability; manufacturing capability; marketing capability (which are defined as core capabilities); learning capability; organizational capability; resource exploiting capability; and strategic capability (defined as supplementary capabilities).

Innovation strategies guide decision making for the firm with respect to innovation and serve as a stimulus allowing workers to feel motivated to participate in the process in a synergistic way (Adner, 2006; Clausen, Pohjola, Sapprasert, & Verspagen, 2012; Pisano, 2015; Veugelers & Cassiman, 1999). The set of innovation strategies analysed in the thesis follow the model proposed by Clausen et al. (2012), which includes ad hoc; supplier based; market-driven innovation; R&D intensive; and science-based innovation strategies. Supply chain strategies refer to a pattern of decisions related to sourcing products, capacity planning, conversion of raw materials, demand management, communication with supply

chain actors, and delivery of products and services (Arora, Arora, & Sivakumar, 2016; Qi, Boyer, & Zhao, 2009). Lean and agile supply chain strategies are adopted as they are the most commonly used in the literature (Christopher, 2000; Christopher & Towill, 2002; Cigolini, Cozzi, & Perona, 2004; Qi et al., 2009; Qi, Zhao, & Sheu, 2011; Qrunfleh & Tarafdar, 2014).

The importance of innovation and supply chain management as independent areas, and the constant need to contribute to the development of each one of the research fields separately, is broadly recognized. However, understanding the relationship, the alignment or the fit between them is a challenge that has a long way to be done (Arlbjorn & Paulraj, 2013). Taking this perception into account, the concept of strategic fit, or just fit – a concept intrinsically related to the field of strategic management – is considered the third "pillar" of the study, in addition to innovation and supply chain management. In this study, fit is understood to be the adjustment of one or more variables – activities, strategies, capabilities, business areas or organisations – relative to the others, such that the combination leads to improved results (Donaldson, 1987; Venkatraman, 1989; Venkatraman & Camillus, 1984; Wu et al., 2014).

Besides introducing the themes under study and contextualizing its motivations, this introduction aims to present the research questions and objectives, the theoretical basis and the research approach adopted throughout the study. Moreover, the structure of the thesis and a synthesis of the methodologies applied are provided, helping to understand the link between all elements of the thesis and providing an overview of the study. The detailed methodology is presented in each chapter.

i. Research questions

There is an evident agreement among researchers and managers, especially in the last two decades, about the complex and collaborative nature of innovation (Berghman, Matthyssens, & Vandenbempt, 2012; Chesbrough, 2003), which led to the rise of the study on its relationship with supply chain management. However, the impact of supply chains on the innovation process and performance, as well as the factors that impact innovation in the context of supply chains, are not clear, as the literature on the topic is relatively

recent and diffuse. Similarly, authors in the field approach different strategies to manage innovation within supply chains, presenting different findings and results.

In this sense, from the assumption that a clear perception of what is known and what is not known on the theme is missing and that a clear view of the intellectual structure of the topic is needed, the following research question is addressed in the first part of this study:

RQ1. How the relationship between innovation and supply chain management has been addressed in the literature? How do supply chains impact the innovation process and performance and what are the main aspects and factors discussed in previous studies on the topic?

Previous studies on the relationship between innovation and supply chain management have mainly addressed the relationship between supply chain partners, while the studies on the relationship between the two areas or processes within firms are relatively scarce (Zimmermann et al., 2016) – even though its importance has been highlighted by important authors in the area (Stentoft & Rajkumar, 2018).

Moreover, the relationship between innovation and supply chain management has not been addressed in a perspective of fit, a concept that, together with the principles of the resource-based view, presents great potential to demonstrate its effect on performance (Arlbjorn & Paulraj, 2013). The analysis of previous studies also showed the need for a more strategic view on the topic, rather than the operational approach prevalent in the literature, as highlighted by Stentoft and Rajkumar (2018); and revealed a set of internal features of firms which are important to potentiate innovation, including supply chain strategy, innovation strategy and innovation capabilities. In this sense, aiming to develop theory that contributes to deepen the knowledge on the topic, the following research question is presented:

RQ2. How supply chain strategies can affect the relationship between innovation (strategies and capabilities) and business performance?

Taking into account the complexity of innovation and supply chain management, it is evident that both "processes" or "areas" are impacted by a multitude of aspects – which

can impact one of them in isolation or both. Thus, starting from the idea that strategies and capabilities can contribute to performance improvement, the understanding of the antecedents of supply chain strategy and its impact on performance revealed to be a fundamental aspect to a broadly perception of its relationship with innovation.

The adoption of the "right" supply chain strategy is a complex task for managers due to the influence of a variety of internal and external features. Two aspects are explored in this study as antecedents of supply chain strategy adoption: product characteristics, which has been explored as an internal feature in previous studies (Qi et al., 2009; Nakano, 2012); and environmental uncertainty, which refers to the dynamism, complexity and munificence of the environment where firms compete, and has not been addressed in the literature. Besides business performance, explored in previous studies (Qi et al., 2009), the impact of supply chain strategies on innovation performance is included – a relationship that has not been explored before and that contributes to elucidate one of the possible aspects of the link between innovation and supply chain. Thus, the following research question emerges:

RQ3. What differentiates the firms that adopt each type of SC strategy in terms of product characteristics, environmental uncertainty and performance?

Finally, based on the theoretical models resulting from chapters 3 and 4, the last question which this study aims to answer concerns the relationship between supply chain strategies and innovation capabilities, as well as its effect on business performance. The choice of innovation capabilities in the empirical part of the thesis, rather than innovation strategies, was mainly due to the perception that the concept of innovation capabilities is more clearly established in the literature. Moreover, innovation capability is a more complex concept, allowing deepest and more interesting discussion and findings.

Furthermore, the moderator perspective of fit was chosen, following the model proposed by Venkatraman (1989), as it proved to be the most suitable to the referred relationship. Thus, the last research question is:

RQ4. How SC strategies moderate the relationship between innovation capabilities and business performance?

ii. Research objectives

The main objective of this study is to contribute to the understanding of the relationship between innovation and supply chain management and, using the concept of fit as a basis, to examine how supply chain strategies affect the relationship between innovation capabilities and business performance.

As specific objectives, the study also aims to:

a. Contribute to the state of the art on the relationship between innovation and supply chain management, identifying the intellectual structure of the literature on the topic; and evaluating the factors that affect the innovation process in the supply chains context and the main approaches or strategies used within the supply chains to manage the innovation process (part 1);
b. Develop theory that contributes to the effective management of the complex relation between innovation and supply chain management, theoretically studying the effect of supply chain strategies on the relationship between innovation strategies and business performance (chapter 3 – part 2) and on the relationship between innovation capabilities and business performance (chapter 4 – part 2);
c. Analyse and discuss the antecedents and consequences of the adoption of supply chain strategies, providing empirical evidence of its relationship with (1) product characteristics, (2) environmental uncertainty, (3) business performance; and (4) innovation performance (chapter 5 – part 3);
d. Empirically evaluate the impact of the fit between innovation capabilities and supply chain strategies on business performance (chapter 6 – part 3).

iii. Theoretical basis and research approach

The study is developed under a positivist paradigm and under the lens of the Resource-based View (RBV). Moreover, following the classification proposed by Collis and Hussey (2009), the study can be considered as analytical regarding the purpose of the research, and essentially quantitative, concerning the process of the research. When it comes to the outcomes of the research, the study is considered an applied research and, looking to the logic of research, the study is classified as deductive.

Positivism is a paradigm originally related to natural sciences. The term positivism (as a concept) was used for the first time by the French philosopher Claude Henri de Rouvroy – count of Saint-Simon and often referred to as Henri de Saint-Simon (1760-1825), but the idea of using the principles of positivism to explore social reality is attributed to his disciple, August Comte (1798–1857). According to Comte, observation and reason are the best means of understanding human behaviour (Eastman & Bailey, 1994).

Positivism is characterised by the belief that reality is not affected by the act of investigating, and the main goal is to develop theories based on empirical research (observation and experiment) (Burgess, Singh, & Koroglu, 2006; Collis & Hussey, 2009). According to the positivist paradigm, knowledge stems from "positive information" as every rationally justified assertion can be scientifically verified (Collis & Hussey, 2009). Researchers conducting business or operations management research under a positivist approach focus on develop theories to explain or predict social phenomena. This study is considered positivist as it aims to develop theory based on empirical methods. Studies in the domain of supply chain management traditionally adopt a positivist approach (Burgess et al., 2006; Wu, Goh, Yuan, & Huang, 2017).

As discussed in the systematic literature review presented in chapter 1 (Zimmermann et al., 2016), RBV is among the most used theories in studies that deal with innovation and supply chain management, separately or together. The RBV has been used as a theory that helps to understand how different resources – which include assets, capabilities, organizational processes, firm attributes, information, knowledge, etc. – can lead to marketplace positional advantage (differentiation or cost leadership), which, in turn, contributes to superior firm performance (Barney, 1991; Menguc, Auh, & Yannopoulos, 2014). Firms resources can be understood as the strengths that firms use to implement their strategies (Barney, 1991; Porter, 1996).

According to the RBV, firms must seek to develop a set of characteristics that are valuable, rare, inimitable and non-substitutable. Although not all firms' resources have these characteristics, the set of resources can be able to differentiate the firm from competitors. Achieving this, firms can create a sustainable competitive advantage (Barney,

1991; Hong et al., 2011; Laosirihongthong et al., 2014; Prajogo, 2016). According to Barney (1991, p. 102), "*a firm is said to have a sustainable competitive advantage when it is implementing a value creating strategy not simultaneously being implemented by any current or potential competitors and when these other firms are unable to duplicate the benefits of this strategy*"

A great number of studies on innovation and supply chain management – and on the relationship between them – use RBV as a theoretical basis (Prajogo, 2016), as it helps to: (1) understand the characteristics that lead to better business performance; (2) compare business performance of firms, based on observable characteristics; (3) explain the antecedents of innovation; (4) understand supply chains as networks in which a set of resources influence business performance of the chain and of each actor.

Contingency Theory (CT) is also considered an important theory for this study as it is also widely used in studies on innovation and supply chain management, as well as in studies that analyse the fit between multiple variables (Acur, Kandemir, & Boer, 2012; Prajogo, 2016). According to CT, there is no universally superior strategy. Context and structure must be adjusted (or fit) in order to favour business performance (Drazin & Van de Ven, 1985; Grotsch, Blome, & Schleper, 2013; Sousa & Voss, 2008). In other words, CT suggests that the best course of action depends upon a multitude of internal and external factors (or contingencies), and the success depends on matching the right strategy, management, leadership or processes to the right situation, considering the changing contextual factors. Internal contingencies, which can be influenced by managers decisions, usually comprise structures, processes, strategies and technologies; while external contingencies can be hardly influenced by managers and are independent of the existence of a single organization (Grotsch et al., 2013).

CT has been widely used in management and operations management research (Sousa & Voss, 2008) as it: (1) allows the identification and the management of the factors that influence business performance; (2) helps to understand the relationship between different factors that influence business performance, favouring an holistic view of the firm; (3) favours the perception that firm's actions, including innovative activities, are contingent upon and are sometimes driven by external factors, including customer

(market) demand, competitors' actions, or even government's legislations (Prajogo, 2016); (4) views firms as open systems where information is exchanged through the input-process-output procedure (Grotsch et al., 2013), which include SC partners.

iv. *Structure of the thesis and methodological synthesis*

The thesis encompasses 3 parts (besides the introduction and the conclusions):

(1) Part one is composed of two chapters and presents a systematic literature review about the relationship between supply chain management and innovation (chapter 1), and a bibliometric analysis that explores the intellectual structure of the topic (chapter 2).

(2) Part two, also composed of two chapters, presents the development of the conceptual framework and the research propositions – chapter 3 discusses the fit between SC strategies and innovation strategies and chapter 4 the fit between SC strategies and innovation capabilities;

(3) In part three, chapter 5 presents an exploratory analysis that helps to understand the antecedents of the adoption of the SC strategies and the differences in the adoption of each strategy; and chapter 6 provides the empirical test of the effects of the fit between innovation capabilities and supply chain strategies on business performance.

Figure 1 presents the structure of the thesis and figure 2 shows its development over time.

Figure 1 - Structure of the thesis

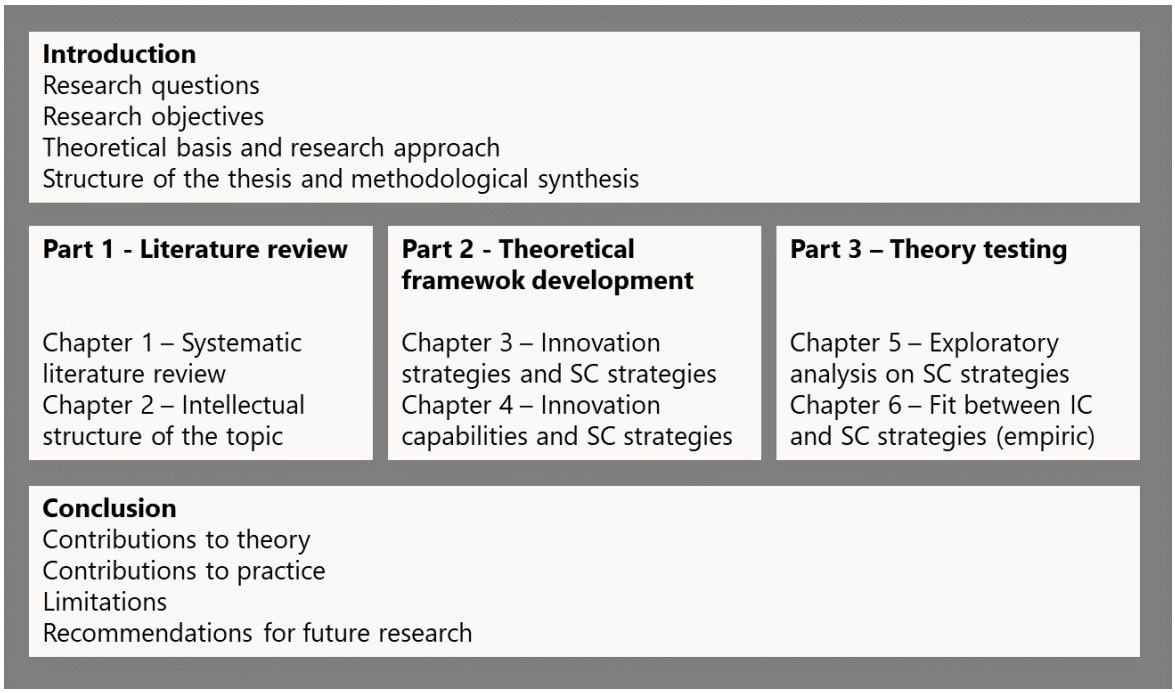
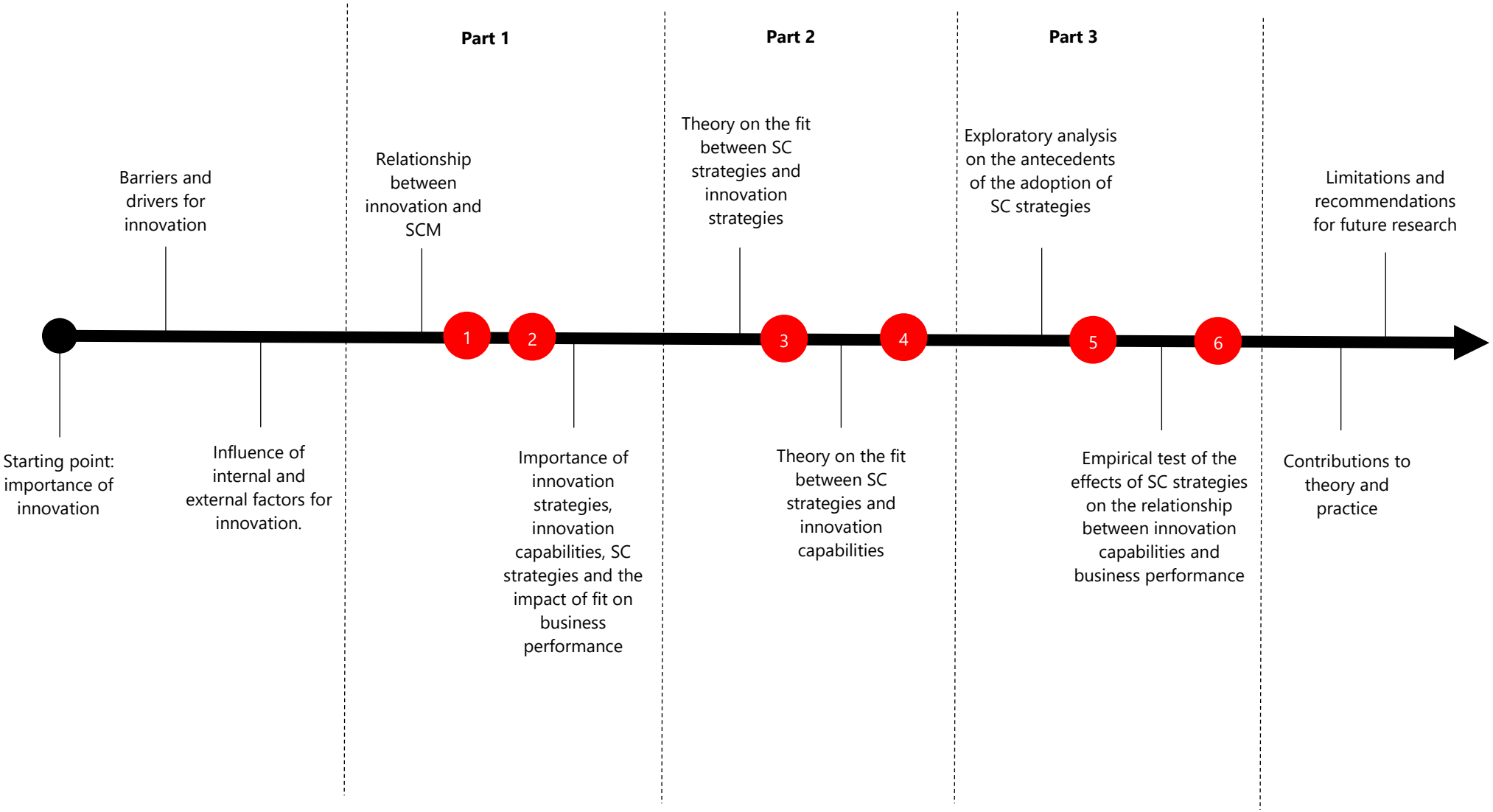


Figure 2 - Development of the thesis



Throughout the chapters, different methods were used to achieve the proposed objectives. A synthesis of the methodologies used in each part of the thesis is provided below and is represented in table 1. The detailed methodologies are presented in each chapter.

Table 1 - Synthesis of the methodology used in the thesis

Part 1	**Part 2**	**Part 3**
- Systematic literature review (Denyer & Tranfield, 2009) - Systematic Literature Network Analysis - bibliometric analysis, including citation and co-citation analysis (Charvet, Cooper, & Gardner, 2008; Denyer & Tranfield, 2009; Gerdsri, Kongthon, & Vatananan, 2013; Strozzi, Colicchia, Creazza, & Noè, 2017).	- Conceptual theory building (Ketchen & Hult, 2011; Lynhan, 2002; Rindova, 2011; Skilton, 2011)	- Survey (Forza, 2002; Krause, Luzzini, & Lawson, 2018; D.M. Lambert & Harrington, 1990; Montabon, Daugherty, & Chen, 2017; Zhao, Flynn, & Roth, 2007) - Hierarchical cluster analysis (Qi et al., 2009) - One-way analysis of variance (ANOVA) (Nakano, 2015; Qi et al., 2009) - Structural equation modelling (Byrne, 2009; Marôco, 2014; Roberts, Thatcher, & Grover, 2010) - Linear Regression analysis and hierarchical regression analysis (Aguinis & Gottfredson, 2010; Arnold, 1982; Gonzalez-Benito, Lannelongue, Ferreira, & Gonzalez-Zapatero, 2016; Sharma, Durand, & Gurarie, 1981)

Part I – Literature review

Chapter 1 is based on the systematic literature review method presented by Denyer and Tranfield (2009). A systematic literature review consists on the identification, selection, analysis and synthesis of existing research on a particular topic and its presentation in a clear manner in order to meet what is known and not known about the topic (Denyer &

Tranfield, 2009). The chapter follows the five steps proposed by the authors: (1) definition of the research question; (2) location of studies; (3) selection and evaluation of studies; (4) analysis and synthesis; (5) presentation of results.

The results are discussed in three parts. In the first part, a quantitative analysis is made in order to characterize the literature on the relationship between innovation and supply chain and provides information related to the date of publication, publication source, location of the authors, methodology used, nature of the sample and the theoretical perspective adopted in the selected papers. The second part presents a qualitative analysis of the papers, while part three discusses the way that supply chains are organized to conduct the innovation process of their actors. A model of innovation performance improvement throughout the supply chain is presented.

Chapter 2 aims to deepen the understanding of the intellectual structure and the knowledge basis of the topic. A bibliometric analysis – including citation and co-citation analysis – was carried out as a way of mapping and profiling the literature on the relationship between supply chain management and innovation. The papers were identified using the principles of the systematic literature review method, as presented by Denyer and Tranfield (2009). According to Strozzi et al. (2017), the combination of the two methods is called Systematic Literature Network Analysis. The program BibExcel was used to conduct the bibliometric and statistical analyses of the papers and the open source software package Gephi was used to carry out the network analysis and graphical investigation.

Part II – Framework development

Part II is composed of two chapters which basically use the same methodology. Chapter 3 and chapter 4 aim to develop theory on the relationship between innovation strategies and SC strategies and innovation capabilities and SC strategies respectively. Both chapters theoretically analyse the effects of the fit on business performance. The method used is a conceptual theory building, as defined by Lynhan (2002). From the analysis of the literature on the topics and based on consolidated theories, a set of research propositions is provided, and a theoretical framework is developed. The objective

is to "*connect stand-alone ideas into a network of concepts and relationships among them, which constitute theory*" (Rindova, 2011, p.19).

Part III – Theory testing

Part three consists on the empirical part of the thesis. A questionnaire was developed using a set of references as a basis. Following the suggestions of Zhao, Flynn and Roth (2007), the reliability and validity of the instrument was ensured by means of a set of actions, including preliminary interviews with experts, translation and back translation to Portuguese and English and pilot test with firms in Portugal and Brazil (the sample population is composed by firms operating in both countries). The questionnaire was made available in the online platform Lime Survey and an invitation was sent to 1.000 firms and Portugal and 1.000 firms and Brazil – the final sample was randomly selected from the data bases provided by Bureau Van Dijk in Portugal and Neoway in Brazil, encompassing firms from various sectors. The total number of responses was 329 (179 from Portugal and 150 from Brazil) and the return rate was 16.5% (17.9% in Portugal and 15.0% in Brazil).

Following the guidelines proposed by Boyer and Verma (2000) and Craighead, Ketchen Jr. and Dunn (2011), the questionnaire was answered by two respondents in each firm, from the areas of innovation and supply chain management, improving the reliability of the data and minimizing the risk of common-method bias. Nonresponse bias was assessed by contacting a random sample of nonrespondents and examining the differences between early and late respondents (the analyses indicated that nonresponse bias does not appear to be a concern). Secondary data were also used to triangulate survey data, reducing the risk of common-method bias (Montabon, Daugherty, & Chen, 2017).

Chapter 5 consists in an exploratory analysis about the antecedents of the adoption of the different SC strategies, as well as its impact on performance. Hierarchical cluster analysis was used to identify patterns among the firms and define the different groups of SC strategies. Next, one-way analysis of variance (ANOVA) was applied to test the relationship between SC strategies and products' characteristics, environmental uncertainty, business performance and innovation performance.

The last chapter presents the empirical analysis of the theory developed in the previous chapters. As mentioned before, innovation capabilities were tested due to their higher relevance and impact compared to innovation strategies. Data were analysed by means of statistical methods, including linear regression analysis, hierarchical regression analysis (Aguinis & Gottfredson, 2010; Arnold, 1982; Gonzalez-Benito, Lannelongue, Ferreira, & Gonzalez-Zapatero, 2016; Sharma, Durand, & Gurarie, 1981) and structural equation modelling (Byrne, 2009). IBM SPSS 25 and IBM SPSS Amos 24 were used in part III as a support to the statistical methods.

v. *Publications related to the thesis*

The publications and presentations presented in table 2 resulted from the present research. Each one of the six chapters which constitute the thesis is based on one or more of these publications (referred in the chapters). The feedback received through the presentations of papers in conferences and thorough the reviewing processes of book chapters and journal articles helped to improve the final chapters presented in the thesis and to deepen the contributions of the research. The publications are presented in chronological order.

Table 2 - Publications related to the thesis

Year	**Type**	**Publication**	**Title**	**Part of the thesis**
2015	Conference paper	Proceedings of the Joint Conference: 9th International Conference on Industrial Engineering and Industrial Management; XXI International Conference on Industrial Engineering and Operations Management; International IIE Conference 2015. Aveiro, Portugal. July 6-8	The impact of Supply Chain Management on the innovation process.	Chapter 1
2016	Journal article	Supply Chain Management: An International Journal, 21 (3)	The influence of supply chain on the innovation process: a systematic literature review	Chapter 1
2016	Conference paper	Proceedings of the International Conference Theory and Applications in the Knowledge Economy, TAKE 2016 – Aveiro, Portugal, 6 to 8 July 2016	Innovation Strategies and Supply Chain Strategies: Analysing the Relationship and the Impact of Fit	Chapter 3
2016	Conference paper	Proceedings of the International Joint Conference - CIO-ICIEOM-IIE-AIM (IJC 2016), San Sebastián, Spain, July 13-15,	Analysing the fit between innovation strategies	Chapter 3

Year	Type	Publication	Title	Part of the thesis
		2016	and supply chain strategies	
2017	Conference paper	Proceedings of the 12th European Research Seminar (ERS), Barcelona, Spain, May 18-19, 2017	The impact of fit between supply chain strategies and innovation capabilities on firm performance.	Chapter 4
2018	Book chapter	Closing the Gap Between Practice and Research in Industrial Engineering, Ed. Viles, E., Ormazábal, M., Lleó, A., Springer International Publishing	Analysing the Fit Between Innovation Strategies and Supply Chain Strategies	Chapter 3
2018	Book (Editors)	Springer International Publishing	Innovation and Supply Chain Management: Relationship, Collaboration and Strategies	Contributes to the entire thesis
2018	Book chapter	Innovation and Supply Chain Management: Relationship, Collaboration and Strategies, Ed. Moreira, A.C.; Ferreira, L.M.D., Zimmermann, R.A., Springer International Publishing	The Intellectual Structure of the Relationship Between Innovation and Supply Chain Management	Chapter 2
2018	Journal article*	Under review in an ISI indexed journal.	Strategic fit between innovation strategies and supply chain strategies: a conceptual study	Chapter 3
2018	Journal article*	Under review in an ISI indexed journal.	The effect of supply chain strategy on the relationship between innovation capabilities and business performance	Chapter 4
2019	Journal article*	Under review in an ISI indexed journal.	An empirical analysis on the relationship between supply chain strategies, products characteristics, environmental uncertainty and performance	Chapter 5
2019	Journal article*	Under review in an ISI indexed journal.	How supply chain strategies moderate the innovation capabilities-business performance relationship	Chapter 6

* The papers were under review when the thesis was delivered.

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PART I – LITERATURE REVIEW

Part I aims to provide a clear view of the literature on the relationship between innovation and supply chain management, presenting a systematic literature review (chapter 1) and an analysis of the intellectual structure of the topic (chapter 2). Besides contributing to the literature, this part has the objective of helping to identify the main research opportunities in the field and provide evidences and inputs for the remaining parts of the thesis.

CHAPTER 1 – THE INFLUENCE OF SUPPLY CHAIN ON THE INNOVATION PROCESS: A SYSTEMATIC LITERATURE REVIEW[2]

Abstract:

Purpose – the importance of innovation as a generator of competitive advantage and the collaborative nature of this process are recurring themes in the literature. This chapter aims to contribute to the improvement of knowledge about the relationship between supply chains and the innovation process by means of a systematic literature review.

Design/methodology/approach – the method used consists in the identification, selection, analysis and synthesis of existing research on the subject and aims to ensure that the review is transparent, auditable and replicable. The chapter presents the analysis of 114 papers from 40 journals and the major contributions are explored.

Findings – the identification and analysis of relevant articles showed the complexity, timeliness and the wide-ranging character of the theme. The analysis of articles allowed the identification of facilitators of the innovation process, as well as five approaches applicable to supply chains to drive the innovation process. From these analyses, a model synthesising the main practices identified for improving innovation performance is presented.

Research limitations/implications – when carrying out literature reviews, the selection of articles might be considered subjective. In order to circumvent this limitation, the papers have been assessed by three researchers.

Practical implications – the results presented can be applied in the decision-making process by managers in the areas of innovation and supply chain.

[2] Part of this chapter was presented and/or published as:

Zimmermann, R.; Ferreira, L. M; Moreira, A. C. (2015) The impact of Supply Chain Management on the innovation process. Joint Conference: 9th International Conference on Industrial Engineering and Industrial Management; XXI International Conference on Industrial Engineering and Operations Management; International IIE Conference 2015. Aveiro, Portugal. July 6-8, 2015.

Zimmermann, R., Ferreira, L. M., Moreira, A. C. (2016). The influence of supply chain on the innovation process: a systematic literature review. Supply Chain Management: An International Journal, 21 (3), 289-304.

Originality/value – the chapter synthesises knowledge involving the relationships between supply chains and the innovation process. The analysis is based on quantitative and qualitative criteria.

Keywords: innovation, innovation performance, supply chain management, systematic literature review.

1.1 Introduction

Innovation generation is increasingly seen as a collaborative process carried out with the participation of different actors within or outside the companies (Arlbjorn & Paulraj, 2013; Berghman, Matthyssens, & Vandenbempt, 2012; Chesbrough, 2003; Ozman, 2009; Roy, Sivakumar, & Wilkinson, 2004). Several studies refer the importance of supply chains and their actors in the innovation process (Ageron, Lavastre, & Spalanzani, 2013; Golgeci & Ponomarov, 2013; Narasimhan & Narayanan, 2013; Oke, Prajogo, & Jayaram, 2013; Roy et al., 2004).

Being the supply chain a network in which suppliers and customers have the common goal of providing products or services to their end-customers, companies increasingly rely on their partners to obtain innovative inputs. Soosay, Hyland and Ferrer (2008) argue that a supply chain management strategy requires integration, co-operation and collaboration, which in turn require aligned goals, open communication, sharing of resources, risks and rewards.

Historically a vital area for companies due to its strategic and financial impact, supply chain management has become even more relevant as we become a society increasingly focused on knowledge (Narayanan & Narasimhan, 2013). 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.

Although the importance of innovation for the competitiveness of companies has been studied for decades, the changes experienced by society make innovation vital to businesses. If innovation is important to: (a) improve performance, (b) increase the demand and (c) reduce costs; developing and managing innovation effectively is a challenge for most companies.

In this sense, this chapter aims at contributing to the improvement of the knowledge about the relationship between supply chains and the innovation process. For that purpose, this systematic literature review was conducted by analysing 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 the chapter aims to answer is: considering that the innovation process is impacted by external factors, how do supply chains impact the innovation process and performance?

The answer to this question will help to understand the relations between supply chains and the innovation process. The chapter will contribute for the definition of themes for future research and also intends to provide useful information for decision making by managers in the areas of supply chain and innovation management.

The next section presents the methodology used for the systematic review of literature, including the formulation of research questions, the definition of the articles selection criteria, as well as the analysis criteria. Afterwards, the results are presented following two different strands: a quantitative and a qualitative analysis. In this second phase, two main aspects are discussed: (1) the influence of supply chains in the innovation process, including facilitators and barriers to this process; (2) and the different approaches or strategies used in the context of the supply chains to manage or enhance innovation. Then, a summary of the major features identified with potential to improve innovation performance is drawn. Finally, the conclusions of the research, including the implications, the limitations of the work and recommendations for future research are presented.

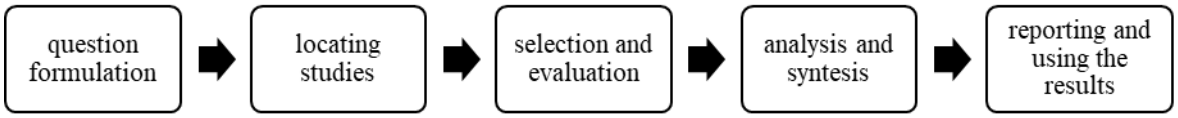
1.2 Methodology

This chapter uses the systematic literature review method as presented by Denyer and Tranfield (2009). A systematic literature review consists on the identification, selection, analysis and synthesis of existing research on a particular topic and its presentation in a clear manner in order to meet what is known and not known about the topic (Denyer and Tranfield, 2009).

This study follows the five steps proposed by Denyer and Tranfield (2009): (1) definition of the research question; (2) location of studies; (3) selection and evaluation of

studies; (4) analysis and synthesis; (5) presentation of results. The method, presented in figure 3, tries to ensure that the review is transparent, auditable and replicable.

Figure 3 - Five steps carried out for the systematic review of the literature



Source: adapted from Denyer & Tranfield (2009)

1.2.1 Question formulation

The first step in conducting a systematic review of the literature is the definition of the research question, which should be clear in order to establish the focus of the study. The research question is the following:

- Considering that the innovation process is impacted by external factors, how do supply chains impact the innovation process and performance?

The following supplementary questions are also going to be addressed:

- What are the main factors that affect positively and negatively the innovation process in the supply chains context?
- What are the main approaches or strategies used within the supply chains to manage or enhance the innovation process?

1.2.2 Locating studies

This step involves the location of relevant studies to answer the research questions. The ISI Web of Science database was defined as the source of research. This strategy is used in other reviews of literature in the area. To search for studies to be analysed three categories of keywords were defined:

- Words related to innovation: innovation, innovate, innovativeness. We decided to use the term innovat* to cover all possibilities.
- Words related to supply chain: supply chain, SCM.
- Words related to alignment/relationship/partnership: we decided again to use the asterisk in the following terms: align*, partner*, coordinat*, collaborat*, relation*.

The search was based on all possible combinations of the three groups of keywords, using the "Topic" field to search. Only journals (articles and reviews) were searched, limited to the areas of "Business Economics", "Engineering" and "Operations Research Management Science". There was no restriction for the date of publication. The first search presented a total of 796 items (survey conducted in March 2015 and updated in March 2017).

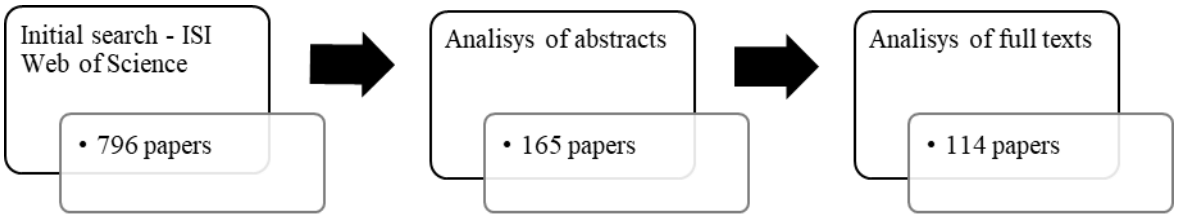
1.2.3 Study selection and evaluation

After the first search stage, the articles were entered into an electronic spreadsheet and the abstracts and keywords were read, knowing that this analysis focuses on the following criteria: are the articles dealing with the relationship between the supply chain and the innovation process of organisations? Using this criterion, 165 articles were selected.

Finally, the articles were fully read and the criterion for selection was the answer to the following question: do the articles help answer the research questions? After this step 114 articles were selected for analysis.

Following the suggestion of other studies, and as a way to increase the reliability of the selection, the articles were evaluated simultaneously by the three researchers and doubts and disagreements were discussed until consensus was reached. The articles were only included if all reviewers agreed. Figure 4 summarises the process of locating and selecting the articles.

Figure 4 - Location and selection of the articles



1.3 Analysis and synthesis

After selecting the most relevant studies for the purposes of this research, the articles were analysed and synthesised in two steps. The goal of the analysis is to examine and dissect individual studies and identify relationships between the components (Denyer

& Tranfield, 2009). On the other hand, the synthesis is the process of grouping the results of different studies "*into a new or different arrangement and developing knowledge that is not apparent from reading the individual studies in isolation*" (Denyer & Tranfield, 2009, p. 685).

To ensure the uniformity of the analysis by the three researchers, a sample was set by each researcher who presented their findings to others. After this phase, the articles were divided between the three reviewers. The first step of the analysis focuses on the categorisation of studies according to the criteria shown in table 3.

The second step, basically qualitative, sought to identify and synthesise the main contributions of articles to answer the research questions. They addressed two main aspects: (1) the influence of supply chains in the companies' innovation process, including the facilitators and barriers of this process; (2) the different approaches or strategies used to manage or enhance innovation (table 4). As such, the aggregative synthesis approach that incorporates quantitative and qualitative elements was used (Denyer & Tranfield, 2009). The explanatory approach was also used in order to synthesise the studies, while trying to determine causal mechanisms in the data and explain how they work (Denyer & Tranfield, 2009).

Table 3 – Criteria for the quantitative analysis of the articles

Criterion	Type of analysis
Date of publication	Verification of the timeliness of the theme.
Publication source	Articles must be published in peer reviewed journals and the analysis is based on the journal's impact factor.
Location	Analysis of the geographical dispersion of the papers based on the location of the authors.
Methodology used	Analysis of the classification of articles (articles or reviews) and the approaches used in the studies (empirical research, survey, case studies).
Nature of the sample	Analysis of the realities studied (sector of activity and size of firms).
Theoretical perspective	Identification and analysis of the main theories used as a basis for carrying out the studies

The following sections are intended to present the main contributions of the studies, i.e., reporting and using the results, according to Denyer and Tranfield (2009). **Appendix 1** presents the main information of the 114 articles analysed.

Table 4 - Criteria for the qualitative analysis of the articles

Criterion	Type of analysis
Influence of supply chains in the innovation process	Analysis of the contribution of articles to answer to the research question
Barriers and facilitators	Identification and analysis of the facilitators and barriers to innovation
Approaches or strategies	Identification and analysis of the approaches or strategies used in the supply chains to manage or enhance firms innovation process

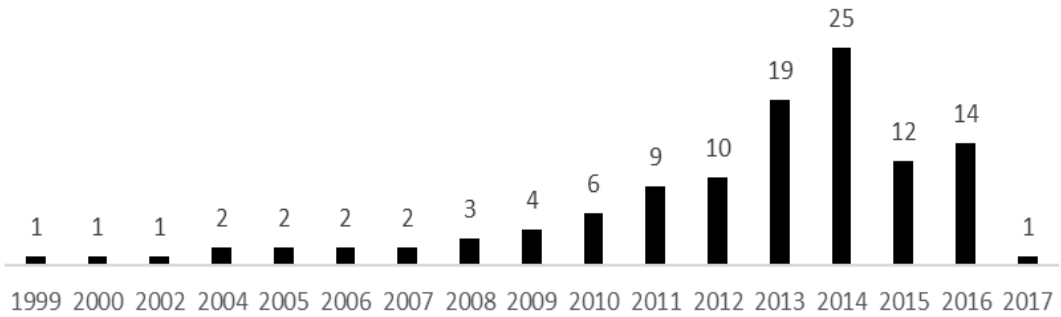
1.4 Descriptive results: Characterising the literature about the relation between innovation and supply chain

This section aims at showing the context of the literature regarding the relationship between the themes of innovation and supply chain, i.e., it analyses quantitatively the papers. For this analysis, we used the HistCite software.

1.4.1 Date of publication

The relationship of innovation with the supply chain is a relatively new theme in literature. Most of the articles identified are quite recent as more than 70% of the articles were published in the past five years (Figure 5).

Figure 5 - Number of articles per year of publication



1.4.2 Publication Source

The articles have been published in 40 different journals. It is a clear indication of the relevance of the theme and of its embracing character. The Journals with the largest number of articles are the International Journal of Production Economics, the Journal of Supply Chain Management and Supply Chain Management: An International Journal. Table 5 presents the publications with more than one article analysed.

Table 5 - Main sources of publication

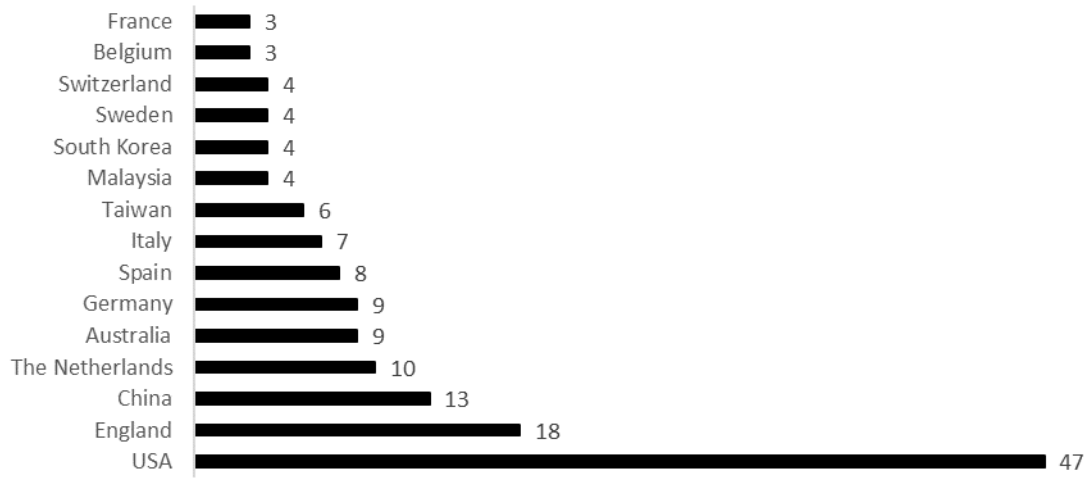
Journal	Papers
INTERNATIONAL JOURNAL OF PRODUCTION ECONOMICS	14
JOURNAL OF SUPPLY CHAIN MANAGEMENT	9
SUPPLY CHAIN MANAGEMENT-AN INTERNATIONAL JOURNAL	8
JOURNAL OF OPERATIONS MANAGEMENT	6
RESEARCH POLICY	5
JOURNAL OF TECHNOLOGY MANAGEMENT AND INNOVATION	5
INTERNATIONAL JOURNAL OF PRODUCTION RESEARCH	4
JOURNAL OF PRODUCT INNOVATION MANAGEMENT	4
PRODUCTION AND OPERATIONS MANAGEMENT	4
INDUSTRIAL MANAGEMENT & DATA SYSTEMS	4
JOURNAL OF PURCHASING AND SUPPLY MANAGEMENT	4
TECHNOLOGY ANALYSIS & STRATEGIC MANAGEMENT	3
DECISION SCIENCES	3
JOURNAL OF BUSINESS RESEARCH	3
INTERNATIONAL JOURNAL OF SIMULATION MODELLING	3
EXPERT SYSTEMS WITH APPLICATIONS	2
INTERNATIONAL JOURNAL OF COMPUTER INTEGRATED MANUFACTURING	2
INTERNATIONAL JOURNAL OF OPERATIONS & PRODUCTION MANAGEMENT	2
PRODUCTION PLANNING AND CONTROL	2
TECHNOVATION	2
THE INTERNATIONAL JOURNAL OF LIGISTICS MANAGEMENT	2
EUROPEAN JOURNAL OF OPERATIONAL RESEARCH	2
IEEE TRANSACTIONS ON ENGINEERING MANAGEMENT	2
JOURNAL OF BUSINESS AND INDUSTRIAL MARKETING	2
JOURNAL OF THE ACADEMY OF MARKETING SCIENCE	2

The publications with the largest number of articles feature high impact factor according to the Journal Citation Report, being that the five first journals are in the first quartile among the publications in their categories.

1.4.3 Location

The articles feature a considerable geographic dispersion (authors from 32 countries were identified), demonstrating that the subject is of global interest. Although there are a large number of papers written by authors from the United States of America (28% of the authors are from USA), the number of articles from Europe, Asia and Oceania is also relevant.

Figure 6 - Countries with the largest number of publications



With respect to the authors, once again there is a wide dispersion, since 22 authors present more than one article; although only two authors published more than two articles, Xenophon Koufteros, professor of Texas A&M University, and Alain Y.L. Chong, of The Hong Kong Polytechnic University, both with three papers.

1.4.4 Methodology used

With respect to the nature of the analysed studies, there was a predominance of quantitative empirical studies – 70 out of the 114 articles. In contrast, 17 papers consisted of case studies, 13 of conceptual studies, 11 of qualitative empirical studies besides three literature review.

1.4.5 Nature of the sample

Regarding the characteristics of the samples used in the studies, there was a predominance of the use of information from industrial companies (87 of the 114 articles, corresponding to 76%), however coming from the most varied sectors, such as consumer goods, automobiles, equipment, food and chemical industry. Five studies examined exclusively the reality of service companies and 19 studied the reality of industrial and service companies. Seven studies have focused specifically on small and medium-sized enterprises.

1.4.6 Theoretical Perspective

The analysis of the papers highlighted the lack of a dominant theory in the study on the relationship between innovation and supply chains. Among the 114 articles, more than 36 different theories were cited. The resource-based view was the theory with the largest number of articles – 14 – followed by the knowledge-based view with ten papers and transaction cost economics with seven. The relational view theory was referenced six times, the network theory and dynamic capabilities theory five times each. Table 6 lists the theories used throughout the years of publication of the articles.

There is a recent trend regarding the use of a few theories in the last five years, especially the resource-based view of the firm (referred to nine times in the last five years), knowledge-based view (six times in five years) and dynamic capabilities theory (five times in five years). On the other hand, within the remaining theories with larger number of citations, one can witness a steady use over time of transaction cost economics theory, used since 2002 and the relational view theory and network theory used since 2004. Another important factor that has to be highlighted is that 37 of the papers analysed do not mention its theoretical basis (or is not applicable, in the case of the literature reviews).

The most used theories in the papers analysed – the resource-based view and the knowledge-based view approach – share the relevance of inter-organisational relationships to build competitive advantages, which increases the importance of the subject treated in this study.

Table 6 - Theories per year of publication

Theory	1999	2000	2002	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Total
Not mentioned or not applicable	1			1		1			2	2	4	4	5	8	4	5		37
Resource-based view							1		1	1		2		5	1	3		14
Knowledge-based view								1	1	1	1		2	2		1	1	10
Transaction cost economics			1		1	1				1	1			2				7
Relational view theory				1				1		1		1		1	1			6
Dynamic capabilities theory													2	1	1	1		5
Network theory				1								1	2		1			5
Contingency theory					1						2	1						4
Game theory															2	1		3
Organizational learning theory											1	1			1			3
Social exchange theory														3				3
Social network theory							1						1	1				3
Complementarity Theory													1			1		2
Complexity theory													1			1		2
Institutional theory														2				2
Resource dependence theory												1	1					2
Theory of modular systems													2					2
Ambidexterity theory													1					1
Collaboration theory										1								1
Diffusion of innovation theory												1						1
Knowledge transfer theory													1					1
Optimal control theory		1																1
Organizational behaviour theory											1							1
Organizational Design theory					1													1

Organizational information-processing theory				1		1
Process view				1		1
Relationship governance theory					1	1
Relationship marketing theory		1				1
Resource advantage theory					1	1
Service-dominant logic					1	1
Social capital theory					1	1
Stakeholder theory					1	1
Strategic choice theory		1				1
System theory			1			1
Theory building process	1					1
Theory of complementarity				1		1
Trust theory					1	1

1.5 Qualitative results: the influence of the supply chain context on the innovation process

The economic crisis that started in 2008 has revealed the importance of conjectural aspects related with opportunities and vulnerabilities (Dervitsiotis, 2010). Clearly, if innovation is affected by the reduction of economic investment, it is also an antidote against the crisis both at organisational as well as at territorial level (Filippetti & Archibugi, 2011) as firms and countries which maintained or even raised efforts toward innovation have demonstrated a higher resilience in times of difficulty.

The innovation capacity of organisations is the result of internal and external factors (Berghman, Matthyssens, & Vandenbempt, 2012; Dervitsiotis, 2010; Fawcett, Jones, & Fawcett, 2012; Hadjimanolis, 1999; Madrid-Guijarro et al., 2009; Roy, Sivakumar, & Wilkinson, 2004). Among the major internal factors that influence innovation are: organisational culture, leadership for innovation, innovation strategy, availability of internal resources, technology ownership and participation of employees (Dervitsiotis, 2010; Gnyawali & Srivastava, 2013). External factors, however, include various aspects that relate to environmental, market and the relations of companies with other actors. The increasing complexity of entrepreneurial environments, result of globalisation, increases the impact of external factors to the overall performance of organisations. These factors, therefore, tend to be more affected in times of crisis.

Great innovators depend on external actors to ensure most of their advantage when it comes to innovation (Fawcett, Jones, & Fawcett, 2012). Ozman (2009) and Radas and Bozic (2009), in turn, claim that innovation is most effective when seen as a collective process and the collaboration with other firms is an important part of the effort of the firms for innovation. For Hsieh and Tidd (2012), the higher the degree of newness, the greater the intensity of knowledge sharing and communication.

Many companies rely on their supply chain partners for innovative inputs. To adopt an innovation strategy, it is necessary to be aligned with other actors in the supply chain, which must share the same innovation strategy. To reduce this dependency, firms can implement strategies to develop their products internally, using new components,

materials and technologies (Oke et al., 2013). However, this kind of strategy is not always possible because companies may lack some internal competencies.

Innovation must be faced by organisations as a collaborative process, where the supply chain has a fundamental role. Narasimhan and Narayanan (2013) strengthen this hypothesis to the point of defining innovation as "*the process of generating changes in products, processes and services that results in the creation of value for the firm and its customers, through the knowledge generated by the company and/or its supply chain partners*". Thus, the main reason to collaborate with other companies is to share and leverage resources unavailable internally (Rese, Gemunden, & Baier, 2013). Few companies have the capabilities or the necessary resources for the development of all the parts that make up their final products (Yeniyurt, Henke, Yalcinkaya, & 2014). To Fitjar and Rodriguez-Pose (2013), companies engaged in external collaboration tend to be more innovative than firms that rely solely on their own resources and knowledge. As such, companies are aware that sharing knowledge with their supply chain partners can be an important factor for obtaining competitive advantage (Saenz, Revilla, Knoppen, & 2014). In addition, Roy, Sivakumar and Wilkinson (2004) claim that innovation is not only influenced by the relationships with suppliers, but is largely a result of these interactions.

Cao and Zhang (2010) adopt the concept of collaborative advantage, understood as the strategic benefits obtained over competitors through partnerships with actors across the supply chain that generate results that could not be achieved by any of the companies alone.

Typically supply chains are designed to harmonise routine activities between partners, not including the innovation process (Bouncken, 2011). As a result of the growing market rivalry, companies try to build relationships with partners in order to complement their internal resources, especially with other supply chain actors (Ettlie & Pavlou, 2006; Oke et al., 2013).

Partners located downstream in the supply chain provide up-to-date information about the preferences of consumers and on new trends. Partners located upstream, in turn, tend to provide knowledge about 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 upstream or downstream an actor is on the value chain, the lower its participation in the innovation process of a focal company (Wynstra, von Corswant, & Wetzels, 2010).

As companies become more specialised, the importance of engaging in the innovation process with the supply chain partners also increases. It becomes crucial that companies align their internal research and development strategies with the knowledge available in the supply 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 supply chain actors allows companies to integrate their operations, generating greater efficiency and facilitating innovation, both radical as incremental.

For Petersen et al. (2005), suppliers have different levels of responsibility within the new product development process. When the supplier is involved informally and superficially, and all decisions are taken by the customer, the relationship is called White Box. In these cases, "*discussions are held with suppliers about specifications / requirements, but the buying company makes all design and specifications decisions*" (Petersen et al., 2005, 379). When there is a formalised integration and decisions and product development are conducted jointly, one can call it a Grey Box. The buyer and supplier enter into a joint development effort, which may include information and technology sharing and joint decision making regarding design specifications. Finally, when the development is coordinated and carried out primarily by the supplier, according to customer specifications, one can call it a Black Box. The supplier is informed of customer requirements and then is given almost complete responsibility for the purchased item (Petersen et al., 2005).

For Modi and Mabert (2010), the efficient management of the supply chain leads the organisation to improve its performance and stability within the supply chain. These elements, in turn, lead to improved performance in factors related to innovation.

Measuring innovation, however, is a controversial subject in the literature. The measurement implies comparison, which requires some degree of similarity. The problem is that innovation, by definition, is something new and, therefore, difficult to compare

(Smith, 2005). Much has been discussed in the literature on ways of measuring innovation and a large number of quantitative and qualitative indicators are defended by different authors. One of the concepts relevant to performance-related innovation is the "persistence of innovation", which concerns the extent to which organisations that innovate once have greater or lesser ability to innovate again in subsequent periods (Clausen, Pohjola, Sapprasert, & Verspagen, 2012).

For Golgeci and Ponomarov (2013), the ability and the magnitude of the firms' innovations are related to the supply chain resilience. Considering the growing importance of the supply chain and the impact of disruptions of supply on the firms' results, the increased resilience can be understood as an improvement in performance, since it reduces risks. For them, companies must invest on their innovation capacity, not only to be competitive and improve their financial and market performance, but also to respond to the risks of disruptions in uncertain environments. Thus, considering the studies analysed, the relationships among actors in the supply chain are potentially facilitators of the innovation process. Some features of the supply chains, however, can act as barriers to this process. One of these barriers is the difference of technology used by the actors, especially between the client and the supplier (Peitz & Shin, 2013). This barrier is more critical in markets where technology exerts an important role for the competitiveness of firms.

Another important barrier is the difficulty to establish trust-based relationships among actors of the supply chains. Fawcett, Jones and Fawcett (2012) claim that building trust-based relationships, beyond being hard, is also potentially expensive, both because of demanding investments and to the vulnerability that these relations impose. The authors argue that the effort and the risk exposure are worth it. The same reasoning applies to building lasting relationships (Fawcett, Jones and Fawcett, 2012; Kim, 2000).

For Narasimhan and Narayanan (2013), in knowledge-intensive industries, value-creation activities are scattered among the firms within the supply chain, that specialise themselves in a particular activity or technology, with the focal firm acting as a knowledge integrator. In this context, the difficulty of the focal firm in integrating knowledge is considered as a barrier to innovation. Finally, Wang et al. (2011) conclude that certain supplier-client contracts can negatively influence the innovation performance.

1.6 Supply chain approaches to conduct the innovation process

As discussed earlier, there are different characteristics of supply chains capable of positively influencing innovation performance. Companies embrace different strategies when involving the rest of the supply chain actors in its innovation process. The following are amongst the most important ones:

- Partnerships for specific purposes (PEP) – development of a new product or process;
- Project coordination by the client company (PCCC);
- Integration of the new product development process (INPDP) among partners;
- Strategic alignment (SA) between actors of the SC (in addition to the innovation process);
- Open innovation strategy (OI).

Table 7 shows the approaches used by year of publication of the papers. We see the prevalence of INPDP, SA and OI approaches in recent articles. On the other hand, the PEP approach is cited in only one paper in 1999.

Table 7 - Approaches used by year of publication

Year	**Approach**					
	PEP	PCCC	INPDP	SA	OI	Total
1999	1					1
2000		1				1
2002				1		1
2004		1	1			2
2005			1	1		2
2006		1	1			2
2007			1	1		2
2008			2	1		3
2009			2	2		4
2010			3	4		7
2011			7	2		9
2012			4	6	1	11
2013		1	8	8	2	19
2014			13	11	1	25
2015		1	5	6		12
2016			7	7		14
2017				1		1

Table 8 compares the use of the basic theories among papers with the approaches used. We highlight some relationships, such as the use of the resource-based view, the knowledge-based view, the relational view theory and the network theory in articles that use the SA approach. We can also highlight how the INPDP approach is distributed among different theories.

Table 8 - Relationship among theories and approaches used

Theory	**Approach**					
	PEP	PCCC	INPDP	SA	OI	Total
Not mentioned or not applicable	1	1	24	11		37
Resource-based view			7	7		14
Knowledge-based view			3	7		10
Transaction cost economics		1	3	3		7
Relational view theory			1	6		7
Dynamic capabilities theory			1	4		5
Network theory				4	1	5
Contingency theory			1	2	1	4
Game theory		1	1	1		3
Organizational learning theory			1	2		3
Social exchange theory			1	1	1	3
Social network theory			2	1		3
Complementarity Theory			1	1		2
Complexity theory				2		2
Institutional theory			1	1		2
Resource dependence theory				2		2
Theory of modular systems			2			2
Ambidexterity theory				1		1
Collaboration theory			1			1
Diffusion of innovation theory				1		1
Knowledge transfer theory					1	1
Optimal control theory		1				1
Organizational behaviour theory			1			1
Organizational Design theory			1			1
Organizational information-processing theory				1		1
Process view			1			1
Relationship governance theory				1		1
Relationship marketing theory				1		1
Resource advantage theory			1			1
Service-dominant logic				1		1
Social capital theory				1		1
Stakeholder theory			1			1
Strategic choice theory				1		1

Theory	Approach					
	PEP	PCCC	INPDP	SA	OI	Total
System theory			1			1
Theory building process				1		1
Theory of complementarity			1			1
Trust theory			1			1

1.6.1 Partnerships for specific purposes

The accomplishment of partnerships among actors of the supply chains for the development of new products or processes is characterised by the use of short-term contracts and may indicate the absence of trust-based relationships among the actors, once relationships tend not to be long lasting (Bruce & Moger, 1999).

This approach was identified in only one of the papers analysed, dating from 1999, which shows that its use, despite being relatively common among companies, has been hardly addressed in the literature, especially recently.

1.6.2 Project coordination by the client company

The coordination of innovation projects by the client company was mentioned by five papers. Tracey and Neuhaus (2013) maintain that any development of new products or processes must be treated as projects and should involve key partners of the supply chain. In these cases, however, the level of responsibility and participation of the partners is limited.

The incorporation of suppliers in project teams raises the level of information and knowledge for the generation of ideas and the use of technologies. It also allows the early identification of potential problems, the elimination of rework, the increase of likelihood of meeting deadlines and the reduction of costs (McIvor & Humphreys, 2004).

For Kim (2000), this type of relationship can be beneficial for both parties. The results will be positive for both actors if the market responds favourably to the innovation developed. Kim (2000) approaches the coordination of the innovation process aiming at the supplier innovation, considering that the innovation generated by the client company can lead to reduced costs on the supplier and, consequently, the reduction in the prices of their products.

The approach of project coordination by the client company shows greater focus on short-term results and the actions or projects are conditioned by the interests of the client company, often with a costs reduction view. Companies that use this kind of approach can behave opportunistically (Wang et al., 2011) in order to get the most out of the relationship only for the period that they understand to be more profitable.

The successful use of this approach, on the other hand, can lead to the improvement of the relationship between the companies (McIvor & Humphreys, 2004), which, in turn, can generate new cooperative projects or lead to the use of new approaches, such as an integrated new product development (NPD) process or a strategic alignment.

The partnerships for specific purposes are little studied in the literature, as well as the project coordination by the client firm, which reflects the low interest that these approaches leverage in the innovation process.

1.6.3 Integration of the new product development process

The integration of the NPD process was the most widely used approach, in 55 of the 114 papers, and occurs when supply chain partners provide information and directly participate in the decision-making process related to the new products, processes or services (Petersen et al., 2005). For Yeniyurt et al. (2014), the involvement of suppliers in the client's NPD process is mutually beneficial.

Salvador and Villena (2013) claim that the integration of suppliers in the client's NPD process occurs not only for the clients to have access to their skills and knowledge, but also as a way of overcoming financial limitations and risk sharing issues. The participation of partners in this process also contributes to reduce the likelihood of failure in launching new products since it reduces the risk of ruptures of supply (Pero, Abdelkafi, Sianesi, & Blecker, 2010).

This approach differs from the previous ones as in order to get these gains continuously, companies that adopt this approach must consider the capability to develop new products as a criterion for selection of suppliers (Johnsen, 2011; Koufteros, Vickery, & Droege, 2012; Koufteros, Cheng, & Lai, 2007). Innovation, in this case, must be part of the company's strategy when building up its supply chain.

Johnsen (2011) explores specifically the integration of sub-suppliers in the NPD process. The author discusses strategies for delegating roles, and the intervention of the client firm with these suppliers as ways for participating in the process.

Although the integration of suppliers in the NPD process is the most common form of integration within supply chains, He et al. (2014) discuss the benefits of the integrating customers in this process.

Two other concepts deserve to be featured within this approach: NPD outsourcing (Peitz & Shin, 2013; Roy & Sivakumar, 2010) and product modularity (Cabigiosu, Zirpoli, & Camuffo, 2013; Caridi, Pero, & Sianesi, 2012; Lau, 2011). These two concepts are used primarily by authors who study the auto industry.

Beyond allowing firms to focus specifically on their core competencies, NPD outsourcing reduces the costs of the NPD process. On the other hand, the outsourcing of higher added value activities entails higher risks for the firm, such as the loss of critical knowledge (Jean, Kim, & Sinkovics, 2012). Modularity, in turn, is used as a tool to facilitate the integration of external sources of innovation. It can improve the results of the development of new products in two ways: (1) enables organisations to easily join the design and production of a product's components; (2) ensures easy and successful integration of components supplied externally in the architecture of the final product (Cabigiosu et al., 2013). For Lau, Yam, and Tang (2007), modularity increases the firm's flexibility, improves customer service and, consequently, improves the product's performance.

Finally, it should be noted that companies that integrate the NPD process may also adopt the strategic alignment or the open innovation strategy, once the last two approaches are more complex than the others. Lau et al. (2007), for example, explores the integration of the NPD process, or co-development, however following a strategic alignment perspective.

1.6.4 Strategic alignment

For authors who follow this approach, used in 51 papers, the innovation performance is a consequence of trust-based relationships (Roy et al., 2004). For this reason, the strategic alignment, or long-term partnership between supply chain actors, can

be understood as a step forward in relation to the integration of the NPD process. It involves the integration of other business processes (beyond innovation), goal alignment, inter-organisational teams, information systems integration and the constant sharing of information (Lau et al., 2007; Roy & Sivakumar, 2010; Roy et al., 2004; Wong, Wong, & Boon-itt, 2013). For Wong et al. (2013), this set of factors has positive effects on NPD and innovation performance as a whole.

For Wagner and Bode (2014), factors such as the duration of the contract, the age of the relationship and co-operation stimulate suppliers to share innovative ideas with their customers, which the authors call innovation push. The strategic alignment with actors of the supply chain allows firms: (a) greater access to the knowledge about customers' needs; and (b) the sharing of this knowledge and the requirements of the NPD process with suppliers (Jean et al., 2012; Wong et al., 2013). This model allows even greater involvement of suppliers in all phases of the innovation process (Narayanan & Narasimhan, 2013).

Jayaram and Pathak (2013) and Craighead et al. (2009) addressed the integration of knowledge between organisations as an effective strategy for improving performance, more specifically regarding the development of new products. However, knowledge sharing with other actors of the supply chain, although necessary, it is not sufficient to ensure the generation of added value. The formalisation and constant interactions among firms, combined with the sharing of knowledge, are important conditions for joint value creation in both the development of new products and in other shared processes (Jayaram & Pathak, 2013). Jean et al. (2012) also highlight the importance of knowledge sharing for the establishment of an effective relationship, which they call relationship learning. For the collaborative innovation process, we can also consider as fundamental factors: trust (Fawcett et al., 2012; Jean, Sinkovics, & Hiebaum, 2014), the sharing of the decision-making process (Kim & Oh, 2005), the facilitated and constant information exchange (Jean et al., 2012), the co-operative behaviour of all actors (Cheng et al., 2014), among others.

Narasimhan and Narayanan (2013) defend the importance of firm's absorptive capacity for the effective use of knowledge of other actors of the supply chain in the innovation process. The absorption capacity is defined as "*the ability of firms to recognise*

the value of new external information, assimilate it and apply it for commercial purposes" (Cohen & Levinthal, 1990, p. 128).

Finally, Oke et al. (2013) approach the creation of strategic partnerships among actors of the supply chain from the perspective of the Resource Dependency Theory, which sees companies as coalitions in which the structures and patterns are moulded in order to gain access to external resources required.

1.6.5 Open innovation strategy

The open innovation concept has been explored by several authors in recent years. However, since the research did not seek specifically this kind of innovation, only four studies address open innovation. However, having open innovation an emphasis on collaborative perspectives, supply chain actors stand out as potential partners.

Open innovation involves the intentional use of external expertise to accelerate internal innovation (Chesbrough, 2003). For Billington and Davidson (2013), companies can and should use external and internal ideas when they look forward to developing or improving their products, processes and business models. For them, with the adoption of open innovation, the flow of ideas is added to the flow of goods, money and information across companies in supply chains.

The use of this approach imposes companies' great challenges. On the one hand, the more open the process, the greater the variety and quality of innovation; on the other hand, the more closed the new product or service development, the lower the time needed and the cost of the process (Hsieh & Tidd, 2012).

Finally, Tomlinson and Fai (2013) emphasise the importance of open innovation for small and medium-sized firms, since it allows the access to knowledge and technologies inaccessible internally by this type of firms.

1.7 Supply Chain-Driven Innovation: some practices to improve the performance

According to Denyer and Tranfield (2009), systematic reviews of the literature in the area of management must present rules, suggestions, guidelines or protocols as outputs, in order to be useful for the solution of managers' real problems. Widing and Wagner (2012) state that the purpose of a systematic review is to support evidence-based decision

making. Thus, we propose some characteristics that, according to the analysis carried out, tend to improve the performance of the innovation process. Some of the factors analysed regard the characteristics of the companies that can encourage innovation and others refer to the characteristics of the supply chain or of the relationship among companies.

Absorptive capacity is the first important feature that tends to encourage innovation, which is the ability of a firm to identify external knowledge and convert it into value for its products or processes (Saenz et al., 2014). This capability allows companies, in addition to the better use of external resources available, to identify the best partners across the supply chain.

The definition of a supply chain strategy that includes innovation has also great potential to improve this process. For van Massow and Canbolat (2014), companies should set their goals taking into account the supply chain strategy. In addition to the minimum standards of quality required from their partners, companies should set standards for the whole supply chain regarding the specific features, such as the innovation capacity of the supply chain.

Bendoly, Bharadwaj, and Bharadwaj (2012) still address the capability of the firm's information systems as a relevant internal factor that allows the best use of the knowledge and resources of the supply chain partners to improve innovation. They discuss the importance of coordinating efforts with external actors for the success of the NPD process, suggesting that the effects of the coordination on market intelligence are moderated by the capability of the company's information systems (Bendoly et al., 2012).

Regarding the relationships among companies, the following characteristics stand out:

- Building trust relationships (Blome, Schoenherr, & Kaesser, 2013; Fawcett et al., 2012; He et al., 2014; Jayaram & Pathak, 2013; Jean et al., 2014; Kim, 2000; Kuehne, Gellynck, & Weaver, 2013; Lee, Ooi, Chong, & Seow, 2014; Modi & Mabert, 2010; Oke et al., 2013; Wang et al., 2011; Yeniyurt et al., 2014);
- Ease and frequency of information sharing between partners (Bakhshi & McVittie, 2009; Bendoly et al., 2012; Berghman et al., 2012; Blome et al., 2013; Caridi et al.,

2012; Kuehne et al., 2013; Peng, Verghese, Shah, & Schroeder, 2013; Tomlinson & Fai, 2013);

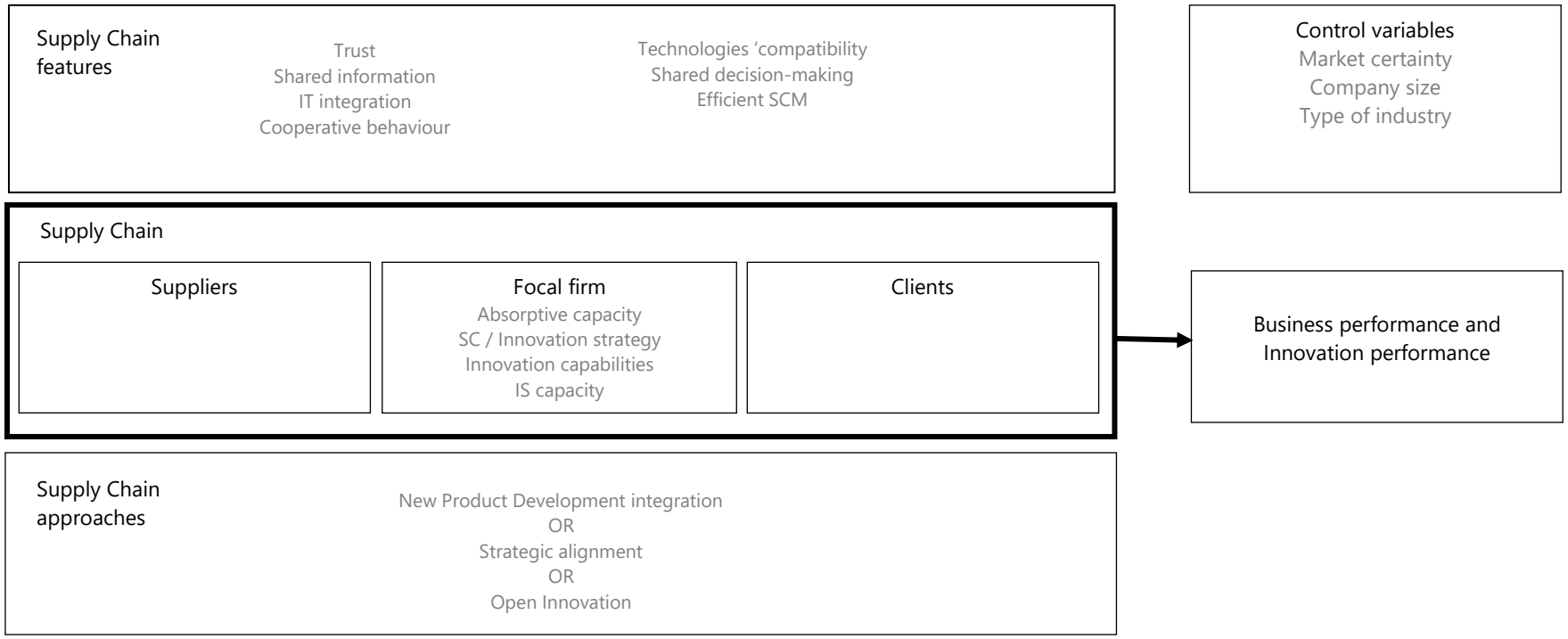
- Shared decision making (Kim & Oh, 2005; Peng et al., 2013; Wu, 2014);
- Information systems integration (Caridi et al., 2012; Cheng, Chen, & Huang, 2014; Ettlie & Pavlou, 2006; Peitz & Shin, 2013);
- Compatibility of technologies used by partners (Chong & Zhou, 2014; Lee et al., 2014);
- Cooperative behaviour of all actors (Cheng et al., 2014);
- Efficient management of supply chains, including their resilience (Golgeci & Ponomarov, 2013; Modi & Mabert, 2010).

In general, the characteristics addressed by the authors are related with the creation of strong relationships among partners. Saenz et al. (2014) claim that the construction of this kind of relationship depends on the selection of appropriate partners to facilitate social interaction, as well as the achievement of common objectives.

It should be noted that the above-mentioned factors are found mainly in three of the five innovation strategies applied to supply chains, in particular the integration of the new product development process; the strategic alignment between actors of the supply chain (in addition to the innovation process); and the open innovation strategy. It is not by chance that these are the strategies found most often in recent papers. Therefore, they can be pointed out as the most suitable for the current business scenario.

Figure 7 presents a model that relates the main facilitators of the innovation process as well as the approaches studied. Based on the studies analysed, the model suggests features and strategies that tend to positively impact the companies' innovation performance.

Figure 7 - Innovation performance improvement model throughout the supply chain



1.8 Conclusions

The growing importance of innovation as a true driver of competitive advantage, coupled with the importance of supply chain management as a competitiveness enhancing factor in the current competitive world, claim for conducting studies intertwining both topics. Similarly, the perception that innovation is a collaborative process involving not only internal but also external actors of the organisation, explains the growing number of published studies regarding the relationship of innovation and supply chains. Additionally, the increasing complexity of business environments, as a result of globalisation, increases the impact of external factors on the overall performance of the organisations.

The systematic literature review exploring the relationship between supply chains and the innovation process demonstrated the complexity of the topic, its timeliness, and its embracing character.

Companies, in general, do not have all the resources necessary to innovate. The main reason to collaborate with other actors is to gain access to these resources, in particular to knowledge. The co-operation with external actors becomes relevant to innovation process and, as the supply chain is an important context for relationships among actors, its relationship to innovation showed up as an important object of study.

Clearly, the relationships among actors of the supply chain are potentially facilitators of the innovation process. The main facilitators covered by the papers analysed are the following: building trust relationships, the facility and/or frequency of information sharing, shared decision-making, the integration of information systems, compatibility of technologies used by partners, cooperative behaviour of all actors and the efficient management of supply chains, including their resilience.

Some barriers to the innovation process were identified among actors of the supply chain as the absence of innovation strategies, the difficulty of establishing trust-based relationships and differences in technology used by actors.

The way organisations manage the innovation process throughout the supply chain is addressed in various forms in the literature. Among the papers analysed, five key innovation strategies were identified: (1) partnerships for specific purposes; (2) projects coordinated by the client firm; (3) the integration of both – new products and processes development between actors in the supply chain; (4) the strategic alignment between actors in the supply chain and (5) open innovation strategy.

The strategy of integration for the development of new products and processes, the strategic alignment and the open innovation strategy tend to generate long-lasting results for businesses. It is also important to point out that the most frequently addressed strategies are precisely those that value the innovation facilitators the most, particularly trust and the ease and frequency of information sharing between partners.

From the literature review, one can conclude that little has been studied on the influence of supply chains on the different types of innovation and the different phases of the innovation process, as well as the reality of service companies and SMEs.

Contribution to supply chain managers and innovation

In addition to addressing the importance of alignment in the context of supply chains for the innovation process, this study contributes for the management of supply chain and innovation as it identifies and presents facilitators and barriers to innovation in the context of the supply chains, as well as possible strategies to be implemented to improve the performance of organisations.

The use of these strategies, according to the characteristics of the organisations, constitutes as an opportunity for the creation of competitive advantages.

Theoretical contribution

This study contributes to the literature since it clearly presents what is presently known – and what is not – about the relationship between supply chain and innovation. It also contributes by means of the discussion of subjects still not widely approached; namely, the facilitators and barriers of the innovation process and innovation strategies applied to supply chains.

The study of the main theories used as a basis for studies is also a contribution to research in the area.

Recommendations for future research

An important gap identified in literature of the area is the study of the alignment of supply chain management strategies and innovation management strategies, as well as the impact of this alignment in the performance of organisations, which constitutes an opportunity for future investigations.

Another important recommendation is the development of in-depth empirical studies about the use of different strategies/approaches to innovation applied to supply chains. Equally, it is recommended the use of empirical studies about facilitators and barriers to the innovation process. Although, as demonstrated in this chapter, some factors have been identified, studies that explore this theme in depth have not been found.

No studies were found dealing with possible differences between the influence of supply chains on different types of innovation, neither by its typology nor by the way innovation was generated. Most of the studies analysed either explore the product innovation exclusively or deal with innovation generically (product, process, management practice or method of marketing). Only one paper covers exclusively process innovation.

Similarly, no studies were identified exploring the influence of supply chains on the different phases of the innovation process. The influence of supply chains on service companies and SMEs also needs greater attention by researchers.

Studying the relationship of the alignment in the context of supply chains with the performance of organisations in other areas, besides innovation, is also an interesting path for researchers. Finally, we highlight that the articles discuss predominantly learning relationships between customers and suppliers and that the study of the impact of relationships between all possible actors of the supply chains for the innovation process should be better exploited in future investigations.

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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.

Tomlinson, P. R., & Fai, F. M. (2013). The nature of SME co-operation and innovation: A multi-scalar and multi-dimensional analysis. *International Journal of Production Economics, 141*(1), 316-326.

Tracey, M., & Neuhaus, R. (2013). Purchasing's role in global new product-process development projects. *Journal of Purchasing and Supply Management, 19*(2), 98-105.

von Massow, M., & Canbolat, M. (2014). A strategic decision framework for a value added supply chain. *International Journal of Production Research, 52*(7), 1940-1955.

Wagner, S. M., & Bode, C. (2014). Supplier relationship-specific investments and the role of safeguards for supplier innovation sharing. *Journal of Operations Management, 32*(3), 65-78.

Wang, L. W., Yeung, J. H. Y., & Zhang, M. (2011). The impact of trust and contract on innovation performance: The moderating role of environmental uncertainty. *International Journal of Production Economics, 134*(1), 114-122.

Wong, C. W. Y., Wong, C. Y., & Boon-itt, S. (2013). The combined effects of internal and external supply chain integration on product innovation. *International Journal of Production Economics, 146*(2), 566-574.

Wu, G. D. (2014). Project-based Supply Chain cooperative incentive based on reciprocity preference. *International Journal of Simulation Modelling, 13*(1), 102-115.

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.

CHAPTER 2 – THE INTELLECTUAL STRUCTURE OF THE RELATIONSHIP BETWEEN INNOVATION AND SUPPLY CHAIN MANAGEMENT[3]

Abstract

Innovation is recognised as an important source of competitive advantage by both academics and managers. Nowadays, supply chain partners play a crucial part in driving many aspects of innovation, from the definition of the product concept to the launch to the market. This chapter analyses how the relationship between supply chain management and the innovation process is addressed in the literature and discuss ways to improve the performance by means of this relationship. A bibliometric analysis – including citation and co-citation analysis – is carried out to study the intellectual structure of the topic. In the end, four literature clusters were identified, and their characteristics are discussed.

2.1 Introduction

Innovation is a complex process that is becoming more and more important for businesses as markets are becoming more competitive than ever (Jean, Kim & Sinkovics 2012). Addressing changes in customer needs, new technologies and trends and performing proactively are all crucial. Supply chain partners play a crucial role in driving innovation forward, both downstream and upstream, from the outset of the product concept phase to the launch of the product to the market. A number of studies refer the importance of supply chains and their actors in the innovation process (Roy & Sivakumar 2010, Golgeci & Ponomarov 2013, Narasimhan & Narayanan 2013, Arlbjorn & Paulraj 2013, Zimmermann, Ferreira & Moreira 2016).

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Innovation enables the development of unique products and services leveraging firms in their quest for competitive advantage (Hilletofth & Eriksson 2011, Blome, Schoenherr & Kaesser 2013, Bellamy, Ghosh & Hora 2014). As firms' ability to innovate is the result of internal and external factors (Roy, Sivakumar & Wilkinson 2004, Berghman, Matthyssens & Vandenbempt 2012, Fawcett, Jones & Fawcett 2012), great innovators depend on external actors to secure most of their advantage when it comes to innovation (Fawcett et al. 2012). Many companies rely on their supply chain partners for innovative input (Koufteros, Cheng & Lai 2007, Zimmermann et al. 2016) and "*the development of supply chain management capabilities focusing on innovation is seen as a key competitive weapon*" (Blome et al. 2013, p.60). However, integrating suppliers in product and process development involves significant risk, time, and financial resources from both parties (Koufteros et al. 2007, Silva & Moreira 2017).

A growing body of literature suggests that, to improve their performance, including innovation performance, firms need to deepen the extent of their supply chain integration, cooperation and collaboration, which involves multiple business processes upstream and downstream involving their suppliers, customers and their internal functional units (Petersen, Handfield & Ragatz 2005, Fawcett et al. 2012, Blome et al. 2013).

Taking these facts into account, this chapter analyses how the relationship between supply chain management and the innovation process is addressed in the literature. In other words, the study has the objective of analysing the intellectual structure of the topic by means of a bibliometric analysis. The following research questions are addressed:

- When and where were studies about the relationship between innovation and supply chain published?
- What is the intellectual structure of the literature?
- How has the diffusion of the topic through research literature taken place?
- What are the main themes addressed in the literature on the topic? Is it possible to identify different clusters? What differentiates the clusters?

2.2 Methodology

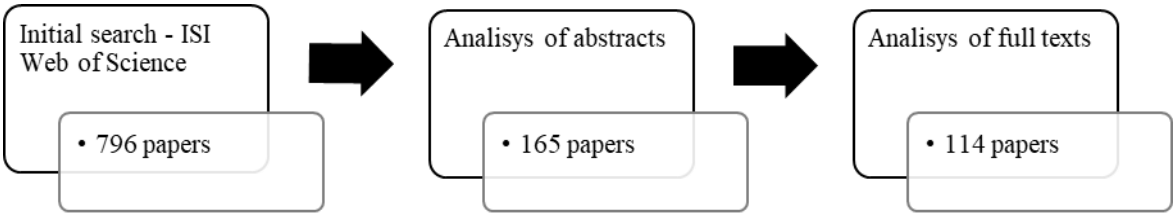
A bibliometric analysis was performed as a way of mapping and profiling the literature on the relationship between supply chain management and innovation. The papers were identified using the principles of the systematic literature review method, as presented by Denyer and Tranfield (2009), and were analysed with the intention of providing useful results for researchers and practitioners. The combination of the two methods is called Systematic Literature Network Analysis (Strozzi et al. 2017). In the first phase the papers are selected and evaluated, and the output of this phase is a set of selected papers. In the second phase the articles are analysed to answer the research questions.

The ISI Web of Science database was chosen as the source of research. This strategy is used in other reviews of literature in the area (Strozzi et al. 2017). To search for studies to be analysed, three categories of keywords were defined: (1) Words related to innovation: innovation, innovate, innovativeness. We decided to use the term innovat* to cover all possibilities; (2) Words related to supply chain: supply chain, SCM; (3) Words related to alignment/relationship/partnership: we decided again to use the asterisk in the following terms: align*, partner*, coordinat*, collaborat*, relation*.

The search was based on all possible combinations of the three groups of keywords, using the "Topic" field to search. Only journals (articles and reviews) were searched, limited to the areas of "Business Economics", "Engineering" and "Operations Research Management Science". There was no restriction on the date of publication.

The abstracts and keywords of the articles were read to identify the focus on the relationship between the supply chain and the innovation process of organizations. Finally, the articles were fully read and, using the same criterion, 114 articles were selected (Appendix 2). The search was conducted in March 2017.

Figure 8 - Location and selection of the articles



Following the suggestion of other studies, and as a way to increase the reliability of the selection, the articles were evaluated simultaneously by the three researchers and doubts and disagreements were discussed until consensus was reached. The articles were only included if all reviewers agreed.

2.3 Bibliometric analysis

Gerdsri, Kongthon and Vatanann (2013, p.404) define bibliometric analysis as *"a method that uses statistical and mathematical methods to analyse the literature of a target discipline by investigating the pattern in its bibliographies*". In this chapter, the main idea is to get a broad and thorough view of the global context on the topic.

Bibliometrics comprises various methods, usually grouped as citation or co-citation analysis (Charvet, Cooper & Gardner 2008). Citation analysis is based on the direct counts of references made to, or received from other documents. Co-citation analysis exploits paired citations as a measure of association between documents or sets of documents. According to Chavert et al. (2008, p.48), "*one of its major applications is the discovery of intellectual linkages amongst (scholarly) communications and the creation of science maps*". Co-citation analysis has been widely used across disciplines, including marketing, operations management, and strategic management.

The program BibExcel was used to conduct the bibliometric and statistical analyses from the 114 articles identified. BibExcel is the software most commonly used for performing bibliometric analysis in management and organizations (Charvet et al., 2008). The data source file used as the input to BibExcel was in a plain text format and contained bibliographic

information on the articles. The analysis focused on authors, titles, journals, years of publication, keywords, affiliations and references.

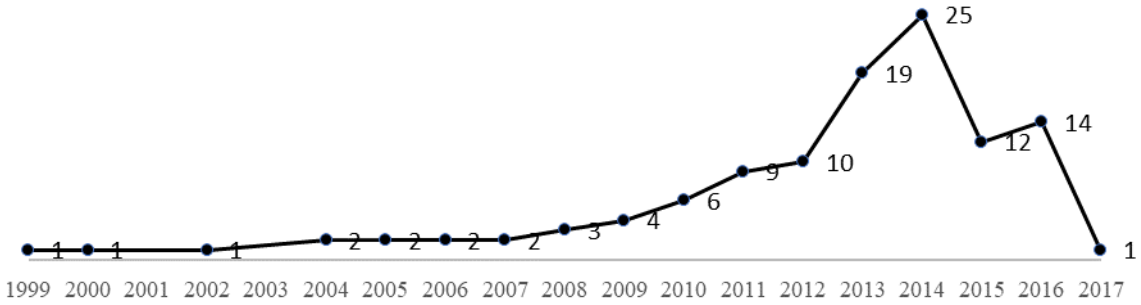
The open source software package Gephi was used to carry out the network analysis and graphical investigation. It uses a 3D render engine to develop illustrations of large networks in real-time and assist in speeding up the exploration process (Gephi,2013). In the graphs generated, the published papers are shown as nodes and citations are represented by the arcs and between the nodes (Fahimnia et al. 2015).

2.3.1 When and where?

Initially, the data from the articles were used to help answering the first research question, which is "When and where were the studies about the relationship between innovation and supply chain published?" The answer to this question should clarify the breadth of interest and the potential for emerging, alternative perspectives on the topic. The aspects observed were year of publication, publication source and location of authors.

Figure 9 shows the evolution of the topic in the literature since 1999, when the first article was published. About 70 per cent of the articles were published in the last five years (since 2012), which shows that the theme is relatively new in the literature.

Figure 9 - Number of articles per year



When it comes to the journals where the papers were published, there is a clear indication of the relevance and the all-embracing character of the theme, as the articles have been published in 40 different Journals. However, it is clear that the journals in the field of

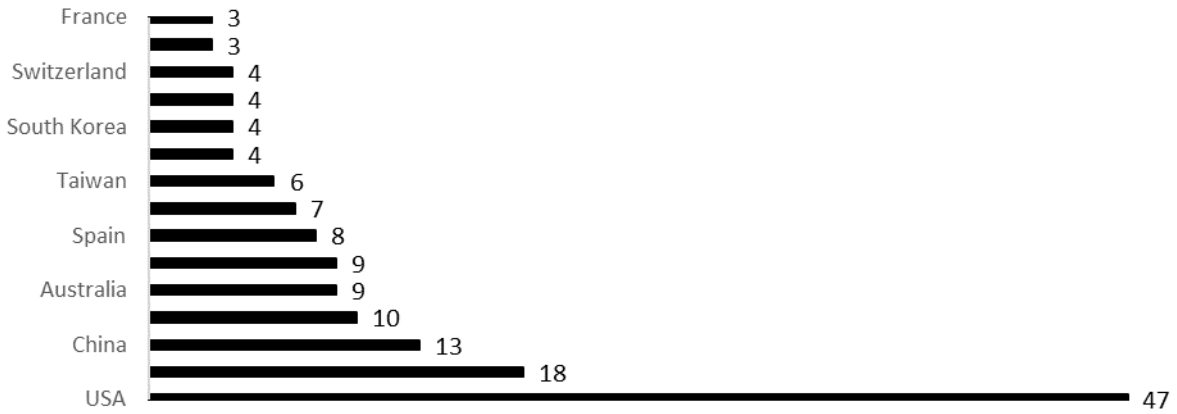
operations management have paid more attention to the topic than the journals in the areas of management, innovation and strategic management. Accordingly, the journals with the largest number of articles are the International Journal of Production Economics, followed by the Journal of Supply Chain Management, and Supply Chain Management: An International Journal. Table 9 presents the main publishing journals.

Table 9 - Main sources of publication

Journal	1999	2000	2002	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Total
International Journal of Production Economics									1	2	1	2	2	3		2	1	14
Journal of Supply Chain Management										1		1	5	2				9
Supply Chain Management: An International Journal					1			1		1			2	2		1	1	9
Journal of Operations Management					1	1	1		1					2				6
Research Policy			1					1					2			1		5
Production Planning & Control													1	1	2	1		5
International Journal of Production Research													1	3				4
Industrial Management & Data Systems							1				3							4
Production and Operations Management												1	1	1	1			4
Journal of Purchasing and Supply Management													1	1	2			4
Journal of Product Innovation Management								1		1				1	1			4

Finally, the articles are also widely dispersed geographically (authors from 32 countries were identified), demonstrating that the subject is of global interest, as Figure 10 shows.

Figure 10 - Countries with the largest number of publications



This first analysis of the literature shows that the topic has aroused the interest of researchers from different parts of the world in recent years and that the theme has potential for continuous growth.

2.3.2 Keyword statistics

Using the data extracted from the papers, an analysis was conducted to identify the most frequently used words and terms in article titles and keywords, respectively. The most frequently used words in paper titles were “supply”, “innovation” and “chain”. On the other hand, the most popular keywords are “innovation”, “supply chain management” and “supply chain”. Considering the search terms used to find the articles, there was no surprise in the main words used in titles and keywords.

However, it is important to highlight the use of the word “performance” among the most used words in titles. The high number of papers that uses this word in the title reveals the contribution of the topic to the improvement of firms’ performance. Concerning the keywords, it is important to highlight the word “integration”, which was used together with the terms “supplier” and “supply chain”, and “trust”.

Table 10 - The most frequently used words in paper titles and keywords

Word in titles	Frequency	Keyword	Frequency
supply	62	innovation	33
innovation	56	supply chain management	25
chain	53	supply chain	13
product	34	new product development	8
performance	25	product development	8
development	21	supplier integration	6
supplier	20	innovativeness	5
new	20	supply chain integration	5
integration	17	China	5
relationships	12	product innovation	5
role	12	trust	5
knowledge	11	game theory	3
management	11	SMEs	3
effects	10	open innovation	3
firm	9	absorptive capacity	3
empirical	8	supply chain performance	3
collaborative	8	performance	3
innovativeness	7	collaboration	3
industry	7	dynamic capabilities	3
chains	7	structural equation modelling	3

2.3.3 Citation analysis

To evaluate the relevance of each publication, a citation analysis was conducted, which counts the number of times a paper is cited in other publications. Citation analysis is frequently used to evaluate or compare articles, journals, academic programs and institutions (Charvet et al. 2008). In this case, we use citation analysis to compare the papers and to identify the most influential studies in the area.

The BibExcel citation analysis results shows that the 114 articles in the sample cited each other 134 times. The most cited papers in the core sample are shown by number of local citations in Table 11.

Table 11 - Articles from core sample with the highest number of local citations (only those articles with 3 or more)

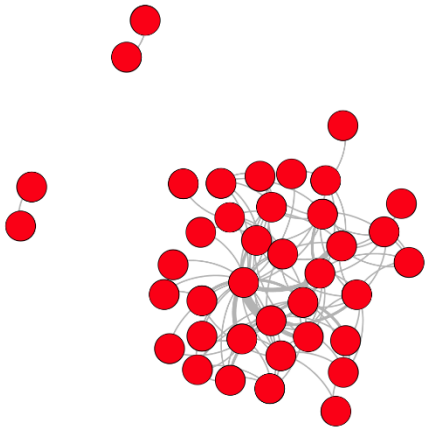
Article	Local Citations
Petersen, K., 2005, V23, P371, J OPER MANAG	21
Roy, S., 2004, V32, P61, J ACAD MARKET SCI	13
Koufteros, X., 2007, V25, P847, J OPER MANAG	10
Soosay, C., 2008, V13, P160, SUPPLY CHAIN MANAG	8
Bhaskaran, S., 2009, V55, P1152, MANAGE SCI	7
Craighead, C., 2009, V27, P405, J OPER MANAG	7
Choi, T., 2006, V24, P637, J OPER MANAG	6
Ettlie, J., 2006, V37, P117, DECISION SCI	4
Jean, R., 2012, V43, P1003, DECISION SCI	3
Kim, B., 2000, V123, P568, EUR J OPER RES	3
Chong, A., 2011, V111, P410, IND MANAGE DATA SYST	3
Narasimhan, R., 2013, V49, P27, J SUPPLY CHAIN MANAG	3
Panayides, P., 2009, V122, P35, INT J PROD ECON	3
Salvador, F., 2013, V49, P87, J SUPPLY CHAIN MANAG	3
Wynstra, F., 2010, V27, P625, J PROD INNOVAT MANAG	3

2.3.4 Co-citation analysis

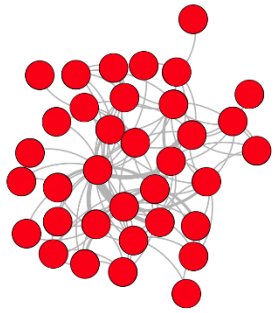
A co-citation analysis was developed to identify the intellectual structure of the theme. Co-citation analysis is used in the majority of bibliometric studies in management and organizations and citation practices to connect documents, authors, or journals (Zupic & Cater 2015). When co-citation is applied to the cited articles, it is able to identify the knowledge base of a topic and its intellectual structure. The knowledge base of a field is the set of articles most cited by the current research. These publications are the foundations on which current research is being carried out and contain fundamental theories, breakthrough early works, and the methodological canons of the field (Zupic & Cater 2015).

Based on the co-citation analysis, 39 articles emerge as the core sample, as they are the studies which have been cited by the others. However, four articles were removed as they appeared as remote nodes (Figure 11).

Figure 11 - Co-citation network with and without remote nodes removed



(a) The initial 39-node co-citation network removing the with remote nodes



(b) The 35-node co-citation network after remote nodes

The 35 papers remaining articles can be understood to be intellectual base of the topic (Table 12).

Table 12 - Intellectual base of the topic based on the co-citation analysis

Author	**year**	**vol**	**Journal**
Koufteros XA	2007	V25	J OPER MANAG
Petersen KJ	2005	V23	J OPER MANAG
Choi TY	2006	V24	J OPER MANAG
Bhaskaran SR	2009	V55	MANAGE SCI
Ettlie JE	2006	V37	DECISION SCI
Lau AKW	2007	V107	IND MANAGE DATA SYST
McIvor R	2004	V32	OMEGA-INT J MANAGE S
Wagner SM	2014	V32	J OPER MANAG
Jayaram J	2013	V51	INT J PROD RES
Billington C	2013	V22	PROD OPER MANAG
Bellamy MA	2014	V32	J OPER MANAG
Roy S	2004	V32	J ACAD MARKET SCI
Soosay CA	2008	V13	SUPPLY CHAIN MANAG
Roy S	2010	V63	J BUS RES
Jean RJ	2012	V43	DECISION SCI
Seo Y.J.	2014	V19	SUPPLY CHAIN MANAG
Wang LW	2011	V134	INT J PROD ECON
Panayides PM	2009	V122	INT J PROD ECON
Pero M	2010	V15	SUPPLY CHAIN MANAG

Author	year	vol	Journal
Blome C	2013	V49	J SUPPLY CHAIN MANAG
Cao M	2010	V128	INT J PROD ECON
Fawcett SE	2012	V55	BUS HORIZONS
Chong AYL	2011	V111	IND MANAGE DATA SYST
Hilletofth P	2011	V111	IND MANAGE DATA SYST
Modi SB	2010	V46	J SUPPLY CHAIN MANAG
Wynstra F	2010	V27	J PROD INNOVAT MANAG
Koufteros X	2012	V48	J SUPPLY CHAIN MANAG
Caridi M	2012	V136	INT J PROD ECON
Craighead CW	2009	V27	J OPER MANAG
Narasimhan R	2013	V49	J SUPPLY CHAIN MANAG
Salvador F	2013	V49	J SUPPLY CHAIN MANAG
Oke A	2013	V49	J SUPPLY CHAIN MANAG
Kim B	2000	V123	EUR J OPER RES
Wong CWY	2013	V146	INT J PROD ECON
He YQ	2014	V147	INT J PROD ECON

2.3.5 Data clustering

Finally, in order to understand how the literature deals with the different themes that are part of the main topic "supply chain management and innovation", a data clustering analysis was conducted. Cluster analysis is a frequently used technique for finding subgroups inside a topic (Zupic & Cater 2015). The nodes of a network can be divided into clusters where the density of edges is greater between the nodes of the same cluster than those of the others (Fahimnia et al. 2015). A cluster can be seen as a group of well-connected articles in a research area with limited connection to papers in another cluster or research area.

From the intellectual base of the topic, the literature mapping and network analysis identified four clusters. The papers that are part of Cluster 1 focus on the structural characteristics of the supply chain network, with a special focus on the supply base. Cluster 2 is predominately characterized by the study of supply chain trust and collaborative advantage. Authors in Cluster 3 highlight the importance of supplier and customer long term integration. Cluster 4, which was the last cluster to emerge, is composed of a set of papers which approach some trends in the topic, mainly related to strategy. Figure 12 shows the position of the four clusters.

Figure 12 - The position of the literature clusters

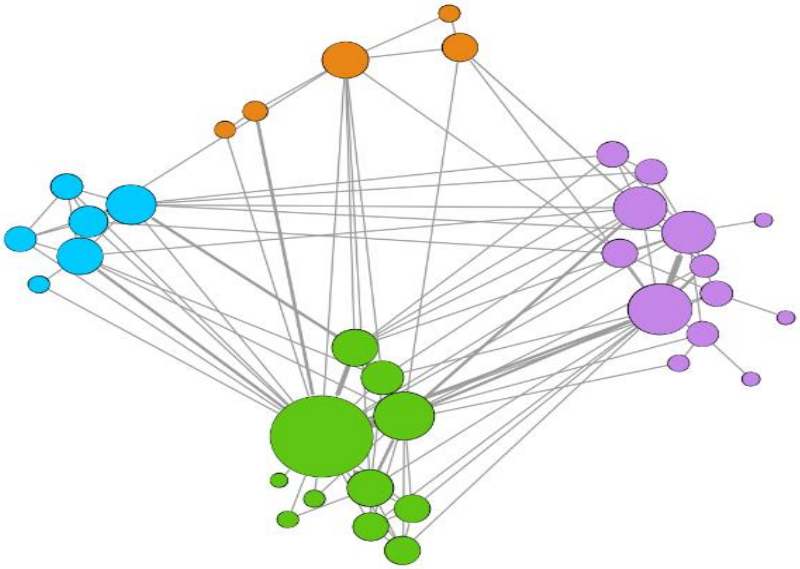


Figure 13 shows the evolution of the clusters over time. It stands out that Cluster 1, 2 and 3 have emerged since the beginning while Cluster 4 emerged later, in 2009. Although Cluster 3 has the first article published on the theme (in 2000), the other papers were published from 2013 onwards, providing evidence of the recent interest in its approach.

Figure 13 - Evolution of the research areas/clusters over time

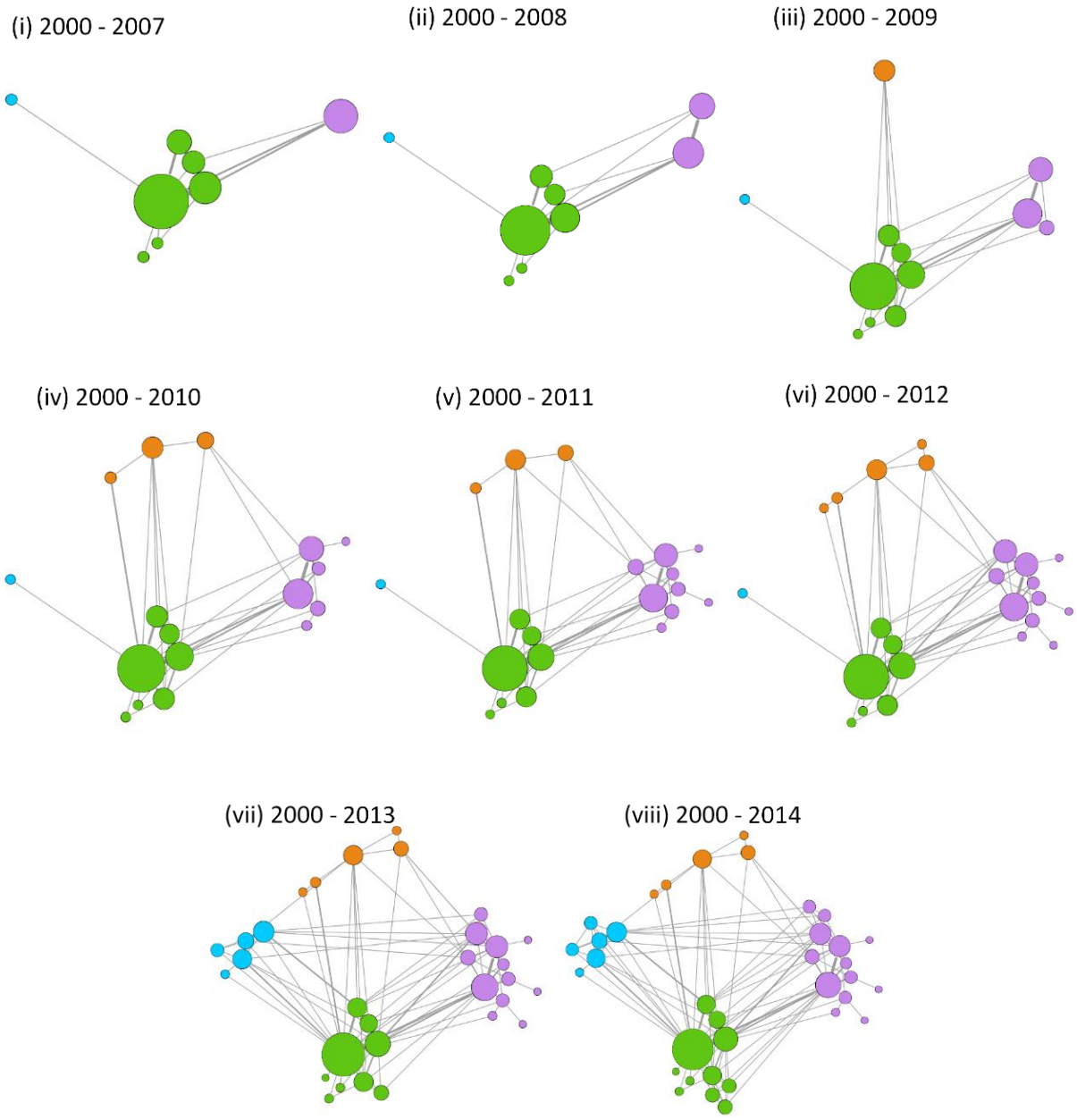


Table 13 shows the number of articles published each year in each cluster and Table 14 shows the articles that belong to each cluster.

Table 13 - Number of published papers per cluster

Year	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Total
2000			1		1
2004	1	1			2
2005	1				1
2006	2				2
2007	2				2
2008		1			1
2009	1	1		1	3
2010	1	3		1	5
2011		3			3
2012	1	2		1	4
2013	2	1	4		7
2014	2	1	1		4
Total	13	13	6	3	35

Table 14 - Papers belonging to each cluster

Cluster 1	**Cluster 2**	**Cluster 3**	**Cluster 4**
Petersen K, 2005, V23, P371, J OPER MANAG	Roy S, 2004, V32, P61, J ACAD MARKET SCI	Narasimhan R, 2013, V49, P27, J SUPPLY CHAIN MANAG	Craighead C, 2009, V27, P405, J OPER MANAG
Koufteros X, 2007, V25, P847, J OPER MANAG	Soosay C, 2008, V13, P160, SUPPLY CHAIN MANAG	Salvador F, 2013, V49, P87, J SUPPLY CHAIN MANAG	Wynstra F, 2010, V27, P625, J PROD INNOVAT MANAG
Bhaskaran S, 2009, V55, P1152, MANAGE SCI	Jean R, 2012, V43, P1003, DECISION SCI	Wong C, 2013, V146, P566, INT J PROD ECON	Koufteros X, 2012, V48, P93, J SUPPLY CHAIN MANAG
Choi T, 2006, V24, P637, J OPER MANAG	Panayides P, 2009, V122, P35, INT J PROD ECON	Oke A, 2013, V49, P43, J SUPPLY CHAIN MANAG	Caridi, M, 2012, V136, P207, INT J PROD ECON
Ettlie J, 2006, V37, P117, DECISION SCI	Wang L, 2011, V134, P114, INT J PROD ECON	He Y, 2014, V147, P260, INT J PROD ECON	Modi, S, 2010, V46, P81, J SUPPLY CHAIN MANAG
Wagner S, 2014, V32, P65, J OPER MANAG	Chong A, 2011, V111, P410, IND MANAGE DATA SYST	Kim B, 2000, V123, P568, EUR J OPER RES	
Billington C, 2013, V22, P1464, PROD OPER MANAG	Seo Y-J., 2014, V19, SUPPLY CHAIN MANAGEM		
Bellamy M, 2014, V32, P357, J OPER MANAG	Blome C, 2013, V49, P59, J SUPPLY CHAIN MANAG		
McIvor R, 2004, V32, P179, OMEGA-INT J MANAGE S	Roy S, 2010, V63, P1356, J BUS RES		
Lau A, 2007, V107, P1036, IND MANAGE DATA SYST	Cao M, 2010, V128, P358, INT J PROD ECON		
Jayaram J, 2013, V51, P1958, INT J PROD RES	Fawcett S, 2012, V55, P163, BUS HORIZONS		
	Hilletofth P, 2011, V111, P184, IND MANAGE DATA SYST		
	Pero M, 2010, V15, P115, SUPPLY CHAIN MANAG		

2.4 The main topics in the literature and the characteristics of the clusters

In this section the main characteristics of the clusters are discussed. However, it is important to highlight some general features of the literature on this topic. Regarding the methodology used, there is a predominance of quantitative empirical studies and concerning the nature of the samples, there was a predominance of the use of information from industrial companies.

When it comes to the theoretical perspective, the analysis of the papers showed that there was no dominant theory on the relationship between innovation and supply chains as more than 30 different theories were mentioned. The resource-based view was the theory with the largest number of articles, followed by the knowledge-based view and transaction cost economics. Moreover, there is a recent trend regarding the use of the resource-based view of the firm, which was heavily cited in recent publications. Another important factor is that there are a considerable number of papers that do not mention their theoretical basis.

2.4.1 Cluster 1 – Supply network structural characteristics

The eleven papers that are part of this cluster study, in general, the structural characteristics of the supply chain network, with special focus on the supply base. The supply base is understood as the "*portion of a supply network that is actively managed by a buying company*" (Choi & Krause 2006, p.637).

The supply network of a firm, and specially the supply base, has been viewed as an important source of innovation – in addition to the operational benefits of managing it effectively – and its structural characteristics have a great influence on a firm's innovation outputs (Bellamy et al. 2014). The supply network provides critical conduits for knowledge and information flows and the structural characteristics define the way in which firms manage knowledge and information sharing (or integration) with their partners (Billington & Davidson 2013, Jayaram & Pathak 2013, Bellamy et al. 2014).

Information and knowledge integration is an effective strategy to achieve superior innovation or new product development performance, and the context of new product

development is important and promising for knowledge integration (Jayaram & Pathak 2013). As the capability share knowledge and information between firms, mainly as a result of the growth of the Internet, often makes it easier for companies to access external resources than to develop them internally (Billington & Davidson 2013), open innovation is addressed by Billington and Davidson (2013) as a network structure that can facilitate the overall relationship between firms, especially the sharing of information, knowledge and decision making and, therefore, collaboration in research and development of new products and processes. In addition, Ettli and Pavlou (2006) argue that information and knowledge sharing make the development of technology-based new products possible.

Although firms use many mechanisms to help preserve and stimulate the creation of knowledge, it is still difficult for many firms to transfer internal knowledge to actors that are external to the firm and vice versa. Accordingly, it is the responsibility of the firms to find the right partners and build what Jayaram and Pathak (2013) call 'enterprise-wide knowledge architectures. Thus, "*to achieve product co-development with suppliers and customers, managers should identify, assess and qualify competent partners as a major supply base*" (Lau, Yam & Tang 2007, p.1054). The importance of the supplier selection for integrating them in the new products process, considering "*not only the capabilities, but also the culture of the supplier, which will have an impact on the buying firm's ability to interact with the supplier effectively*" has to be emphasised (Petersen et al. 2005). Therefore, Lau et al., (2007) discuss three types of co-development: supplier co-development (SC); customer co-development (CC); and internal co-development (IC). The type of co-development determines the main partner(s) in the innovation process.

Regarding the level of involvement of the supply chain partners, Petersen et al. (2005) suggest three basic forms of supplier involvement in product development: white-box, grey-box and black-box approaches. In summary, in the white-box approach, the suppliers are consulted about new product development and the integration is informal. In the grey-box model, the supplier and the customer work alongside each other and the supplier provides expertise, suggestions and other inputs to the product development effort but typically will not assume sole responsibility for developing parts, let alone modules, for the final product (Koufteros et al. 2007). Finally, a black-box approach implies

that each company will concentrate on certain tasks and components. In this case, the supplier can be ''trusted'' to develop parts and components.

Besides the level of involvement, it is also important to discuss when the partners will participate in the innovation or new product development process. Several authors (McIvor & Humphreys 2004, Petersen et al. 2005, Lau et al. 2007), highlight the role of early supplier, and client, involvement in the design process as a central attribute for the success of the co-development of new products.

The management of the supply network also can be seen as a cost sharing mechanism and a way of optimizing the research and development process. Bhaskaran and Krishnan (2009) propose a model which includes the interfirm interaction, the co-development process, technological uncertainty, the information structure and decision sequence. Depending on the type of project, the investment and revenue are shared. Wagner and Bode (2014) discuss the important differences between process and product innovation sharing, and the role of supplier-relationship-specific investments and safeguards for the investments for supplier innovation sharing.

2.4.2 Cluster 2 – Supply chain trust and collaborative advantage

The thirteen articles in Cluster 2 focus on the relationships, as opposed to the structural characteristics. The two most important features for the authors in this cluster are trust between partners (Panayides & Lun 2009, Wang, Yeung & Zhang 2011, Fawcett et al. 2012, Blome et al. 2013, Jean, Sinkovics & Hiebaum 2014) and building alliances (Roy et al. 2004, Soosay, Hyland & Ferrer 2008, Blome et al. 2013).

For Fawcett et al. (2012, p.163), "*trust is at the heart of a collaborative innovation capability*". The objective of the relationships is to gain collaborative advantage, which is defined as "*strategic benefits gained over competitors in the market place through supply chain partnering and partner enabled knowledge creation, and it relates to the desired synergistic outcome of collaborative activity that could not have been achieved by any firm acting alone*".

Trust between supply chain partners can be seen as a catalyst for collaborative innovation (Fawcett et al., 2012). It is important to search for supply chain partners with

distinctive complementary capabilities and create unique collaborative relationships with them to generate unparalleled process and product innovation (Fawcett, 2012). In this context, trust is an essential element of relational architecture and "*without a foundation of trust, collaborative alliances can neither be built nor sustained*" (Fawcett, 2012, p. 164). Fawcett et al. (2012) identified four stages of trust: limited trust, transactional trust, relational trust, and collaborative trust. In the last stage, relationships entail a common belief leading parties to view supply chain partners' capacity and capabilities as an extension of their own business. Soosay et al. (2008) also describe trust as one of the most important characteristics to reinforce collaboration and, as a consequence, improve innovation performance.

Trust allows supply chain partners to build collaborative relationships (Roy et al. 2004, Fawcett, Magnan & McCarter 2008, Cao & Zhang 2010, Hilletofth & Eriksson 2011). In the supply chain context, building collaborative relationships can help firms share risks, access complementary resources, reduce transaction costs and enhance productivity, and, therefore, enhance profit performance and competitive advantage over time (Cao & Zhang 2010, Chong et al. 2011). According to Cao and Zhang (2010), by collaborating, supply chain partners can work as if they were part of a single enterprise and such collaboration can increase joint competitive advantage. Collaborating with supply chain partners can involve activities such as sharing information, synchronizing decisions, sharing complementary resources, and aligning incentives with partners' costs and risks (Cao & Zhang, 2010).

Roy et al. (2004) propose a framework in which the link between interactions and innovation generation is moderated by several factors, which can be grouped as internal or external. In the set of internal and dyadic buyer /supplier relationship factors, they highlight IT adoption, commitment and trust. The authors focused on the upstream supply chain relationships. Roy and Sivakumar (2010) studied innovation generation considering upstream and downstream relationships. In this study, the authors highlight the importance of complexity and globalization as moderator effects for the relationship between interaction and innovation generation. Chong (2011) emphasizes that through

strategic supplier partnerships, organizations can work closely with suppliers who can share responsibility for the success of products, in a relationship characterised by trust.

In addition to the partnership with suppliers and clients in the new product development process, it is important to coordinate the different functions inside the company. Hilletofth and Eriksson (2011) defend the involvement of members of the main functions of the company in the design stage of new products and single out the role of the supply chain in the success of the products and the improvement of performance. The model presupposes a strong view on the demand side and a consumer-oriented perspective.

Finally, Jean et al. (2012) discuss the role of power-dependence and study the supplier dependence on the buyer as a moderator of the effects of supplier market knowledge acquisition, relationship learning, systems collaboration, and technological uncertainty on supplier innovation generation. The authors claim to provide "*a strong theoretical and empirical foundation for understanding how suppliers can augment their innovation capabilities by working with their customers in cross-border exchange relationships, and thus improve performance outcomes*" (Jean et al., 2012, p. 1030).

2.4.3 Cluster 3 – Supplier and customer long term integration

The six papers which compose Cluster 3 highlight the importance of supplier and customer long term integration. Topics such as partnership, strategic alignment and strategic relationships are discussed by the authors. According to Wong, Wong and Boon-it (2013, p.567), "*external integration involves the strategic alignment of business processes, information sharing and joint collaboration with suppliers and customers*" and helps firms to establish mutual understanding and gain information through network relationships.

Strategic relationships with supply chain partners, are defined by Oke et al. (2013, p.44) "*in terms of the extent to which the relationship is enduring and on a long-term basis*". Considering the risks involved in the innovation process, suppliers are more likely to align with customers for innovation if there is a long-term relationship in place (Oke et al., 2013). In addition to the importance of building long-term relationships with partners, the authors highlight the need to create strategic collaboration with the most important

partners, which creates mutual benefits. For Lee et al. (2014) integration with other supply chain actors presupposes partnership, which is characterized by a long-term commitment between the collaborators. The authors emphasize that integration in the context of NPD has different forms, internal or external to the firm boundaries, such as cross-functional team integration, intra-process or concurrent integration, resource integration, supply chain or external integration. For the authors, supplier integration has a positive effect on customer integration and they recommend that managers adopt the practice of supplier integration first. According to Salvador (2013), integrating suppliers into NPD projects offers manufacturers the potential for substantial improvements in the new product being designed.

Kim (2000) approaches coordination of the innovation process as a way to manage supplier innovation, considering that the innovation generated by the client company can lead to reduced costs for the supplier and, consequently, a reduction in the prices of their products. The coordination of innovation, for Kim (2000), is based on the long-term relationship between client and supplier, which is characterised by trust and shared information and decision making.

Finally, for Narasimhan and Narayanan (2013) it is crucial that companies align their internal research and development strategies with the knowledge available in the supply chain in order to achieve better performance with regard to innovation (Narasimhan & Narayanan, 2013). The authors define innovation as the process of generating changes in products, processes and services that result in the creation of value for the firm and its customers, through the knowledge generated by the company and/or its supply chain partners. Thus, the main reason to collaborate with other companies is to share and leverage resources unavailable internally.

2.4.4 Cluster 4 – Emergent topics – Strategy

Cluster 4, which was the last cluster to emerge and is composed of five articles, is a set of papers that approach some trends in the topic. However, it is important to highlight that, considering that the analysis is based in the co-citation of papers, the newest studies

in the area are not included in any cluster because they were not co-cited at the time the analysis was carried out.

The papers in this cluster mainly deal with topics related to strategy, such as knowledge management and supply chain knowledge, strategic supplier selection, supplier strategic focus on innovation, supply chain efficiency and product modularity. Supply chain strategy, knowledge, and action are key antecedents to firm performance (Craighead, Hult & Ketchen Jr 2009, Wynstra, von Corswant & Wetzels 2010). Supply chain knowledge, in turn, can be understood in terms of three constructs: learning progression, use of existing knowledge, and organizational memory (Craighead et al., 2009). Companies "*need to fit a supply chain's innovation–cost strategy to knowledge elements in a way that enhances action and creates superior firm performance*" (Craighead et al. 2009, p.418).

Efficiency is a core concept for operations management that influences firms' success in a general way and a central facet of supply chain management is the efficient flow of materials within the organization and across the firm's boundaries (Modi & Mabert 2010). Modi and Mabert (2010) study the relationship between efficient supply chain management and innovation and conclude that over time a firm's supply chain performance and supply chain stability positively influence the volume of its innovations.

Supply chain efficiency is also related to supplier selection. As firms become more dependent on their suppliers, the capabilities of those suppliers serve as key resources in the development of the buyer's own capabilities and performance (Koufteros, Vickery & Droege 2012). Strategic supplier selection has a positive effect on firm performance, including innovation performance (Wynstra et al. 2010, Koufteros et al. 2012). Moreover, supplier product development activity is directly affected by the supplier's position in the supply chain, by an explicit strategic focus on innovation and by commitment to customer development (Wynstra et al., 2010). The selection and the position in the supply chain will affect supplier innovation and, consequently, the customer innovation process and performance.

Finally, the product characteristics also influence the way that suppliers and clients participate in the innovation process (Caridi, Pero & Sianesi 2012). The level of modularity, for example, is significantly related to new product performance (Caridi et al. 2012). Thus,

identifying and qualifying the appropriate partners as a supply base for module design and production enhances the firm's capability to modularize products successfully, by leveraging the technological resources from the supply base.

2.5 Conclusions

Innovation is a complex process which is becoming more and more important for companies as markets become more competitive. This chapter has described and discussed how the relationship between innovation and supply chain management is addressed in the literature, identifying the intellectual structure of the topic. The analysis of the literature shows that the topic has aroused the interest of researchers from different parts of the world in recent years and that the theme has the potential for continuous growth. The dispersed character of the publications that are sources of information and the theoretical perspectives used also reinforce the broader character of the theme.

Different ways of addressing the topic were found in different journals and in different contexts. The importance of strong collaboration among supply chain partners for innovation performance is clear, even though that collaboration is seen and discussed in different ways in the literature.

After a bibliometric analysis of 114 studies, the intellectual base of the field was identified, composed by 35 studies. From this intellectual base, four main clusters were identified: the papers which are part of Cluster 1 focus on the structural characteristics of the supply chain network. Cluster 2 is predominately characterized by the study of supply chain trust and collaborative advantage. Authors in Cluster 3 highlight the importance of supplier and customer long term integration. And Cluster 4 is composed of a set of papers that explore some new trends on the topic.

However, in addition to identifying particular features of each cluster, it is also possible to find great similarities between the four groups of studies. As common characteristics, we can highlight the willingness to collaborate and the importance of communication between firms.

This chapter contributes to theory by identifying the different approaches that address the relationship between innovation and supply chains in the literature, and it

contributes to practice by providing some ideas to stimulate this relationship and improve performance.

As a recommendation for future research, we highlight the emergence of new topics which can be explored in the future, such as the importance of new technologies for the relationship between innovation and supply chain, the study of the fit between innovation capabilities and strategies and supply chain strategies, and the effects of supply chains on the different types of innovation (for example, product or process, radical or incremental).

Finally, as a limitation, the study is based on the analysis of published papers available in the ISI Web of Science database. Accordingly, themes which are in vogue at the moment, such as new technologies – the Internet of Things, virtual reality, autonomous vehicles and drones – and their importance for supply chains and innovation, were not considered in this study. Moreover, considering that the cluster analysis is based on the co-citation of the papers, the newest studies in the area are not included in any cluster because they were yet to be co-cited at the time the analysis was conducted.

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PART II – THEORY BUILDING

The second part plays an important role as it is responsible for developing and presenting the theoretical model of the thesis. Built from the gaps and opportunities identified in part I, chapters 3 and 4 rely on previous studies and concepts to take the first steps toward the development of theory regarding the fit between supply chain strategies and innovation strategies and between supply chain strategies and innovation capabilities. Characterised as conceptual theory building studies, chapters 3 and 4 presents research propositions which will be used as research hypotheses to be tested in the last part of the thesis.

CHAPTER 3 – STRATEGIC FIT BETWEEN INNOVATION STRATEGIES AND SUPPLY CHAIN STRATEGIES: A CONCEPTUAL FRAMEWORK[4]

Abstract

Purpose – drawing on the concept of strategic fit, this conceptual study seeks to discuss and clarify the relationship between innovation and supply chain strategies, answering the following research question: how does the fit between the different innovation and supply chain strategies influence business performance? This work also seeks to propose a conceptual framework to help advance research in this area.

Design/methodology/approach – a literature review was conducted for the topics of innovation and supply chain strategies as the basis for developing a unified conceptual framework, based on the principles of resource-based view and contingency theory.

Findings – the different innovation and supply chain strategies are studied and discussed with respect to the expected effects of fit on business performance. Five propositions and a conceptual framework are presented to show the complexity of the relationship between both strategies.

Research limitations/implications – the conceptual model put forward allows for an interrelationship between innovation and supply chain strategies, something that has not been adequately researched from the perspective of strategic fit. The main limitation of

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Zimmemann, R.; Ferreira, L.M.; Moreira, A.C. (2016). Innovation Strategies and Supply Chain Strategies: Analysing the Relationship and the Impact of Fit. In: Theory and Applications in the Knowledge Economy - TAKE, 2016, Aveiro. Proceedings of the International Conference Theory and Applications in the Knowledge Economy. Lisboa. v. 1.

Zimmermann, R.; Ferreira, L.M.; Moreira, A.C. (2018). Analysing the Fit Between Innovation Strategies and Supply Chain Strategies. In: Viles, E, Ormazábal, M, Lleó, A. Springer International Publishing, Cham, p. 153-160.

Under review in an ISI and Socpus indexed Journal when the thesis was delivered.

the study is related to the nature of the chapter; being a conceptual study based on a literature review, future research needs to test the propositions proposed.

Originality/value – this chapter contributes to the advancement of knowledge about the relationship between innovation management and supply chain management and provides insights for managers who are seeking substantive improvement of business performance.

Keywords: supply chain strategies, innovation strategies, strategic fit, conceptual study

3.1 Introduction

Corporate strategies are recognised to be very important in the search for competitive advantage. Strategies cover a wide range of areas within any business, including operations, marketing and finance. Commonly, they also include concepts related to innovation and supply chain (SC) management, two areas of great importance to business competitiveness. At the same time, many of the problems and difficulties associated with the management of innovation (Anthony, Eyring, & Gibson, 2006; Pisano, 2015) and the supply chain (Fisher, 1997; Qi, Boyer, & Zhao, 2009) stem from the lack of clear strategies that define the objectives of these processes.

The importance of strategic fit, or just fit, is one of the oldest ideas in strategic management (Porter, 1996; Venkatraman & Camillus, 1984). Porter (1996) highlights the importance of fit for the success of a firm's strategies, stating that a lack of fit between activities leads to a failure to differentiate the strategy. If operational efficiency leads to the individual excellence of activities, strategies refer to the fit or combination of these activities. Competitive advantage arises from the ability to align strategies and activities and the mutual reinforcement between the two. In turn, the difficulty of achieving a good fit comes from the need to integrate decisions and actions internally – across areas, functions, processes, units or independent strategies, or externally – with suppliers, customers or other partners. Fit is the adjustment of one variable in relation to another, in such a way that the combination gives rise to the best results (Donaldson, 1987; Venkatraman, 1989; Venkatraman & Camillus, 1984; Wu, Wu, Chen, & Goh, 2014). This concept is associated with what Venkatraman (1989) defines as 'fit as matching'.

In the literature on innovation there is growing agreement that the combination of internal and external sources of knowledge is a fundamental factor in the success of innovation strategies (Veugelers & Cassiman, 1999, Hazen et al., 2012, Lasch, 2016, Kim et al., 2017). This study is based on the principle that both innovation and SC strategies must be aligned with the requirements of the overall corporate strategy, as well as market demands, customer profile, technology and resources. Considering the important relationship between innovation and supply chain management, supply chain strategies need also to embrace the overall corporate goal into account. Accordingly, the study of fit between the two functional strategies should clarify which combinations of the different innovation and SC strategies tend to lead to better business performance. As such, this chapter addresses the following research question: how does the fit between the different innovation and supply chain strategies influence business performance? In order to answer this question, a literature review is carried out and a conceptual framework is proposed.

Although the relationship between innovation and supply chains is relatively strict and has attracted considerable attention from researchers in recent years, the relationship between innovation and SC strategies is a subject that has not yet been extensively explored in the literature (Zimmermann, Ferreira, Moreira, 2016). In understanding the effects of fit (as matching) between the different types of innovation and SC strategies on business performance, the chapter can bring a new perspective to the topic and makes several key contributions to the literature. First, by focusing on the strategic view of SC and innovation management, the study enhances the understanding of the strategic importance of the two areas – and their relationship – for business performance. According to Zimmermann et al. (2016), prior studies have focused on a more operational perspective and have been looking at the different forms of the relationship between the focal firm and its SC: (1) partnerships for specific purposes (Bruce and Moger, 1999); (2) project coordination by the client company (Kim, 2000; McIvor and Humphreys, 2004; Wang et al., 2011); (3) integration of the new product development process amongst actors in the supply chain (Petersen, Handfield and Ragatz, 2005; Roy and Sivakumar, 2010; Salvador and Villena, 2013); (4) strategic alignment between actors of the supply chain (Lau et al, 2007; Wagner and Bode, 2014); and (5) open innovation strategy

(Chesbrough, 2003; Billington and Davidson, 2013). The second theoretical contribution lies in the understanding of interactions between those two strategies and how they impact business performance. Given the link between strategies, it is important to understand their relationship.

This conceptual study seeks to contribute to theory building. Ketchen and Hult (2011) highlight the importance of using theory building in supply chain management research, and claim that theory provides, not just scholarly value, but also practical value. For Rindova (2011, p.19), the challenge is to "connect stand-alone ideas into a network of concepts and relationships among them, which constitute theory". According to Lynhan (2002), theory building is a research method that involves different research paradigms and does not use a single model. In this study, the method used is conceptual theory building, which "generates and presents theory, defined as a system of abstract concepts and the relationship between them" (Skilton, 2011, p. 23).

Finally, this chapter also offers practical implications for firms seeking substantive improvement in their overall performance through innovation and SC. In doing so, this study highlights the importance of aligning both strategies.

This chapter is divided into six sections. The introduction identifies the research gap and presents the research question. Section 3.2 addresses the theoretical foundations of the chapter and discusses the current state of the literature regarding the concept of fit. Section 3.3 evaluates how the fit between the functional areas of innovation and supply chain has been addressed in the literature. Section 3.4 presents a classification of innovation and SC strategies in order to understand the effect their fit has on business performance. Following from this, the conceptual framework and the propositions are presented in Section 3.5 and, finally, the results and implications are discussed in Section 3.6.

3.2 Theoretical foundations and the concept of fit

The study is developed based on two theories: Resource-based View (RBV) and Contingency Theory. According to the RBV, firms can conceive and implement strategies that improve their efficiency and effectiveness (Barney, 1991). In practice, the definition of innovation and SC strategies reflects the resources available and the same characteristics,

or resources, can influence both strategies. Consequently, the same resources can exert an influence on the fit between the strategies. In this study, the use of a RBV-based approach underpins the understanding of the dynamics of the relationship linking the two strategies, based on the resources that influence them.

In addition, according to the RBV, firms have unique sets of resources and capabilities – valuable, rare, inimitable and nonsubstitutable – that can provide sustainable competitive advantage (Barney, 1991; Hong et al., 2011; Laosirihongthong et al., 2014; Prajogo, 2016). According to Prajogo (2016), a range of studies use this theory as a theoretical base to demonstrate the benefits of innovation strategies for the performance of firms. The RBV defends the view that successful innovation strategies can generate improvements in performance, depending on the extent to which the innovations resulting from those strategies: (1) add value for the customers through differentiation from the competition; (2) produce results which are hard to imitate and; (3) create products or services which are not substitutable (Barney, 1991; Prajogo, 2016). According to Hong et al. (2011), firms with more resources are more likely to have improved chances of maintaining their competitive advantage. Finally, the RBV theory is a theoretical perspective that has been used to explain the differences between the performance of firms (Laosirihongthong et al., 2014), which is also a central concern of the present study.

The Contingency Theory looks at how the fit between context, structure and processes influences performance (Drazin & Van de Ven, 1985). This theory, frequently used as a basis for studying fit (Acur et al., 2012), suggests that organizational outcomes, such as performance, are dependent on the level of internal fit among key organizational elements, such as strategy, and structure (Eva et al., 2018). In a contingency approach, the conditional association of two or more independent variables can be studied (in this case innovation and SC strategies) together with the influence they exert on a dependent variable (in this case business performance) (Prajogo, 2016). Finally, from the perspective of contingency theory, there are no universally superior strategies. The context and structure should be adjusted to benefit the performance of the organisation (Drazin & Van de Ven, 1985).

To understand the relationship between innovation and SC strategies, with the objective of developing a guiding framework, both in terms of theory and practice, this study is based around the concept of fit, which has gained ground in the literature over the last few years (Acur, Kandemir, & Boer, 2012; Wu et al., 2014, Gumusluoglu & Acur, 2016, Gligor, 2017).

The concept of fit is a fundamental element for constructing theory in a wide range of different areas, including strategic management (Venkatraman, 1989; Prajogo, 2016, Miles and Van Clieaf, 2017). Naman and Slevin (1993) state that understanding the concept of fit is fundamental for understanding the difference between the field of strategic management and other fields, such as finance, human resources and marketing.

Venkatraman (1989) describes fit as an adjustment between two or more variables or components. Although the way in which the fit takes place can vary depending on the context and the methods used, the final objective is always the search for the best results by varying the variables under analysis (Prajogo, 2016; Eva et al., 2018).

In this study, fit is understood to be the adjustment of one or more variables – activities, strategies, business areas or organisations – to others, so that the combination leads to improved results (Donaldson, 1987; Venkatraman, 1989; Venkatraman & Camillus, 1984; Wu et al., 2014). This concept is reflected in what Venkatraman (1989) defines as *fit as matching*: "*This perspective is invoked for strategy concepts in which fit is a theoretically defined match between two related variables*" (Venkatraman, 1989, p. 431).

3.3 Innovation and supply chain strategies

Strategy is the creation of a unique and valuable position, involving a set of activities, which can be understood as the creation of alignment among the different activities of the business (Porter, 1996). Strategic positioning is based on carrying out different activities from those of your competitors or carrying out similar activities in a different way. A strategy is a commitment to a set of activities, policies and behaviours which are coherent and mutually supportive, seeking to achieve objectives that contribute to the competitiveness of the business. For Pisano (2015), good strategies encourage

alignment between the different groups in the organisation, clarify objectives and help maintain the focus on the stated priorities.

External factors for companies, such as technological change or a change in the behaviour of competitors, are often seen as the main threats to strategies. However, although external changes are relevant, the main threats to strategies normally come from inside the company (Porter, 1996). Consequently, the search for sustainable competitive advantage should be primarily focused on that which is within the sphere of influence of the firm, and has attainable results – in other words, the firm's activities. However, by itself, the operational efficiency of the different activities of the firm is not enough to ensure success (Porter, 1996). The activities should be aligned with each other and they should reflect the defined corporate strategies.

Moreover, strategy can be understood as the act of combining the different elements that make up the strategic mix of the company – some of which are internal, such as skills and resources, and others external, such as opportunities and threats. Such a combination is often known as fit (Venkatraman & Camilus, 1984).

3.3.1 Innovation strategies

Confronted with increasing competition in their target markets, firms from different sectors and with different styles typically include objectives linked to innovation in their strategic plans (Veugelers & Cassiman, 1999). However, adopting innovation strategies is not yet common practice in companies (Anthony et al., 2006; Guan, Yam, Tang, & Lau, 2009; Pisano, 2015) and receives relatively little attention in the academic world.

Because of its complexity, the management approach to innovation varies depending on the needs of the company. The innovation process includes management and decision making activities at the organisational and individual level. The ability of the company to manage its day-to-day tasks and invest resources in complex and uncertain environments determines how, and to what degree, innovative products and processes will be generated (Ferreira, Fernandes, Alves, & Raposo, 2015).

Successfully maintaining or developing the innovation capacity of companies depends on the objectives laid down and the defined innovation strategy (Bowonder, Dambal, Kumar, & Shirodkar, 2010; Guan et al., 2009). This is the basis that allows for

conscious and coherent decision making, with a view to achieving the best performance for the process (Adner, 2006; Clausen, Pohjola, Sapprasert, & Verspagen, 2012; Ferreira et al., 2015; Pisano, 2015; Veugelers & Cassiman, 1999). In other words, it considers the development of new products, processes or business models, or a significant improvement in the current ones, which are tailored to the needs of customers, and, as a result, helps improve the results for the firm as a whole. Innovation strategies guide decision making for the firm with respect to innovation and serve as a stimulus motivating workers to participate in the process in a synergistic way.

Some authors classify innovation strategies based on characteristics that they consider important and differentiate them in this process. Whitley (2000) proposes that strategies be classified into: dependent; craft-based responsive; generic; complex and risky; and transformative. Guan et al. (2009) divide innovation strategies into: technology importer; defender; imitator; follower; and leader. Love et al. (2014) focus on the differences between the sources of knowledge for innovation and define four strategies: no R&D or external linkages (neither); no R&D but with external linkages (external); R&D but no external linkages (internal); and both R&D and external linkages (both).

Clausen et al. (2012) propose a typology that considers five strategies which represent what the authors understand to be the main differences among firms in the approach taken to the process: ad hoc; supplier based; market-driven innovation; R&D intensive; and science-based innovation. These innovation strategies are based on data from the Community Innovation Survey (CIS), which reflects decades of research effort to understand the sources and effects of innovation in a broader context. These strategies are similar to those proposed previously in the literature, such as Pavitt (1984), Marsili and Verspagen (2002) and Castellacci (2008), but with the advantage of using data collected at firm level, as opposed at industry level. Finally, the strategies proposed by Clausen et al. (2012) reflect firms' internal characteristics and external relationships – encompassing supply and demand factors (where previous approaches have focused on product or process characteristics or on external relationships). As such, Clausen et al. (2012) model is aligned with the objectives of this chapter since it represents the differences among firms

regarding the characteristics of innovation and supply chain. The main characteristics of each type of strategy are presented in Table 15.

Table 15 - Characteristics of the different types of innovation strategies

Characteristics	Ad hoc	Supplier based	Market-driven innovation	R&D intensive	Science-based
R&D investments	Low	Low	High	Very high	Very high
Sunk costs	Low	Low	High	High	High
Sources for innovation	Limited	Few	Some	Many	Many
Spectrum of goals	Limited	Limited	Broad	Broad	Broad
Persistent innovation	No	No	Yes	Yes	Yes
Absorptive capacity	Low	Medium	Medium / High	High	Very High

Source: Adapted from Clausen et al. (2012)

It is important to note that, just like the innovation process itself, the innovation strategy involves constant experimentation, learning and adaptation. This means that a strategy never reaches a point where it is definitively defined, with relevant internal and external aspects that require consideration undergoing constant change.

3.3.2 Supply chain strategies

Supply chain management, like innovation management, is a common theme in the corporate strategic plans of many organisations. However, while it is recognised as a source of competitive advantage, firms do not always define their objectives with respect to the SC. The topic has received little attention in the academic world (Qi et al., 2009; Qrunfleh & Tarafdar, 2014; Sharifi, Ismail, Qiu, & Tavani, 2013).

Effective management of the flow of material from the supply sources to the final customers represents a major challenge for managers. Companies need a clearly defined plan to be able to organise their activities, resources and communications for this complex and complicated process (Qi et al., 2009). For Christopher (2000), followed by Lee (2002) and Qrunfleh and Tarafdar (2014), SC strategies reflect the nature of the supply chain and lay down its objectives and goals. Moreover, they should be aligned with the product

characteristics, with the adopted competitive strategy and with the environment where the firm competes (Qi et al., 2009).

For Arora et al. (2016, p. 206), "*supply chain strategy describes a pattern of decisions related to sourcing products, capacity planning, conversion of raw materials, demand management, communication across the SC, and delivery of products and services and thereby links SCM strategy to business and corporate-level strategy*".

The model proposed by Marshall Fisher (Fischer, 1997) in his important and influential article published in the Harvard Business Review in 1997 led many authors to adopt two types of SC strategy: lean – equivalent to Fisher's Efficient strategy, and agile – equivalent to Fisher's Market-responsive strategy (Christopher, 2000; Christopher & Towill, 2002; Cigolini, Cozzi, & Perona, 2004; Qi et al., 2009; Qi, Zhao, & Sheu, 2011; Qrunfleh & Tarafdar, 2014). For Christopher (2000), there are three critical dimensions that determine which approach – agile or lean – makes greatest sense for a company: variety, variability (or predictability) and volume. Agility is needed in less predictable environments where demand is volatile and the requirement for variety is high. On the other hand, lean works best in high volume, low variety and predictable environments.

Table 16 presents the main characteristics of the Lean and Agile strategies.

Table 16 - The main characteristics of the Lean and Agile SC strategies

SC Strategy	**Lean**	**Agile**
Objective	Focuses on cost reduction and incremental improvements for existing products. Focuses on elimination of waste and non-value-added activities across the supply chain	Tracks and understands customer requirements by interacting closely with market. Aims to produce in any volume (and not just the optimal capacity utilization volume) and deliver simultaneously to a wide variety of markets. Provide customized products as short lead times (i.e. focuses on responsiveness)
Inventory strategy	Generates high inventory turnover and minimizes inventory through the supply chain	Deploys significant stocks of parts to tide over unpredictable market requirements
Lead time focus	Shortens lead-time only so long as doing so does not increase delivery or inventory costs	Reduces lead times to customer specifications and requirements
Manufacturing	Maintains high average	Deploys excess/buffer capacity to ensure

SC Strategy	Lean	Agile
focus	capacity utilization rate	that raw material/components are available to manufacture the product according to market requirements
Product design strategy	Reduces the cost of production	Produces to modular designs, by using a limited number of basic components and processes that can be assembled into different products

Source: Qrunfleh & Tarafdar (2014)

Some authors have adopted a lean and agile, or leagile strategy (Nailor, Naim & Berry, 1999; Bruce, Daly & Towers, 2004; Qi et al., 2009). Leagile is understood as the combination of the two strategies and can operate, for example, cost-effectively in upstream activities of the supply chain and responsively to volatility in the market downstream (Bruce et al., 2004).

Finally, just as with innovation management, supply chain management is a process which goes through constant changes and, as a result, the choice of SC strategy is also a dynamic process. Differences between the products of a firm should also be taken into account, which means that an organisation can apply different strategies at the same time. As Christopher and Towill (2002) state, Lean and Agile are not opposing philosophies. It is just that they are better suited to different contexts.

Lee (2002) argues that a successful SC strategy depends on two factors: (1) the strategy should be designed in accordance with the needs of the customers; and (2) a product with a stable demand and with reliable sources of supply does not need the same sort of management as a product with unpredictable demand and unreliable supply sources. As Lee (2002, p. 106) states, "*strategies that are based on a one-size-fits-all or try-everything mentality, will fail*".

3.4 The fit between innovation and supply chain strategies – propositions and framework

From the aggregation of the theoretical foundations, the concept of fit, the study of fit between innovation and SC in the literature, and the characteristics of innovation and SC strategies, theoretical propositions and a conceptual framework are presented. The way firms manage innovation and their supply chains, as well as the strategies they embrace,

impact on business performance. The fit between different variables (activities, strategies or business areas) in the firm can be a driver for optimising results (Eva et al., 2018). This chapter is based on the principle that the fit between the different types of strategies affects a firm's business performance in different ways and that some combinations of innovation and SC strategies are more likely than others to achieve better results for the firm.

According to Clausen et al. (2012), the firms that are part of the ad-hoc group invest little in research and development activities (or in other words, they avoid sunk costs[5]) and have no solid commitment to others (knowledge sources). These firms have slower learning paths and, given that this strategy produces relatively little innovation, the firms are less able to invest the profits from previous innovation in future rounds of innovative activity (Clausen et al., 2012).

The lean strategy seeks to create efficient supply chains, in terms of costs, focusing on the reduction of lead times and the elimination of stock waste. This strategy fits well with stable and predictable demand and products that change little (Christopher & Towill, 2002; Qi et al., 2009; Qi et al., 2011; Qrunfleh & Tarafdar, 2014). The main objective of an SC lean strategy is to reduce costs and increase efficiency by eliminating waste, both in the internal processes and the external processes of the organisation (Qi et al., 2009).

Based on these considerations, the first proposition is presented, considering the concept of fit and the characteristics of ad-hoc innovation strategies and lean SC strategies:

RP1: Firms with Ad-hoc innovation strategies tend to obtain better business performance by adopting a lean SC strategy as opposed to an agile SC strategy.

Firms that rely mainly on their suppliers (specially of machinery and equipment) as a source of knowledge for innovation belong to the group of supplier-based strategy (Clausen et al., 2012). This strategy can be seen as a reactive and incremental approach to

[5] "Sunk cost" is a term used in economics to describe costs that have already been realised and cannot be recovered, at least a significant part of them (Sutton, 1991). Investments in innovation (or R&D), which may or may not result in new and "lucrative" products, cannot be recovered.

innovation where the firms do not heavily invest on innovative internal competencies, so that they do not incur sunk costs. This is consistent with lean SC strategies. Based on these considerations, the second proposition is presented:

RP2: Firms with supplier-based innovation strategies tend to achieve better business performance by adopting a lean SC strategy as opposed to an agile SC strategy.

On the other hand, firms that adopt a market-driven innovation strategy have their innovation focus centred on the customer and look for knowledge from industry sources, such as competitors and customers (Clausen et al., 2012). Such firms seek out this type of relationship and they invest highly in innovative activities, based on both incremental and radical innovation, with the objective of developing a sustainable competitive edge. High investment means that this strategy requires more long-term commitment than the two above mentioned strategies and an outward focused perspective.

An agile SC strategy seeks to guarantee the flexibility and adaptability of the SC given constant changes in both customer needs and the competitive environment, using fast, dynamic and continuous responses (Christopher & Towill, 2002; Qi et al., 2009; Qrunfleh & Tarafdar, 2014). The objective of this type of strategy is to devise customer-driven products, focused on customers with unique characteristics, so that the competitive advantage is retained in constantly changing environments. The shortening of product life cycles and rapidly changing customer requirements have increased the pressure throughout the SC to provide products and services in a quicker and more responsive manner (Qi et al., 2009). Following, from this, the third proposition in this study is:

RP3: Firms with market-driven innovation strategies tend to achieve better business performance by adopting an agile SC strategy as opposed to a lean SC strategy.

The R&D intensive strategy is adopted by firms that tend to have a wide range of objectives and innovation sources, while being especially focused on internal and external R&D processes (Clausen et al., 2012). This strategy favours the development of radical innovations and increases the learning capacity of the firm. The strong R&D capabilities lead firms to deploy brand new products and services to exploit market opportunities that

other firms cannot exploit as they are not as technology-oriented as firms that have a R&D intensive strategy. This approach requires continual effort and attentiveness from the supply chain, which are characteristics associated with the agile strategy type, leading to the following proposition:

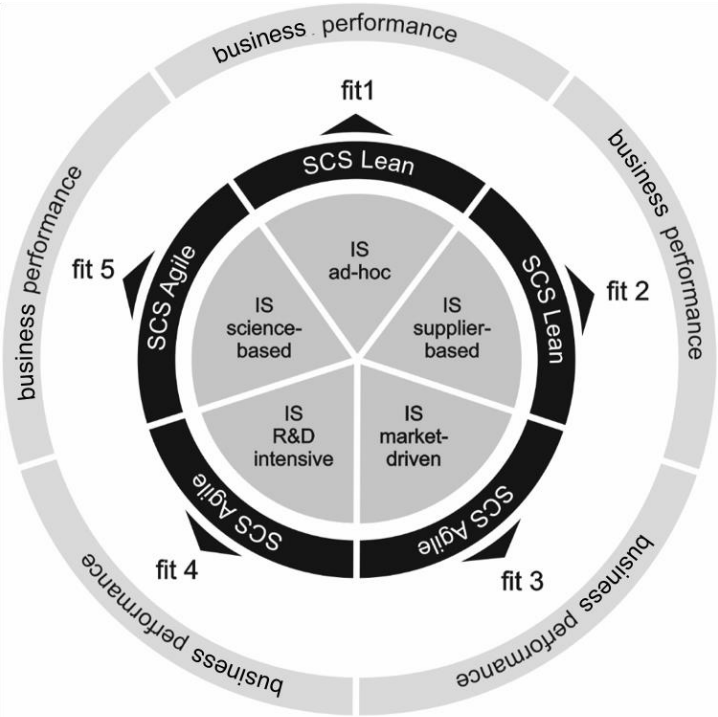
RP4: Firms with R&D intensive strategies tend to achieve better business performance by adopting an agile SC strategy as opposed to lean SC strategies.

Firms with science-based innovation strategies are highly dependent on scientific knowledge sources, such as patents, and the relationship with universities and research institutes as part of their innovation process. Firms in this group tend to be persistent innovators – measured by the number of innovations, given that they have greater ability to innovate again in subsequent periods – with basic science offering great technological opportunities (Clausen et al., 2012). Science-based innovation strategies rely heavily on the firms' capabilities to create new technological knowledge and to explore scientific advances knowledge providers (Castellaci, 2008). This type of strategy also requires a systematic commitment from the supply chain to underpin the development of new products, which is associated with an agile supply chain strategy, leading to the fifth proposition of this study:

RP5: Firms with science-based innovation strategies achieve better business performance by adopting an agile SC strategy as opposed to a lean SC strategy.

Figure 14 shows the conceptual framework, which reflects the results of the joint use of different strategies.

Figure 14 - Conceptual framework



The propositions shown here reveal the complexity of the relationship between the areas of innovation and SC, and especially between the corresponding strategies. On the one hand, the innovation strategy deployed by a firm defines the type of products/services it produces and influences the SC strategy it adopts. On the other hand, the nature of the supply chain exerts a strong influence on the innovation process and strategies adopted. The relationship between those functional strategies have a mutual influence on each other.

3.5 Implications and conclusions

The chapter contributes for a strategic view of the relationship between innovation and SC, as prior studies have focused mainly on a more operational perspective (Zimmermann et al., 2016). The chapter also provides some insights for both innovation and SC managers who are looking to improve the global performance of their organisations and highlights the importance of achieving an alignment between those strategies.

The propositions that have emerged from this chapter contribute to theory providing a new perspective to the topic and have the potential to be used as a guide by managers for decision making in terms of adopting innovation and supply chain strategies, although empirical validation is needed. In addition, they can be used as a way to encourage alignment between these and other functional areas.

In this work we have identified possible combinations of innovation and supply chain strategies and have discussed the expected effects of these combinations on business performance. The discussion shows not only that the adoption of the various types of innovation strategies – which depend on a variety of aspects – influence business performance, but also support the alignment between innovation and SC strategies. As such, the chapter contends that the innovation and supply chain functional areas may play an important role in business performance as they are more interrelated than originally thought. Moreover, it is also possible to contend that supply chain strategies may moderate the relationship between the innovation strategy deployed by the firm and business performance.

Several studies point to direct evidence that complementarity between internal activities of R&D and external access to knowledge is a fundamental factor for the innovation process (Love et al., 2014; Veugelers & Cassiman, 1999). Alignment between the innovation and SC strategies also leads to an improved fit between the internal activities of the firm and the activities of its partners throughout the supply chain. One possible explanation for this is the fact that the SC strategy steers the relationship with external suppliers and clients – information and knowledge exchange, inter-organisational innovation, collaborative product development, quality management activities, among others – that influence the way innovation activities with other actors of the supply chain really works, which end up influencing business performance.

We highlight the fact that corporate strategies are dynamic processes. Changes in the way innovation is carried out within the firm should always lead to a re-evaluation of the SC strategies. The opposite is also true; changes in the supply chain structure or in the SC strategies can lead to changes in the way the firm manages innovation.

Considering the uncertainty of the business context, the variety of firm's processes and products, we also conclude that different strategies can coexist in a single organisation – both in innovation and SC – depending on the types of markets the firm serves, and the types of products developed to match those market needs. It is also possible that a different alignment between the functional strategies would be necessary, to make the most efficient use of the relationship between the uncertainty of the demand (often associated with innovation) and the operational efficiency.

Limitations and future research

The main limitation of this chapter is related to the nature of the work, namely carrying out a literature review with the goal of developing a conceptual study. For future research, we recommend the test of the conceptual framework involving an empirical analysis and additionally to review the conceptual model to include the unpredictability of supply and the demand.

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CHAPTER 4 – THE EFFECT OF SUPPLY CHAIN STRATEGY ON THE RELATIONSHIP BETWEEN INNOVATION CAPABILITIES AND BUSINESS PERFORMANCE[6]

Abstract

Purpose – although the relationship between supply chain (SC) and innovation, two important areas within organizations, has attracted attention from researchers, the relationship between innovation capabilities and supply chain strategies is a subject that has not yet been extensively explored. The main objective of this chapter is to examine how supply chain strategies affect the relationship between innovation capabilities and business performance.

Design/methodology/approach – characterized as a conceptual study with the aim of contributing to theory building, this chapter is based on the concept of fit and on the principles of Contingency Theory and the Resource-based View. Besides a literature review and a theoretical discussion, a theoretical model is introduced, which represents the relationship between innovation capabilities, SC strategies and business performance. A set of research propositions is presented.

Findings – the chapter discusses the ways that SC strategies affect the relationship between innovation capabilities and business performance. The theoretical model and the research propositions show the potential for performance improvement through this relationship and the complexity and relevance of the topic.

Originality/value – the theoretical model and the propositions put forward in this chapter could be used to boost empirical research on the topic and to guide managers' decision making (in the areas of innovation and supply chain) who are seeking substantial improvement in business performance.

Keywords: supply chain strategies, innovation capabilities, business performance, fit.

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4.1 Introduction

Innovation is recognized as an important source of competitive advantage and its effect on business performance has been highlighted in recent studies (Borjesson & Elmquist, 2011; Saunila, Pekkola, & Ukko, 2014; Mir et al., 2016). Due to its complexity, innovation is affected by a variety of different resources and contingencies and its success depends on the best use of innovation capabilities, composed of skills and assets which result in the ability to develop and explore new ideas successfully (Borjesson & Elmquist, 2011; Calantone, Cavusgil, & Zhao, 2002; Guan & Ma, 2003).

The relationship between innovation and supply chain (SC) has attracted attention from researchers in recent years (Primus & Stavrulaki, 2017; Mikkelsen & Johnsen, 2018). However, the relationship between innovation capabilities and SC strategies is a subject that has not yet been extensively explored (Zimmermann, Ferreira, & Moreira, 2016). SC strategy describes a pattern of decisions related to sourcing products, transformation of raw materials, demand management, communication across the SC and delivery of products and services (Arora, Arora, & Sivakumar, 2016). SC strategies reflect the nature of the supply chain (Lee, 2002; Qrunfleh & Tarafdar, 2014; Tracey & Neuhaus, 2013) and should be aligned with the product's characteristics, with the competitive strategy adopted and with the environment where firms compete (Qi, Zhao, & Sheu, 2011).

The relationship between two or more areas, functions, processes, units, strategies or capacities can be studied through the lens of the concept of fit – or strategic fit –, which is one of the oldest ideas in strategic management (Porter, 1996; Venkatraman & Camillus, 1984). Fit indicates consistency between two or more factors, and a good fit is believed to have an impact on performance (Peng, Schroeder, & Shah, 2011; Venkatraman, 1989). Fit is the adjustment of one or more variables in relation to another, in such a way that the combination gives rise to the best results for the firm (Venkatraman & Camilus, 1984; Wu et al., 2014).

Considering the relationship between innovation and supply chain (Zimmermann et al., 2016), this chapter seeks to discuss how fit between SC strategies and innovation capabilities affect business performance. In other words, the following research question is

addressed: how SC strategies can affect the relationship between innovation capabilities and business performance?

In understanding the effects of fit between the different types of innovation capabilities and SC strategies on business performance, the chapter can bring a new perspective to the topic and makes several key contributions to the literature. By focusing on the strategic view of SC and innovation capabilities, the chapter enhances the understanding of the strategic importance of the two areas – and their relationship – for business performance. According to Zimmermann et al. (2016), prior studies have focused on a more operational perspective and have been looking at the different forms of the relationship between the focal firm and its SC partners.

This conceptual study is a first step towards discussing the effect of SC strategies on the relationship between innovation capabilities and business performance and seeks to contribute to theory building. Ketchen and Hult (2011) highlight the importance of using theory building in supply chain management research, and claim that theory provides, not just scholarly value, but also practical value. For Rindova (2011, p.19), the challenge is to "*connect stand-alone ideas into a network of concepts and relationships among them, which constitute theory*." In this study, the method used is conceptual theory building, which generates and presents theory, defined as "*a system of abstract concepts and the relationship between them*" (Skilton, 2011, p. 23).

Finally, this chapter also offers practical implications for firms seeking substantive improvement in their overall performance through innovation and SC. In doing so, this study highlights the importance of aligning both areas and particularly SC strategies and innovation capabilities.

The next section presents the theoretical background of the study and the concept of fit, followed by a literature review about innovation capabilities, SC strategies and business performance. Afterwards, a theoretical discussion, the research propositions and the theoretical model are presented. Finally, the conclusions of the research, including the limitations of the work and recommendations for future research, are provided.

4.2 Theoretical background and the concept of fit

This study is based on the concept of fit and on the principles of Resource-based View (RBV) and Contingency Theory (CT). The concept of fit has gained ground in the literature over the last few years (Acur, Kandemir, & Boer, 2012; Wu et al., 2014). The concept is a fundamental element for constructing theory in a wide range of different areas, including strategic management (Venkatraman, 1989). Naman and Slevin (1993) state that understanding the concept of fit is fundamental for understanding the difference between the field of strategic management and other fields, such as finance, human resources and marketing.

Fit indicates consistency and harmony between two or more variables, and it is believed that the better the fit, the better the impact on performance (Peng et al., 2011; Venkatraman, 1989). The concept of fit has been applied to examine a multitude of internal and external factors "*such as organizational climate, (innovation) strategy, technology, environment, management style, and organizational structure and the implication of fit or misfit toward an efficient, effective, and viable organization*" (Strese, Adams, Flatten, & Brettel, 2016, p. 1152). Peng et al. (2011, p. 486) state that "*researchers adopting a fit perspective investigate consistency among subsystems within a firm (internal fit) and fit among the organizational structure, strategy and the external environment (external fit)*." This chapter focuses on the internal fit between SC strategies and innovation capabilities.

The concept of fit is strongly related to the contingency theory, which looks at how the fit between context, structure and processes influences performance (Acur et al., 2012; Drazin & Van de Ven, 1985). Drazin and Van de Ven (1985) state that fit is the key concept for CT. Under a contingency approach, the conditional association of two or more independent variables (in this case the innovation capabilities and SC strategies) and the influence they exert on a dependent variable (in this case business performance) can be studied (Prajogo, 2016). Therefore, consistent with CT, our theoretical model proposes that the particular situation or nature of the innovation capabilities and SC strategies – as well as the features that influence the relationship between them – generate different effects on business performance.

According to the RBV, firms' resources and their heterogeneity determine the possibility of obtaining sustainable competitive advantages (Barney, 1991). The RBV helps us to understand how competitive advantage is achieved and how this advantage might be sustained over time (Eisenhardt & Martin, 2000).

The definitions of SC strategies and innovation capabilities reflect the resources available, which also influence the relationship between them. Thus, in this chapter, the use of the RBV underpins the understanding of the dynamics of the relationship linking the two fields. In this sense, the RBV supports this study as it provides the foundation for the assertion that innovation capabilities and supply chain strategies serve as strategic resources and thus influence key outcomes, such as business performance (Craighead, Hult, & Ketchen Jr, 2009).

Additionally, the RBV is widely used both in supply chain management (Huang, Yang, & Wong, 2016; Carter, Kosmol, & Kaufmann, 2017; Huo, Ye, Zhao, & Shou, 2016; Lin, 2017) and innovation management literature (Yang, 2015; Sears, 2017; Tsinopoulos, Sousa, & Yan, 2018). According to the RBV, an effective innovation process depends on the leveraging of organizational capabilities and resources, which are usually owned by internal functional units and other organizations, such as suppliers, customers, universities and research institutions (Lau et al., 2007).

4.3 Innovation capabilities, SC strategies and business performance

4.3.1 Innovation capabilities

Several theories, namely the RBV (as well as the core competency theory and knowledge-based view), have been used to explain firms' growth by means of capabilities, abilities or assets (Yang et al, 2015). Typically, firms' capabilities are described as what firms are able (or unable) to do (Borjesson & Elmquist, 2011) and are often seen as the ability to apply available resources to achieve the expected results. Innovation capabilities, which have received increasing attention from researchers in the last few years (Calantone et al., 2002; Guan & Ma, 2003; Mir, Casadesus, & Petnji, 2016; Ngo & O'Cass, 2012; Oura, Zilber, & Lopes, 2016), result from the abilities to develop and explore new ideas successfully (Francis & Bessant, 2005; Menguc, Auh, & Yannopoulos, 2014) and are

determinant factors in generating competitive advantages (Adler & Shenhar, 1990; Guan & Ma, 2003).

A great variety of assets, resources, and capabilities are necessary for the success of innovation (Guan & Ma, 2003; Oura et al., 2016). Moreover, innovation capabilities are relevant factors that help to determine the firms' performance (Calantone et al., 2002; Guan & Ma, 2003; Hortinha, Lages, & Lages, 2011; Ribau et al., 2017).

Adler and Shenhar (1990) define innovation capabilities as: (1) the capacity of developing new products to satisfy the market's needs; (2) the capacity of applying appropriate process technologies to produce these new products; (3) the capacity of developing and adopting new product and processing technologies to satisfy the future needs; and (4) the capacity of responding to accidental technology activities and unexpected opportunities created by competitors. Thus, innovation capabilities can be understood as the ability to continuously transform knowledge and ideas into new products, processes and systems to benefit the firm and its stakeholders (Lawson & Samson, 2001). In this sense, innovation capabilities help to improve the persistence of innovation, which concerns the extent to which organizations that innovate once have greater or lesser ability to innovate again in subsequent periods (Clausen, Pohjola, Sapprasert, & Verspagen, 2012).

The capacity of firms to innovate depends on the competences, skills and resources that, together, increase the chances of successfully developing new products, processes or business models. This set of factors composes the driving force that allows the organization to generate and explore new ideas and concepts, try new solutions, identify potential opportunities and transform them into innovation adjusted to customers' needs and desires (Borjesson & Elmquist, 2011). Innovation capabilities reflect the strength of the set of organizational practices that leads to the development of new products and processes (Peng et al., 2011). Because they are based on practices and routines, capabilities increase the barriers to imitation by competitors and, consequently, support organizations in establishing sustainable competitive advantages and maximizing their performance (Ngo & O'Cass, 2013).

In this chapter Guan and Ma's (2003) classification of innovation capabilities is going to be used, which is based on seven dimensions: (1) learning capability; (2) Research and Development (R&D) capability; (3) manufacturing capability; (4) marketing capability; (5) organizational capability; (6) resource exploiting capability; and (7) strategic capability. Table 17 presents the main characteristics of these seven dimensions. This classification complements previous studies (Adler & Shenbar, 1990; Lawson & Samson, 2001) regarding the needs for firms to transform knowledge and ideas into new products, processes and systems based on: the development of new products to satisfy market needs; the deployment of process technologies and methods competitively in the market; the development and adoption of new product and process technologies to anticipate future market needs; and the way firms respond to unexpected opportunities created by competitors and the external environment.

Table 17 - The main characteristics of the seven dimensions of the innovation capabilities

Dimension	**Characteristics**
Learning capability	The capacity to identify, assimilate and exploit new knowledge essential for a firm's competitive success.
R&D capability	Helps the firm to embrace many novel technologies and approaches when developing new assets.
Manufacturing capability	Refers to the ability to transform R&D results into products, which meet market needs, in accordance with design demand and can also be manufactured in batches.
Marketing capability	Indicates the capacity to publicize and sell the products on the basis of understanding consumers' current and future needs, customers' access approaches, and competitors' knowledge.
Organizational capability	Is the capacity to constitute a well-established organizational structure, coordinate the work of all activities towards shared objectives, and influence the speed of innovation processes through the infrastructure it creates for developmental projects.
Resource exploiting capability	Represents the firm's ability to mobilize and expand its technological, human and financial resources.
Strategic capability	Is the capacity to adopt different types of strategies that can adapt to changes in the environment to excel in the highly competitive environment.

Source: adapted from Guan & Ma (2003)

Finally, innovation capabilities are constructed through managerial decisions taken over time (Borjesson & Elmquist, 2011; Ngo & O'Cass, 2012) from the identification, development and integration of routines and processes that guide the behaviour of

people and processes towards innovation. According to Guan and Ma (2003), the relevance and degree of importance of each dimension of innovation capabilities may vary according to firms' strategies and should be suitable to both the market conditions and the competitive environment.

Teece (1986) and Guan and Ma (2003) divide the innovation capabilities into two groups: core innovation capabilities, composed by R&D, manufacturing and marketing capabilities; and supplementary innovation capabilities, composed by learning, organizational, resource-exploiting and strategic capabilities.

Each group of innovation capabilities influences firm performance in different ways and in different situations with consequences to the fit with SC strategies. Core innovation capabilities are more related to intellectual property (Teece, 1986) and are understood as the ability to transform innovation ideas through R&D, manufacturing and marketing process (Guan & Ma, 2003). On the other hand, supplementary innovation capabilities are key determinants for firm performance in markets where barriers to imitation and entrance of new competitors are smaller (Teece, 1986). According to Teece (1986, p. 285), "*when imitation is easy, markets don't work well, and the profits from innovation may accrue to the owners of certain complementary assets, rather than to the developers of the intellectual property*." Guan & Ma (2003) also highlight the role of supplementary capabilities to support and harmonize core innovation capabilities, improving their effectiveness.

4.3.2 SC strategies

The main question in the field of strategic management is how firms achieve and maintain competitive advantage (Pisano, 2015; Porter, 1996; Teece, Pisano, & Shuen, 1997). Strategic positioning is based on carrying out activities different from those of competitors or carrying out similar activities in a different way. In this sense, a strategy is a commitment to a set of activities, policies and behaviours, which are coherent and mutually supportive, seeking to achieve objectives that contribute to the competitiveness of the firms. For Pisano (2015), good strategies encourage alignment between the different functional / business areas of the organization, clarify objectives and help maintain the focus on the stated priorities.

External factors, such as technological change or a change in the behaviour of competitors, are often seen as the main threats to firms' strategies. However, although external changes are relevant, the main threats to firms' strategies normally come from within (Porter, 1996). As such, the search for sustainable competitive advantage should be primarily based on the firms' unique internal activities/characteristics that have leveraged the firms' results over time, and that have attainable results – in other words, the firms' activities. However, by itself, the operational efficiency of the firms' different activities is not enough to ensure success (March, 1991; Porter, 1996). The activities should be aligned with each other and should reflect the defined strategies.

Supply chain management is a common theme in firms' strategic plans. However, while it is recognized as a source of competitive advantage, firms do not always define their strategies with respect to the SC (Qi, Boyer, & Zhao, 2009; Qrunfleh & Tarafdar, 2014; Sharifi, Ismail, Qiu, & Tavani, 2013). Managing the flow of materials from the supply sources to the final customers effectively represents a major challenge for managers. Firms need a clearly defined plan to be able to organize their activities, resources and communications for this complex and complicated process (Qi et al., 2009). For Lee (2002) and Qrunfleh and Tarafdar (2014), SC strategies reflect the nature of the supply chain and lay down their objectives and goals. Moreover, they should be aligned with the product's characteristics, with the adopted competitive strategy and with the environment where the firms compete.

For Arora et al. (2016, p. 206), "*supply chain strategy describes a pattern of decisions related to sourcing products, capacity planning, conversion of raw materials, demand management, communication across the SC, and delivery of products and services and thereby links SCM strategy to business and corporate-level strategy*.". In this sense, SC strategy is often understood as an extension of the operations strategy and represents a set of choices that firms need to make to match the environmental contingencies they confront (Lo & Power, 2010).

The model proposed by Marshall Fisher in his important and influential article published in the Harvard Business Review in 1997 (Fisher, 1997) led many authors to adopt two types of SC strategy: lean – equivalent to Fisher's Efficient strategy, and agile –

equivalent to Fisher's Market-responsive strategy (Abdollahi, Arvan, & Razmi, 2015; Christopher & Towill, 2002; Qi et al., 2009; Qi et al., 2011; Qrunfleh & Tarafdar, 2014). Some authors have adopted other strategies in their studies, such as lean/agile, or leagile (Bruce, Daly, & Towers, 2004; Naylor, Naim, & Berry, 1999), which is a combination of the lean and agile approaches, and quick SC (Cigolini, Cozzi, & Perona, 2004). Table 18 presents the main characteristics of the Lean and Agile strategies.

Table 18 - Characteristics of Lean and Agile SC strategies

SC Strategy	**Lean**	**Agile**
Objective	Focuses on cost reduction and incremental improvements for existing products. Focuses on elimination of waste and non-value-added activities across the supply chain	Tracks and understands customer requirements by interacting closely with market. Aims to produce in any volume (and not just the optimal capacity utilization volume) and deliver simultaneously to a wide variety of markets. Provide customized products with short lead times (i.e. focuses on responsiveness)
Inventory strategy	Generates high inventory turnover and minimizes inventory through the supply chain	Deploys significant stocks of parts to tide over unpredictable market requirements
Lead time focus	Shortens lead-time only so long as doing so does not increase delivery or inventory costs	Reduces lead times to customer specifications and requirements
Manufacturing focus	Maintains high average capacity utilization rate	Deploys excess/buffer capacity to ensure that raw material/components are available to manufacture the product according to market requirements
Product design strategy	Reduces the cost of production	Produces to modular designs, by using a limited number of basic components and processes that can be assembled into different products

Source: Qrunfleh & Tarafdar (2014)

The model proposed by Fisher, as well as the models derived from it, considers the characteristics of products to determine SC strategy. In these models, lean or efficient SC match with functional products, while agile or responsive SC match with innovative products (Fisher, 1997; Lo & Power, 2010; Qrunfleh & Tarafdar, 2014).

One can claim that supply chain management is a process that goes through constant changes and, as a result, the choice of SC strategy is also a dynamic process. Besides this, the differences between a firm's products should be considered, which means that an organization can apply different strategies at the same time. As Christopher and Towill (2002) state, Lean and Agile are not opposing philosophies, they are just better suited to different contexts. As Lee (2002, p. 106) states, "*strategies that are based on a one-size-fits-all or try-everything mentality, will fail*."

4.3.3 Business performance

Business performance has been analysed and measured in a great variety of ways (Rauch, Wiklund, Lumpkin, & Frese, 2009; Richard, Devinney, Yip, & Johnson, 2009). There are several possible dimensions to measure performance, which may differ for business managers and for researchers, and a consensual model does not exist (Franco-Santos et al., 2007). It is considered one of the most relevant constructs in various research fields, such as management and operations management, and is often used as the main dependent variable (Morgan & Strong, 2003; Richard et al., 2009). A measure of business performance can be understood as a set of metrics used to quantify both the efficiency and effectiveness of firms' actions (Franco-Santos et al., 2007; McAdam & Bailie, 2002; Neely, Gregory, & Platts, 1995).

Contemporary knowledge suggests that financial and economic issues need to be combined with market-based assets in order to generate a more composite assessment of business performance attributes (Morgan & Strong, 2003). Thus, a common distinction in the literature regarding business performance is between financial and nonfinancial measures (Rauch et al., 2009). Nonfinancial measures include satisfaction and global success ratings, while financial measures include factors such as sales growth and return on investments.

For Richard et al. (2009), organizational performance encompasses three areas: (a) financial performance (profits, return on assets, return on investment, etc.); (b) product market performance (sales, market share, etc.); and (c) shareholder return (total shareholder return, economic value added, etc.). Similarly, Gonzalez-Benito (2007) measures business performance using a set of items that refer to ratios based on

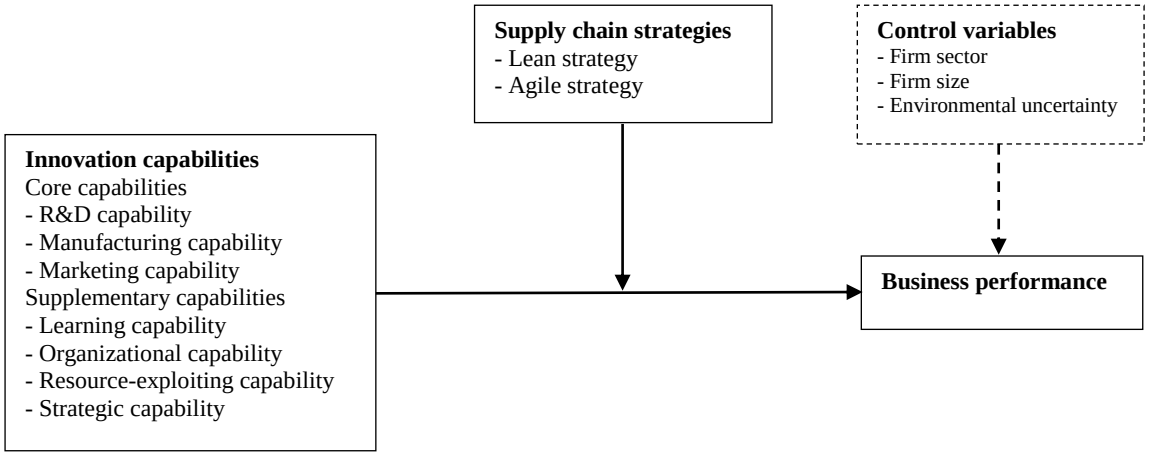
accounting data and related to the economic and financial benefits and productivity; and another set that contains items to measure the commercial success of the firm.

Studies usually rely on self-reported data (subjective) or archival data collected from secondary sources (objective) to measure business performance. Subjective measures have been adopted by various researchers in management disciplines (Kristal, Huang, & Roth, 2010) and may offer greater opportunities for testing multiple dimensions of performance, such as comparisons with competitors. However, this kind of data may be subject to bias because of social desirability, memory distortion, and/or common method variance (Rauch et al., 2009).

4.4 A theoretical model on the relationship between SC strategies, innovation capabilities and business performance

This study aims to discuss the relationship between innovation capabilities, SC strategies and business performance. Lean and agile SC strategies are used to represent how SC strategies are deployed, as they are the most widely used in the literature and are consistent with the objectives of this study. On the other hand, the set of innovation capabilities used to study the relationship with the SC strategies is based on Guan and Ma (2003). These capabilities best represent the differences between firms when it comes to the characteristics of the innovation process and are best aligned with the objectives of this work as they support the firms' unique assets in generating and sustaining competitive advantages in terms of scientific R&D assets; process innovative assets; product innovative assets; knowledge generation activities; organizational innovation activities; and the deployment of marketing and strategy based functions to exploit and explore present and future market needs to respond to (un)expected opportunities. Figure 15 shows the theoretical model of the study.

Figure 15 - Theoretical model on the effect of SC strategies on the relationship between innovation capabilities and business performance



The primary relation that helps to understand and build the theoretical framework put forward in this study is between innovation capabilities and business performance. Although this relationship is not new (Borjesson & Elmquist, 2011; Calantone et al., 2002; Mir et al., 2016; Saunila, Pekkola, & Ukko, 2014), it is central to understanding the overall context of this study and the relationship between two of the main variables. According to Saunila et al. (2014) and Calantone et al. (2002), for instance, firms that present a higher level of innovation capabilities have been found to have higher levels of productivity and economic growth. Thus, the first research proposition is as follows:

RP 1. Innovation capabilities affect business performance.

The second proposition introduces the third variable studied and helps to understand the overall relationship between innovation capabilities, SC strategies and business performance.

RP2. SC strategies affect the relationship between innovation capabilities and business performance.

However, the relationship between the three variables become more complex as we consider the different types of innovation capabilities and SC strategies and their different natures – following the principles of contingency theory. Thus, to complement RP 2, it is important to discuss the characteristics of each one of the variables – SC strategies and innovation capabilities – and the expected results according to the relation between them.

Lean strategies seek to create efficient supply chains, in terms of costs, focusing on the improvement of the efficiency of processes and on the elimination of waste. This strategy fits well with stable and predictable demand with products and processes streamlined to enable the organization to satisfy current customers' needs (Christopher & Towill, 2002; Qi et al., 2009; Qi et al., 2011; Qrunfleh & Tarafdar, 2014). In a way, innovation capabilities are tuned to the exploitation of innovation activities in which new products and processes need to be adapted to the needs of the demand based on incremental innovation.

On the other hand, agile SC strategies seek to guarantee the flexibility and adaptability of the SC given the constant changes of customers' needs and of the competitive environment, using rapid, dynamic and continuous responses (Christopher & Towill, 2002; Qi et al., 2009; Qrunfleh & Tarafdar, 2014). The objective of this type of strategy is to adapt the organization, developing new products and processes to unique market characteristics, in order to generate and retain new competitive advantages based on constantly changing environments. The reduction in the life cycles of products leads to an increase in pressure on the SC to provide products and services quicker and in a more responsive way (Qi et al., 2009). In this sense, this strategy is expected to have a better fit with most of the innovation capabilities.

Although all the innovation capabilities proposed by Guan and Ma (2009) are related to the capacity of the firms to create new or significantly improved products or processes, constantly changing environments may have different consequences for firms' innovation capabilities as well as for supply chains as some firms are more likely to have a better fit between the stability and predictability of their environments and their lean SC strategies whereas others are more tuned to contextual flexibility and adaptability through the use of agile SC strategies.

R&D capabilities are developed by means investing in R&D, acquiring new technologies and employing qualified industrial experts. These capabilities support firms by embracing many novel technologies and approaches when developing new technological assets, resulting in the recognition for technological-endowed products (Guan & Ma, 2003). However, it is expected that R&D capabilities are tuned to both agile

and lean SC strategies for different reasons: firstly, R&D capabilities are better fit with agile SC strategies where firms acquire the generation of new unique products and processes tune to constantly changing environments; and secondly, R&D capabilities are also tuned to lean SC strategy when firms favour the development of products and processes that need to be adapted to the constant changes of the demand. As such, on one hand, firms' exploration of innovative activities need to be tuned to agile SC strategies and, on the other hand, firms' exploitation of innovative activities is more tuned to firms deploying lean SC strategies. In both cases business performance is supported by R&D capabilities. In this sense:

RP 2.1 Firms with high levels of R&D capabilities tend to obtain good business performance by adopting an agile or a lean SC strategy.

Manufacturing capabilities are related to the consistency of the manufactured product quality and the employment of advanced technologies compared to competitors. Those capabilities also refer to the ability to transform R&D results into products that meet the market's needs in accordance with design demands (Guan & Ma, 2003). As manufacturing capabilities and an agile SC require not only understanding customer requirements, but also developing brand new products according to future market needs, based on exploration-based innovation, a good fit is expected. On the other hand, the fit between manufacturing capabilities and a lean SC can favour the development of exploitation innovation activities, as both can focus on incremental improvements for existing products and processes, which also generates a positive effect on business performance.

RP 2.2 Firms with high levels of manufacturing capabilities tend to obtain a good business performance by adopting an agile SC strategy or a lean SC strategy (especially incremental innovation).

Marketing capabilities indicate the firms' capacity to segment and target specific markets and to utilize marketing tools (product design, pricing, advertising) to differentiate products on the basis of understanding consumers' current and future needs, customers' access approaches, and competitors' knowledge. Thus, firms exploring future

market needs tend to develop unique products and processes tuned to peculiar market characteristics in which marketing capabilities play a critical role in generating new competitive advantages. As such, agile SC strategies need to be deployed to accommodate those new requirements throughout the supply chain. Complementarily, firms tuned to exploitation innovation activities in which market needs can lead to incremental improvements in products and processes tend to favour lean SC strategies.

RP 2.3 Firms with high levels of marketing capabilities tend to obtain a good business performance by adopting an agile or a lean SC strategy.

Learning capabilities are related to the promotion of a learning culture that allows the identification and assimilation of new knowledge essential to the competitive success of the firm, which is reflected in the identification and application of trends within the industry and the development and acquisition of the new and necessary skills or technologies to develop new products (Guan & Ma, 2003). Explorative innovation activities are more tuned to develop unique products and processes based on constantly changing environments, which require firms to be tuned to an outward, opportunity-based perspective in order to keep abreast of future market perspectives. On the other hand, exploitation innovation activities are more tuned to firms' current performance, in which learning capabilities are easier to accommodate than in the previous case. In this sense, it is expected that learning capabilities will have a better fit with agile SC strategies, as they presuppose understanding and adapting to customer requirements and need a certain degree of flexibility, when compared to lean SC strategies.

RP2.4 Firms with high levels of learning capabilities tend to obtain better business performance by adopting an agile SC strategy as opposed to a lean SC strategy.

Resource exploiting capabilities represent the firms' ability to mobilize and expand their technological, human and financial resources, by combining internally and externally developed technologies (e.g., technologies developed by business partners) while maintaining a continuous flow of financial resources for the introduction of new products on the market, also being skilled in the allocation of personnel and continually striving to improve products and processes. Taking into account that exploration innovation activities

are riskier than exploitation innovation activities as the former are tuned to the firm capacity to generate new competitive advantages for the future market needs, which involve long-term, riskier partnerships and technologies, the following proposition is put forward:

RP 2.5 Firms with high levels of resource exploiting capabilities tend to obtain better business performance by adopting an agile SC strategy as opposed to a lean SC strategy.

Organizational capability is the capacity to constitute a well-established organizational structure; coordinate the work of all activities towards shared objectives, and influence the speed of innovation processes through the infrastructure created. They include: the adoption of a flexible organizational structure to adjust to new projects focused on product or process innovation; managers' autonomy in the innovation process; strong coordination between technical (e.g., engineering, projects), sales and manufacturing departments; implementation of new management techniques to improve routines and work practices and to facilitate the use and exchange of information, knowledge and skills within the company and the implementation of new organizational methods for work to better distribute responsibilities and decision-making tasks. In this sense, flexibility and adaptability tend to be key organizational capabilities among successful firms that adopt agile SC strategies and stability and predictability are characteristics that tend to be valued among firms that seek to deploy lean SC strategies.

RP 2.6 Firms with high levels of organizational capabilities tend to obtain better business performance by adopting an agile SC strategy as opposed to a lean SC strategy.

Strategic capability is the capacity to adopt different types of strategies that can adapt to changes in the business environment in order to excel in today's highly competitive environments. Firms with these capabilities shape their strategy formulation by a strong entrepreneurial vision and senior managers are highly capable of understanding external factors that may affect business operations and can quickly anticipate the movements of outstanding competitors and adjust strategies to these changes. In these firms, there is a strong connection between innovation and customers' value recognition. Thus, it is expected that strategic capabilities have a better fit with an

agile SC strategy, as both presuppose a solid understanding of customers' evolving requirements and the capacity to face external environmental changes.

RP 2.7 Firms with a high level of strategic capabilities tend to obtain better business performance by adopting an agile SC strategy as opposed to a lean SC strategy.

Finally, in this paper the control variables considered to influence the relationship between innovation capabilities and SC strategy are: firm sector, firm size and environmental uncertainty.

The firm sector is controlled to account for the specific priorities and practices associated with different industries (Gligor, 2016). The size of the firm can impact on the resources a firm has available for implementing initiatives, as well as the firm's profitability (Gligor, 2016).

Environmental uncertainty helps us to understand the impact of business environment on the context of SC and innovation – and consequently on the fit between them. It is expected that the greater the uncertainty of the environment (reflected in environmental munificence, environmental dynamism, and environmental complexity), the greater the influence of SC strategies over the relationship. Aldrich (1979) and Dess and Beard (1984) classify environmental uncertainty in three dimensions: environmental munificence, environmental dynamism, and environmental complexity. Environmental munificence refers to the extent to which the environment can support sustained growth. Environmental dynamism refers to the extent that the environment in which the firm competes is characterized by changes that are hard to predict and that heighten uncertainty for key organizational members. Environmental complexity refers to the complexity of the environment, measured by the extent that the environment in which the firm competes is characterized by great uncertainty and a great information-processing requirement (Dess and Beard, 1984).

The last research proposition is:

RP3: The effect of SC strategies on the relationship between innovation capabilities and business performance is influenced by environmental uncertainty, firm sector and firm size.

4.5 Implications and conclusions

By identifying and collating supply chain strategies and innovation capabilities and by analysing the possibilities for aligning them, this study helps advance research in the area. It also provides some insights for managers who are seeking the implementation of effective improvements in business performance.

We have identified possible combinations between innovation capabilities and supply chain strategies and discussed the expected effects of these combinations in this work. The propositions reveal the complexity of the relationship between the areas of innovation and SC, and especially between SC strategies and innovation capabilities. Based on the propositions shown, it is plausible that theories can be constructed on the subject by using empirical evidence.

The contingency theory and resource-based view are explored in this chapter in order to provide theoretical foundations to the discussion and to the development of a theory related to the effect of SC strategies on the relationship between innovation capabilities and business performance. The theoretical model helps us to understand the relationship between the main variables used in the study and to explain the effect of the fit between innovation capabilities and SC strategies on business performance.

In general, SC strategies are expected to influence the relationship between innovation capabilities and business performance. However, due to the valuable, rare, difficult to imitate and difficult to substitute unique characteristics of the supplementary innovation capabilities – learning, resource-exploiting, organizational and strategic – it is expected that business performance of firms adopting agile SC strategies outperform the business performance of firms adopting lean SC strategies.

As showed in the research propositions, agile SC strategies favour in a special way the development of exploration-based innovative activities. On the other hand, the adoption of a lean SC strategy tends to favour characteristics of exploitation-based innovation that embrace the stability and predictability of the contextual environment. This happens because, in general, exploitation-based innovations require less flexibility and less ability to adapt to market changes, since they are related to the refinement of existing products, processes, technologies and methods.

Limitations and future research

The main limitation of the study relates to the limitations imposed by the nature of the work; in other words, carrying out a literature review and a theoretical discussion with the goal of developing a theoretical model. However, as this is a first step in developing a theory of the relationship between innovation capabilities and supply chain strategies, we believe that this study represents a significant contribution to the literature.

For future research, we recommend to empirically test the propositions put forward in this chapter. Finally, the concept of ambidexterity and the trade-off between exploration and exploitation could be tested in future research.

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PART III – THEORY TESTING

The third and last part of the thesis aims to reinforce and deepen the theories developed so far by means of empirical methods. Considering the positivist paradigm adopted in this study, this part is fundamental to provide validity and consistency to the discussion and to consolidate its contribution.

Chapter 5 analyses the antecedents of the adoption of the supply chain strategies and the impact on performance. Besides its contributions to the literature on the field as an independent work, chapter 5 helps to clarify several aspects related to supply chain strategies that helps to analyse their role as a moderator in chapter 6. Moreover, along with the previous discussion, chapter 5 provides the necessary background and ensure the reliability of the data regarding supply chain strategies.

Chapter 6 uses the theoretical model and the research propositions developed in previous chapters to test and consolidate a theory on the moderator effect of supply chain strategies on the relationship between innovation capabilities and business performance. It is important to highlight that the choice of test innovation capabilities, instead of innovation strategies, is due to the analysis of the previous chapters, where a greater complexity and consolidation of the chosen concept was perceived.

CHAPTER 5 – AN EMPIRICAL ANALYSIS OF THE RELATIONSHIP BETWEEN SUPPLY CHAIN STRATEGIES, PRODUCT CHARACTERISTICS, ENVIRONMENTAL UNCERTAINTY AND PERFORMANCE[7]

Abstract:

Purpose – this chapter investigates supply chain strategies empirically, analyzing the adoption of lean, agile, leagile and traditional supply chains with respect to product characteristics, environmental uncertainty, business performance and innovation performance.

Design/methodology/approach – the study presents an exploratory analysis carried out from an empirical study based on a sample of 329 firms from Portugal and Brazil. Hierarchical cluster analysis was applied, based on the constructs for lean and agile SC characteristics, in order to identify patterns among different supply chain strategies. One-way analyses of variance (ANOVA) of the different constructs by supply chain strategies clusters was conducted.

Findings – cluster analysis indicates (confirming previous research) that the firms studied adopt four types of supply chain strategies – lean, agile, leagile and traditional. Many differences between the clusters are identified and discussed, highlighting that those firms with a leagile SC strategy present the highest performance, while those with a traditional SC present the lowest; firms with an agile SC compete in the most complex and dynamic environments, while firms with a lean SC present a clear predominance of functional products rather than innovative.

Research limitations/implications – this study provides empirical evidence of the antecedents and consequences of the adoption of different SC strategies concerning: product characteristics, environmental munificence, environmental complexity, environmental dynamism, business performance and innovation performance. The results may help managers to better prioritize strategies by considering a set of features. As a limitation, the results are based on survey research with quite a limited sample size.

[7] Under review in an ISI and Scopus indexed Journal when the thesis was delivered.

Originality/value – the chapter adds to the knowledge regarding the role of supply chain strategies within firms, as well as the antecedents and consequences of their adoption.

Keywords: supply chain strategies, environmental uncertainty, product characteristics, business performance, innovation performance.

5.1 Introduction

Supply chain (SC) strategy has attracted attention from academics in the last years due to its potential to help firms to improve performance and obtain competitive advantage (Lo & Power, 2010; Naylor, Naim, & Berry, 1999; Perez-Franco & Phadnis, 2018; Qi, Boyer, & Zhao, 2009; Roh, Hong, & Min, 2014). The choice of the most appropriate SC strategy is a challenge to managers, as such a choice needs to consider the various features of firms and their environments (Fisher, 1997; Lee, 2002).

Previous studies have theoretically and empirically discussed and tested different patterns of the adoption of SC strategies, whether using lean and agile (Lee, 2002; Qi et al., 2009; Qrunfleh & Tarafdar, 2014; Wagner, Grosse-Ruyken, & Erhun, 2012) or efficient and responsive SC strategies (Fisher, 1997; Gunasekaran, Lai, & Cheng, 2008; Nakano, 2015), and the importance of their alignment with a variety of aspects (Lo & Power, 2010; Prajogo, Mena, & Nair, 2018; Qrunfleh & Tarafdar, 2014; S.M. Wagner et al., 2012). It is widely discussed in the literature that firms adopting a lean (or efficient) SC strategy prioritize efficiency in terms of costs and seek to reduce waste, while those with an agile (or responsive) SC strategy intend to improve their capacity to respond to a constantly changing demand (Fisher, 1997; Qi et al., 2009; Tarafdar & Qrunfleh, 2017). Hence, each type of SC strategy requires different conditions and produces different results. Product and environmental characteristics are often viewed as antecedents to SC strategies, as they help to understand the choice of a particular strategy, while performance can be understood as a consequence of the chosen strategy (Arora, Arora, & Sivakumar, 2016; Prajogo et al., 2018; Qi et al., 2009). However, the relationship between SC strategies, the nature of the products and performance is not consensual, as some authors have studied different aspects (Nakano, 2010) and have found different results (Lo & Power, 2010).

In this sense, the aim of this study is to add to the knowledge about the role of SC strategies within firms by means of an exploratory analysis of their relationship with product characteristics, environmental uncertainty, business performance and innovation performance. Part of the chapter is developed as a complement to previous studies, that assessed the fit of product characteristics with SC strategies (Qi et al., 2009), as well as their impact on financial and operational performance, contributing to the generalizability of the previous findings, while assessing the same subjects under different conditions (Goldsby & Autry, 2011). As stated by Goldsby and Autry (2011) and by van Weele and van Raaij (2014), replication of previous studies should be more frequent in SCM research, as it helps to increase the validity, credibility and relevance of theory developed in the field.

Moreover, this study will try to go further by contributing to extending the knowledge regarding the role of SC strategies by including an assessment of the adoption of the different strategies with respect to environmental uncertainty, munificence, complexity and dynamism and innovation performance. Thus, the objectives of this study are: (1) to assess/confirm the taxonomy of SC strategies adopted by firms; (2) to assess/confirm the link between product characteristics and the different SC strategies; (3) to assess the link between environmental uncertainty and the different SC strategies; (4) to assess/confirm the impact of SC strategies on business performance; and (5) to assess the impact of SC strategies on innovation performance. The following question will be addressed: what differentiates the firms that adopt each type of SC strategy in terms of product characteristics, environmental uncertainty and performance?

In this sense, this chapter contributes to theory, as it analyzes a set of characteristics related to the adoption of the different SC strategies that have not been tested together before, in a logic of replication and extension of previous studies; and to practice, as the results may help managers in the challenging task of choosing the most appropriate SC strategy.

Resource-based view (RBV) constitutes the theoretical foundation for this chapter as it is widely used in strategic management literature and has been applied to operations management, and more specifically to supply chain management (SCM) in recent years (Fawcett, Jones, & Fawcett, 2012; Sjoerdsma & van Weele, 2015; Yan & Azadegan, 2017).

According to the RBV, the resources and capabilities of firms are the key sources of sustained competitive advantage (Barney, 1991; Menguc, Auh, & Yannopoulos, 2014) and SC strategy can be understood as the adoption and development of capabilities that cannot be easily imitated or acquired by competitors.

The rest of the chapter is organized as follows: section 2 provides the theoretical background of the study and presents a literature review about the topics under analysis. Section 3 presents the methodology used in the study, including the data collection and the measures. In section 4, the results of the exploratory analysis are presented, followed by the discussion, where a comparison between the different groups of firms adopting each one of the SC strategies is provided. Finally, the conclusions and implications of the study are presented in section 5.

5.2 Theoretical background and literature review

5.2.1 Adopting the right SC strategy

The competitiveness that characterizes today's business environments leads firms to incorporate strategic SCM in their competitive strategies (Arora et al., 2016; Narasimhan & Narayanan, 2013; Zimmermann, Ferreira, & Moreira, 2016). In the literature on strategic management, it is clear that the alignment between strategy and other management elements is key to the success of the adopted strategy (Miles & Snow, 1984) and it is broadly recognized that SC strategies must be aligned with a firm's set of internal and external characteristics to achieve the best results (Lee, 2002; Prajogo et al., 2018; Qi et al., 2009).

The choice of an SC strategy is a complex and dynamic process, as the main elements that constitute the nature of the SC, such as product life-cycle, product demand and product variety, can be dynamic as well (Abdollahi, Arvan, & Razmi, 2015; Christopher, 2000). Firms have to adapt their strategies and practices constantly to maintain the fit with changing contextual aspects and to obtain higher performance (Perez-Franco & Phadnis, 2018; Prajogo et al., 2018). Thus, the SC strategy adopted must help to overcome the (more or less) volatile environment and influence the competitiveness of firms positively.

To respond to the different requirements of the environments where firms compete, two main approaches are presented and discussed in the literature: increasing efficiency

(usually described as a lean or efficient SC) and/or responding quickly to market demands (usually described as an agile or responsive SC).

The lean paradigm, similar to an efficient SC, as proposed by Fisher (1997), focuses on the improvement of the efficiency of the business processes and on the elimination of waste (Christopher & Towill, 2002; Naylor et al., 1999; Qrunfleh & Tarafdar, 2014). Firms that adopt this strategy are often characterized by mass production, preserve long-term relationships with suppliers and implement practices such as just-in-time systems (Qi et al., 2009). On the other hand, firms adopting an agile SC strategy, similar to a responsive SC, seek not just to respond quickly to demand, but also to improve flexibility, therefore becoming able to exploit opportunities in volatile markets (Christopher, 2000; Mason-Jones, Naylor, & Towill, 2000). For that reason, these firms need more capacity buffers to respond to the market volatility (Qi et al., 2009).

Although each SC strategy demands different and specific requirements, the complexity of the business environment makes the existence of conditions that require purely lean or agile SCs unusual. Firms adopt different levels of leanness and agility to meet the specific needs of their business conditions (Mason-Jones et al., 2000; Naylor et al., 1999). As highlighted by Christopher and Towill (2002, p. 1), "*lean and agile are not mutually exclusive paradigms and may be married to advantage in a number of different ways*." The combination of the two paradigms is often called leagile (or lean/agile) (Bruce, Daly, & Towers, 2004; Qi et al., 2009). On the other hand, when firms do not emphasize either lean or agile principles, they adopt what is known as a traditional SC strategy (Qi et al., 2009).

Among the most relevant aspects that guide firms to choose the right SC strategies, which can be called antecedents or drivers, it is possible to point out a set of characteristics that influence a firm's conditions to compete and perform its business, such as product characteristics (Christopher & Towill, 2002; Fisher, 1997; Qi et al., 2009), supply and demand uncertainty (Lee, 2002; Sun, Hsu, & Hwang, 2009), the dynamism and competitiveness of the business environment (Prajogo et al., 2018), technological and marketing turbulence (Arora et al., 2016), supplier management practices (Prajogo et al., 2018), suppliers' tactics (Jajja, Kannan, Brah, & Hassan, 2016), among others. In this study,

besides product characteristics, the relationship of environmental uncertainty with SC strategies is analyzed.

Fisher (1997) discussed the issue of adopting the right SC strategy from the point of view of a firm's products, especially considering the characteristics of the demand. According to Fisher (1997), products can be categorized as primarily functional – they do not change much over time, have a stable and predictable demand and present long life-cycles – or primarily innovative – with unpredictable demand and short life-cycles; and each type of product requires different kinds of SC strategy. The model proposed by Fisher (1997) indicates that functional products match with efficient SCs and innovative products match with responsive SCs. Following Fisher's idea, Qi et al. (2009) tested the fit between SC strategies (lean and agile) and product characteristics empirically.

Lee (2002) added the concept of uncertainty to the model presented by Fisher, theoretically discussing strategies that help to reduce uncertainty in supply and demand. According to Lee (2002), firms with functional products and stable SC processes must develop efficient SCs; firms with functional products and evolving SC processes should have a risk-hedging SC (when the risks are shared among the SC partners); firms with innovative products and stable SC processes should pursue responsive SC strategies; and firms with innovative products and evolving and unstable SC processes have to utilize agile SCs (which, according to Lee, is the combination of risk-hedging and responsive strategies).

Prajogo et al. (2018) address the external links between the business environment and SC strategies and the internal links between SC strategies and supplier management practices. The authors discuss the fit between the dynamism and competitiveness of the business environment with the characteristics of the SC strategies, namely the focus on cost reduction or flexibility; and the fit between supplier practices – such as: the strategic relationship with suppliers, suppliers' assessment, logistics integration and SC strategies; concluding that a dynamic environment presents a better fit with flexibility and that a competitive environment does not present a stronger fit to a "low-cost strategy", contrary to the authors' expectations (Prajogo et al., 2018).

From the point of view of the consequences of the adoption of SC strategies, business performance has been used in previous research to evaluate the effects of the adoption of each strategy (Arora et al., 2016; Qi et al., 2009; Tarafdar & Qrunfleh, 2017).

5.2.2 Product characteristics and environmental uncertainty as antecedents of SC strategies

As a way to extend the existing knowledge on the topic, this study evaluates two aspects and their impact on the choice of the SC strategy empirically: product characteristics (Fisher, 1997; Qi et al., 2009) and environmental uncertainty (Dess & Beard, 1984).

Product characteristics is a concept traditionally linked to SC strategies (Fisher, 1997; Huang, Uppal, & Shi, 2002; Qi et al., 2009) as it is one of the main features that has to be considered when defining a strategy. To choose the most suitable SC strategy, firms have to consider characteristics such as product life-cycle length, predictability of demand, product variety and market standards for lead times and services (Fisher, 1997; Huang et al., 2002; Qi et al., 2009). Two types of products are considered in this study: functional and innovative, replicating the measures used by Qi et al. (2009).

The second aspect assessed as an antecedent of SC strategies is environmental uncertainty. Uncertainty has been considered a phenomenon intrinsically linked to the most diverse activities of firms and with great relevance in operations and business research for the last decades (Buchko, 1994; Courtney, Kirkland, & Viguerie, 1997; Lopez-Gamero, Molina-Azorin, & Claver-Cortes, 2011; Miller & Shamsie, 1999; Wernerfelt & Karnani, 1987). The concept of enviromental uncertainty has been widely used in SCM literature (Azadegan, Patel, Zangoueinezhad, & Linderman, 2013; Wong, Boon-it & Wong, 2011). The definition of environmental uncertainty encompasses the inability, at different levels, to establish the probability of future events and to predict the consequences of the decisions accurately (Miller & Shamsie, 1999; Sia, Teo, Tan, & Wei, 2004).

Environmental uncertainty is adopted in this study according to the model proposed by Aldrich (1979) and Dess and Beard (1984), who classify the concept in three dimensions: environmental munificence, environmental dynamism, and environmental complexity. Environmental munificence refers to the extent to which the environment

where firms compete can support sustained growth (Aldrich, 1979). The concept is linked to the availability of resources in the environment (Pan, Chen & Ning, 2018), as it is defined by Castrogiovanni (1991, p.542) as "*the scarcity or abundancy of critical resources needed by (one or more) firms operating within an environment*".

Environmental dynamism is related to the extent that the environment in which the firm competes is characterized by changes that are hard to predict and that heighten uncertainty for key organizational members (Aldrich, 1979; Dess & Beard, 1984). Environmental Dynamism is closely linked to aspects such as unpredictability and absence of pattern. Environmental complexity refers to the complexity of the environment, measured by the extent that the environment in which the firm competes is characterized by great uncertainty and a great information-processing requirement (Dess & Beard, 1984).

Considering the characteristics of each one of the three dimensions, it is expected that firms which compete in environments with high degrees of dynamism and complexity tend to adopt agile SC characteristics, while firms in an environment with low degrees of dynamism and complexity tend to adopt lean SC characteristics. These assertions are supported by the relevant theory, as agile is related to uncertainty and flexibility, and lean is characterized by predictability (Azadegan et al., 2013; Tarafdar & Qrunfleh, 2017).

Environmental munificence, on the other hand, is expected to have a lower level of correlation with the choice of the SC strategy, as munificence can be found in different types of environments, both more or less dynamic and complex (Pan et al., 2018). Nevertheless, as munificence refers to the availability of resources, it can be said that a higher level of munificence, or a greater abundance of resources, can lead firms to predominantelly adopt a lean SC strategy (Pan et al., 2018).

5.2.3 Performance as consequences of SC strategies

The impact of the adoption of SC strategies on innovation performance is analyzed, as well as business performance in this study. Business performance has been used in a great variety of ways (Gonzalez-Benito, 2007; Rauch, Wiklund, Lumpkin, & Frese, 2009; Richard, Devinney, Yip, & Johnson, 2009). There are several possible dimensions to measure performance, which may differ for business managers and for researchers, and a

consensual model does not exist (Franco-Santos et al., 2007). A measure of business performance can be understood as a set of metrics used to quantify both the efficiency and effectiveness of firms' actions (Franco-Santos et al., 2007; McAdam & Bailie, 2002; Neely, Gregory, & Platts, 1995).

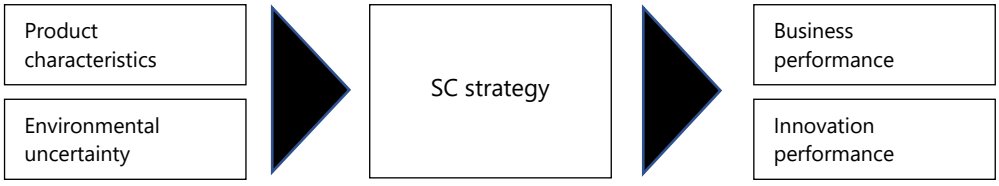
Contemporary knowledge suggests that financial and economic issues need to be combined with market-based assets in order to generate a more composite assessment of business performance attributes (Morgan & Strong, 2003). Thus, a common distinction in the literature regarding business performance is between financial and non-financial measures (Rauch et al., 2009). Non-financial measures include satisfaction and global success ratings, while financial measures include factors such as sales growth and return on investments. Qi et al. (2009) assessed business performance by means of financial performance and operational performance while Gonzalez-Benito (2007) assess the commercial success and economic and productivity performance of firms.

The performance of innovation is included in this study as a way to contribute to theory and practice, evaluating whether or not SC strategy is related to the performance of innovation and complementing the idea behind the relationship between SC strategies with product characteristics (functional or innovative products), previously evaluated by Qi et al. (2009).

Innovation performance is a complex and non-consensual issue. In this study, the concepts of product and process innovation effectiveness are used, following Alegre and Chiva (2008), who based their model on the Oslo Manual (OECD & Eurostat, 2005). Nowadays, many innovation studies use this widely validated scale (Alegre & Chiva, 2013).

Figure 16 shows the research model adopted in this study, where product characteristics and environmental uncertainty act as antecedents to the adoption of an SC strategy, which, in turn, have an impact on business performance and innovation performance.

Figure 16 – Research model



5.3 Methodology

5.3.1 Data collection

Data were collected from firms operating in Portugal and Brazil using an online survey made available on the platform Lime Survey. The questionnaire was developed from a variety of sources to measure the intended constructs.

Following Zhao, Flynn, & Roth (2007), a combination of methods was employed to ensure the reliability and validity of the instrument. The first version was reviewed by two professors in the field and answered by two potential respondents. This version, designed in English, was translated to Portuguese and translated back to English. The back-translated English version was checked against the original English version. The questionnaire was also pilot-tested in five firms in Portugal and five firms in Brazil. Besides answering the questionnaire, the respondents were asked to provide comments on the comprehensibility and clarity of the items. After minor changes suggested by the respondents on the pilot test, the final version was reviewed by two academic experts and was considered ready to send to a large sample for data collection.

Following the guidelines proposed by Craighead, Ketchen Jr. and Dunn (2011) and the principles discussed by Krause, Luzzini and Lawson (2018) and Flynn, Pagell and Fugate (2018), the questionnaire was designed to be answered by two respondents in each firm: the part concerning SC strategies by an SC manager; while the section on enviromental uncertainty and innovation performance by an innovation manager; and the business performance section by both. The answers relating to business performance were compared, ensuring the reliability of the information. When significant differences between the answers were found, the respondents were contacted again. The firms which had incomplete answers were discarded. The most common functional responsibilities of the respondents included: operations director/manager; purchasing director/manager; supply-chain director/manager; and innovation and new product development director/manager.

The sample, composed by 1,000 firms in Portugal and 1,000 firms in Brazil, was selected randomly from the data bases provided by Bureau Van Dijk in Portugal and by Neoway in Brazil (firms that collect and provide information about firms), and includes

firms from various sectors, such as automotive and parts, construction and materials, electronic and electrical equipment, food and beverages, machinery and plant construction, pharmaceuticals and biotechnology and textiles and apparel. Data were collected from September 2017 to January 2018 and totalized 329 responses – 179 from Portugal and 150 from Brazil. The return rate was 16.5% (17.9% in Portugal and 15.0% in Brazil), which is not an unusual return rate when the unit of analysis is a firm and it involves an extensive organizational-level survey. Table 19 presents the composition of the sample.

Table 19 – Sample composition

Variable	**Portugal**		**Brazil**		**Total**	
	Number	**%**	**Number**	**%**	**Number**	**%**
Number of responses	179	54.2%	150	45.5%	329	100.0%
Response rate	17.9%		15.0%		16.5%	
Number of employees	**Number**	**%**	**Number**	**%**	**Number**	**%**
< 50	10	5.6%	10	6.7%	20	6.1%
50 – 100	19	10.6%	27	18.0%	46	14.0%
101 – 500	69	38.5%	68	45.3%	137	41.6%
501 - 1000	43	24.0%	19	12.7%	62	18.8%
> 1000	38	21.2%	26	17.3%	64	19.5%
Total	179	100.0%	150	100.0%	329	100.0%
Industrial Sector	**Number**	**%**	**Number**	**%**	**Number**	**%**
Food and beverages	42	23.5%	26	17.3%	68	20.7%
Automotive and parts	40	22.3%	15	10.0%	55	16.7%
Construction and materials	17	9.5%	14	9.3%	31	9.4%
Machinery and plant construction	8	4.5%	15	10.0%	23	7.0%
Industrial metals	9	5.0%	13	8.7%	22	6.7%
Textiles and apparel	10	5.6%	11	7.3%	21	6.4%
Household goods and personal care	9	5.0%	11	7.3%	20	6.1%
Chemical	9	5.0%	10	6.7%	19	5.8%
Electronic and electrical equipment	7	3.9%	8	5.3%	15	4.6%
Forestry and paper	6	3.4%	5	3.3%	11	3.3%
Pharmaceuticals and biotechnology	6	3.4%	5	3.3%	11	3.3%
Electricity	5	2.8%	5	3.3%	10	3.0%

Variable	Portugal		Brazil		Total	
	Number	%	Number	%	Number	%
Oil and gas	4	2.2%	4	2.7%	8	2.4%
Medical equipment	1	0.6%	3	2.0%	4	1.2%
Mining	2	1.1%	2	1.3%	4	1.2%
Technology hardware and equipment	2	1.1%	2	1.3%	4	1.2%
Aerospace	2	1.1%	1	0.7%	3	0.9%
Total	179	100.0%	150	100.0%	329	100.0%

Non-response bias was assessed by contacting a random sample of 30 non-respondents (15 in Portugal and 15 in Brazil) and asking them to respond to a set of non-demographic questions, as suggested by Mentzer and Flint (1997). No statistical difference was found between the answers of respondents and non-respondents. Non-response bias was also tested by examining the differences between early (n = 198) and late respondents (n = 131), considering that late respondents have some similar characteristics that non-respondents – they took more time and effort to respond to the questions. The differences in the means and factor loadings were not significant for the constructs analyzed. These results indicate that a non-response bias does not appear to be a concern in the present study.

Procedural and statistical methods were adopted to minimize potential common-method bias. Besides the two answers from each firm, secondary data were used to triangulate the survey data as a way to limit the risk of common method bias and to enhance causal inference by reducing the likelihood of rival method-based explanations (Montabon, Daugherty, & Chen, 2018). The databases made available by Bureau Van Dijk and Neoway, were consulted to collect archival data such as: size, age, industry sector, financial ratios, and other miscellaneous data on the firms in the sample. The results showed no significant differences among all participating firms. Additionally, the respondents' anonymity was protected, the respondents were assured that there were no right or wrong answers and the ambiguity of the items was reduced during the pilot test.

5.3.2 Measures

The main measures used in the exploratory analysis are: SC strategies, product characteristics (functional and innovative), environmental uncertainty (munificence, dynamism and complexity), business performance and innovation performance.

SC strategies are measured by adapting the items proposed by Qi et al. (2009) which, in turn, are based on a variety of sources, including Katayama and Bennett (1996), Yusuf, Sarhadi and Gunasekaran (1999), Naylor et al. (1999), Christopher (2000) and Mason-Jones et al. (2000). Seven statements describing the characteristics of a lean SC and seven describing an agile SC were listed and the respondents were asked to answer the question: "*to what extent do you agree that the SC of your firm's major product/product mix has the following characteristics?*" A seven-point Likert scale (with 1 = strongly disagree and 7 = strongly agree) is used as the measurement scales.

Product characteristics were measured based on the principle that, when selecting an appropriate SC strategy, the first step for manufacturers is to consider the characteristics of their end-products, including product life cycle length, predictability of demand, product variety, and market standards for lead times and services (Fisher, 1997; Qi et al., 2009). The question asked was "*to what extent are the following statements suitable descriptions of your firm's end products or production process*." These items use a seven-point Likert scale with 1 = most unsuitable and 7 = most suitable as the anchors. The last question (CS6) requires the respondents to provide estimates regarding the introduction interval for new products. The respondents were asked to indicate the best estimate for times ranging from 1 = <3 months to 7=≥5 years.

Environmental uncertainty was measured as proposed by Aldrich (1979) and Dess and Beard (1984), who classify environmental uncertainty in three dimensions: environmental munificence, environmental dynamism, and environmental complexity. The respondents were asked to indicate their opinion on the statements concerning the business condition of the firm on a seven-point Likert scale with 1 = strongly disagree and 7 = strongly agree.

Business performance was measured based on the model used by Gonzalez-Benito (2007). Five items measure commercial success and three items are related to ratios based

on accounting data and refer to the economic benefits and productivity of the firm. The respondents were asked to evaluate their firm's performance in comparison with their competitors for each of the aspects on a seven-point Likert scale (1 = lower, 4 = equal, 7 = higher). The items measured are: sales growth, reputation and image, customer satisfaction, market share (of the main product), success of new product launches (commercial success), return on investment (ROI), profits as a percentage of sales, and labor productivity (economic and productivity performance).

Finally, innovation performance was measured using the concepts of product and process innovation effectiveness, proposed by Alegre and Chiva (2013). The respondents were asked to compare their firm's performance to that of their competitors over the last three years using a seven-point Likert scale (1 = much worse, 4 = at the same level, 7 = much better). Table 20 presents the constructs used in the study.

Table 20 – Constructs used in the study

Construct		**Source**
Supply chain strategies		
Lean	AL1. Our supply chain supplies predictable products	Qi, Boyer and Zhao (2009)
	AL2. Our supply chain reduces any kind of waste as much as possible	
	AL3. Our supply chain reduces costs through mass production	
	AL4. Our supply chain provides customer with standardized products	
	AL5. Our supply chain needs to maintain a long and rigid relationship with a small number of Suppliers	
	AL6. Our supply chain selects the suppliers based on their performance on cost and quality	
	AL7. Our supply chain structure seldom changes	
Agile	AA8. Our supply chain always faces the volatile customer demand	Qi, Boyer and Zhao (2009)
	AA9. Our supply chain responds to the changing market environment quickly	
	AA10. It is necessary for our supply chain to maintain a higher capacity buffer to respond to volatile market	
	AA11. Our supply chain provides customer with personalized products	
	AA12. Our supply chain selects the suppliers based on their performance on flexibility and responsiveness	
	AA13. Our supply chain needs to maintain a short and flexible relationship with a large number of Suppliers	
	AA14. Our supply chain structure often changes in order to cope with volatile market	
Business conditions		
Environmental uncertainty	CM1. The environment in which the firm competes can support sustained growth and sustainability (environmental munificence)	Dess and Beard (1984)
	CD2. The environment in which the firm competes is characterized by changes that are hard to predict and that heighten uncertainty for key organizational members (environmental dynamism)	
	CC3. The environment in which the firm competes is characterized by great uncertainty and great information-processing requirement	

Construct		Source
	(environmental complexity)	
Product characteristics	CS4. To what extent the demand of each type of end product vary quickly	Qi, Boyer, and Zhao (2009)
	CS5. To what extent the new product's time-to-market is very short	
	CS6. To what extent the volume of each type of end product is very high	
	CS7. Indicate the best estimate time for the introduction interval of new products (1) <3 months (2) 3–6 months (3) 7–11 months (4) 1–2 years (5) 2–3 years (6) 3–5 years (7) >5 years	
Business performance		
Commercial performance	DC1. Sales growth	González-Benito (2007)
	DC2. Reputation and image	
	DC3. Customer satisfaction	
	DC4. Market share (of the main product)	
	DC5. Success of new product launches	
Economic and productivity performance	DF6. Return on investment – ROI	González-Benito (2007)
	DF7. Profits as percent of sales	
	DF8. Labor productivity	
Innovation performance		
Product innovation	DIPT9. Replacement of products being phased out	Alegre and Chiva (2013)
	DIPT10. Extension of product range within main product field through new products	
	DIPT11. Extension of product range outside main product field	
	DIPT12. Development of environment-friendly products	
	DIPT13. Opening of new markets abroad	
	DIPT14. Opening of new domestic target groups	
Process innovation	DIPS15. Improvement of production flexibility	Alegre and Chiva (2013)
	DIPS16. Reduction of production costs by cutting labor cost per unit	
	DIPS17. Reduction of production costs by cutting material consumption	
	DIPS18. Reduction of production costs by cutting energy consumption	
	DIPS19. Reduction of production costs by cutting rejected production rate	
	DIPS20. Reduction of production costs by cutting design costs	
	DIPS21. Reduction of production costs by cutting production cycle	
	DIPS22. Improvement of product quality	
	DIPS23. Improvement of labor conditions	
	DIPS24. Reduction of environmental damage	

5.4 Results and discussion

The data collected through the online questionnaire were analyzed by means of an exploratory analysis. Hierarchical cluster analysis was employed to find patterns among the SC strategies adopted by the firms and grouping them into different clusters, while one-way analysis of variance (ANOVA) was conducted to study the relationship between SC strategies and the other variables. SPSS Statistics 25 was used to perform the analyses.

5.4.1 Reliability and validity of the constructs

A set of methods was applied to assess the reliability and validity of the constructs. First, exploratory factor analyses were conducted for each construct as proposed by Qi et al. (2009). The complete results of the factor analyses are presented in the Appendix. The first analysis was made according to lean and agile SC characteristics. All the items were maintained as they presented factor loadings greater than 0.5 in the factors they were supposed to measure (AL1 to AL7 to measure lean and AA1 to AA7 to measure agile).

The second factor analysis was made for the items of product characteristics and, once more, none of the items were excluded. CS1 and CS2 measured the characteristics of innovative products and CS3 and CS4 the characteristics of functional products. Regarding business performance, DC1 to DC5 were designed to measure commercial performance while DF1 to DF3 measure economic and productivity performance. The item DC5 was excluded from the final construct, as it presented high cross loadings (higher than 0.4), following the suggestion of Hair, Black, Babin and Anderson, (2010). The next factor analysis assessed the constructs for innovation performance. Items DIPT1 to DIPT5 measure product innovation performance and DIPS1 to DIPS10 measure process innovation performance. Items DIPS8, DIPS9 and DIPS10 were excluded due to the presence of high cross-loading values (higher than 0.4).

Cronbach's alpha results for SC strategy, business performance and innovation performance are also presented in the appendix as they help to assess the internal consistency of the constructs (Hair et al., 2010; Peng & Lai, 2012). All the Cronbach's alpha results presented are greater than 0.8, suggesting that the constructs have sufficient reliability (Peng & Lai, 2012).

Eigenvalues were also analyzed for the constructs and are presented in the Appendix. The analysis of the constructs for SC strategy showed that the scale for agile explains 27.0% of the variance (eigenvalue = 3.78/7 items) and the scale for lean explains 25.8% of the variance (eigenvalue = 3.61/7 items). The factor analysis for business performance also resulted in two factors – commercial performance – which explains 34.65% of the variance (eigenvalue = 2.43/4 items) – and economic and productivity performance – which explains 31.98% of the variance (eigenvalue = 2.24/3 items).

Innovation performance also presents two factors, where product innovation performance explains 32.1% of the variance (eigenvalue = 4.17/5 items) and process innovation explains 26.2% (eigenvalue = 3.40/7 items). Regarding product characteristics, the scale for innovative products explains 38.1% (eigenvalue = 1.52/2 items) and the scale for functional products explains 26.9% (eigenvalue = 1.08/2 items).

The fit indices of the structural model were also tested, and the results obtained are satisfactory ($p < 0.001$, IFI = 0.926, TLI = 0.912, CFI = 0.924 and RMSEA = 0.054), providing support for the nomological validity of the structural model hypothesized.

Moreover, as two different samples were collected, one from Portugal and the other from Brazil, two one-sided tests (TOST) for equivalence was applied, as proposed by Schuirmann (1987), and showed that there was no significant difference in their means.

5.4.2 Adoption of different SC strategies

Hierarchical cluster analysis (Ward's method, squared Euclidean distance) was conducted, based on the constructs for lean and agile SC characteristics, in order to identify patterns among the respondent firms and classify them according to their different SC strategies.

The analysis of the number of clusters followed the method proposed by Frohlich and Dixon (2001) in order to be precise and, at the same time, identify a number of clusters that would permit a proper analysis of the groups. Lehmann (1979) suggests that the number of observations in each cluster should be between 30 and 60. Considering the size of the sample (N = 329), the number of clusters in this study should be between 5 and 10. However, taking into consideration that the choice of the final number of clusters is subjective, and after analyzing solutions with four and five clusters, the solution with four clusters was chosen as it provided a better understanding of the characteristics of each cluster. Moreover, the solution with four clusters matches with the solutions applied by Qi et al. (2009) and, for that reason, the clusters were named according to this study, where the four clusters are defined as: lean, agile, leagile and traditional.

Next, a one-way analysis of variance (ANOVA) was conducted to test for differences in group means. The ANOVA and the Scheffe post hoc tests of mean differences helped to

analyze the specificities of each cluster and interpret the results. Table 21 shows the analysis of variance of the SC strategies by the SC characteristics.

Table 21 – Analysis of variances of SC strategies using hierarchical cluster analysis

	Cluster 1 – Leagile N = 90		**Cluster 2 – Agile N = 40**		**Cluster 3 – Traditional N = 74**		**Cluster 4 – Lean N = 125**		
	Mean*	SE	Mean*	SE	Mean*	SE	Mean*	SE	F Value
Lean SC	5.55 (2,3)	0.11	2.95 (1,3,4)	0.16	4.14 (1,2,4)	0.18	5.72 (2,3)	0.10	156.02**
Agile SC	5.39 (2,3,4)	0.12	5.83 (1,3,4)	0.12	4.81 (1,2,4)	0.17	3.71 (1,2,3)	0.11	308.66**

SE = standard error; * Based on a seven-point Likert scale; ** p<0,001; Numbers in parentheses indicate the cluster from which this cluster is significantly different at .05 level of significance based on the Scheffe pairwise comparison.

The four clusters identified present very well-defined features when analyzing the constructs for SC characteristics, which can be seen by means of the results of Scheffe's multiple comparison test, which indicates significative differences among the clusters.

As showed in table 3, the firms which are part of the leagile cluster present high means for the characteristics of lean and agile SCs, which means that they demonstrate a balance between leanness and agility in upstream and downstream SCs, according to the environment where they compete (Mason-Jones et al., 2000). Leagility can be understood as an evolution from lean to agile, as the firms can provide a comparable service level at an acceptable cost (Qi, Huo, Wang, & Yeung, 2017).

Firms in cluster 2 present the highest means for agile SC characteristics among all the groups and the lowest value for lean, meaning that this group clearly prioritize characteristics such as: a quick response to the changing market environment, high capacity buffer, personalized products, selection of suppliers based on their performance concerning flexibility and responsiveness and a short and flexible relationship with a large number of suppliers (Qi et al., 2009).

On the other hand, firms in cluster 4 present the highest values for lean, and the lowest values for agile, characteristics. This group has a clear predominance of practices that focus on predictability and reduction of waste, reducing costs through mass production, providing customers standardized products, maintaining long and rigid

relationships with a small number of suppliers and selecting suppliers based on their performance regarding cost and quality.

Finally, cluster 3 group firms do not present a clear focus on leanness or agility, as they show low levels of both strategies. This group is called traditional SC (Qi et al., 2009).

Following this assessment, the characteristics of each cluster were analyzed with respect to demographic characteristics of the firms that are part of each cluster. Two aspects were analyzed: firm size and industry sector. These analyses were intended to evaluate the impact of the two characteristics on the choice of the SC strategy and help to find connections and patterns for later discussion. Tables 22 and 23 show the results of the analyses.

Table 22 – Firm size by SC strategy cluster

Variable	**Cluster 1 – Leagile N = 90**		**Cluster 2 – Agile N = 40**		**Cluster 3 – Traditional N = 74**		**Cluster 4 – Lean N = 125**		**Total**	
	Number	%	Number	%	Number	%	Number	%	Number	%
< 50	6	6.7%	3	7.5%	3	4.1%	6	4.8%	18	5.5%
50 – 100	8	8.9%	9	22.5%	7	9.5%	24	19.2%	48	14.6%
101 – 500	46	51.1%	14	35.0%	35	47.3%	42	33.6%	137	41.6%
501 - 1000	13	14.4%	8	20.0%	13	17.6%	28	22.4%	62	18.8%
> 1000	17	18.9%	6	15.0%	16	21.6%	25	20.0%	64	19.5%
Total	90	100.0%	40	100.0%	74	100.0%	125	100.0%	329	100.0%

Regarding the size of the firms, as presented in table 4, no significative difference was found among the clusters, indicating that the choice of the SC strategy does not depend on this feature. This result is similar to previous studies, although Qi et al. (2009) have verified that medium-sized firms have a lower emphasis on lean strategies compared to small firms.

Table 23 – Firm industry sector by SC strategy cluster

	Cluster 1 – Leagile N = 90		**Cluster 2 – Agile N = 40**		**Cluster 3 – Traditional N = 74**		**Cluster 4 – Lean N = 125**		**Total**	
	N	**%***	**N**	**%***	**N**	**%***	**N**	**%***	**N**	**%**
Food and beverages	25	36.8%	7	10.3%	12	17.6%	24	35.3%	68	20.7%
Automotive	12	22.2%	5	9.3%	9	16.7%	28	51.9%	54	16.4%

	Cluster 1 – Leagile N = 90		Cluster 2 – Agile N = 40		Cluster 3 – Traditional N = 74		Cluster 4 – Lean N = 125		Total	
	N	%*	N	%*	N	%*	N	%*	N	%
and parts										
Construction and materials	8	25.8%	3	9.7%	6	19.4%	14	45.2%	31	9.4%
Machinery and plant construction	6	26.1%	4	17.4%	9	39.1%	4	17.4%	23	7.0%
Textiles and apparel	4	17.4%	7	30.4%	7	30.4%	5	21.7%	23	7.0%
Industrial metals	4	18.2%	4	18.2%	6	27.3%	8	36.4%	22	6.7%
Household goods and personal care	6	30.0%	2	10.0%	5	25.0%	7	35.0%	20	6.1%
Others	25	28.4%	8	9.1%	20	22.7%	35	39.8%	88	26.7%
Total	90	27.4%	40	12.2%	74	22.5%	125	38.0%	329	100.0%

* % of firms in the industry sector which adopt the SC strategy

Concerning the industrial sector, some interesting findings can be highlighted. Firms in the food and beverage sector (the most common among the respondents) adopt lean and leagile SC strategies predominantly. Although food and beverage is a highly diverse and heterogeneous sector (Bayraktar et al., 2010), the results indicate that part of this group can be characterized by mass production and relatively low variability. Moreover, more than 50% of the firms in the automotive and parts sector and 45% in the construction and material sector adopt a lean SC strategy, indicating a predominance of this strategy among firms in these sectors, which can be explained by the characteristics of these sectors, especially mass production, when compared with other sectors. Among the firms that adopt an agile SC strategy, it is possible to note the presence of those from the textile and apparel sector, although this sector presents a relative homogeneity regarding the choice of SC strategy. Firms in the sector of machinery and plant construction predominantly choose a traditional SC strategy. Looking at the other sectors, no substantial differences among the clusters were found.

5.4.3 Antecedents to the doption do SC strategies

One-way analysis of variance was also conducted to analyze the differences between the clusters regarding product characteristics and environmental uncertainty (table 24).

Table 24 – Analysis of variance of business conditions by SC strategy clusters

	Cluster 1 – Leagile N = 90		**Cluster 2 – Agile N = 40**		**Cluster 3 – Traditional N = 74**		**Cluster 4 – Lean N = 125**		
	Mean*	SE	Mean*	SE	Mean*	SE	Mean*	SE	F Value
Functional product	4.03 (2,4)	0,17	3.41 (4)	0,23	3.76 (4)	0,18	5.35 (1,2,3)	0,14	4.89***
Innovative product	4.61	0,18	5.13 (4)	0,25	4.29 (4)	0,19	4.00 (2,3)	0.14	6.29***
E. Munificence	5.70	0,11	5.40	0,18	5.49	0.13	5.62	0,08	1.11
E. Complexity	4.53 (2)	0.16	5.30 (4)	0.23	4.49 (2)	0,17	4.38 (2)	0,13	3.89***
E. Dynamism	4.51	0.17	5.45 (4)	0.21	4.39	0.18	4.16 (2)	0,13	7.36**

SE = standard error; * Based on a five-point Likert scale; ** p<0.001; *** p<0.01; Numbers in parentheses indicate the cluster from which this cluster is significantly different at 0.05 level of significance based on the Scheffe pairwise comparison.

The results show significant differences among the clusters, especially when it comes to product characteristics (both functional and innovative products) and environmental complexity. It is possible to highlight the frequent significant differences between agile and lean.

Cluster 1, leagile, consists of the firms that adopt lean and agile principles simultaneously (Mason-Jones et al., 2000; Qi et al., 2017). Firms in this group have relatively high levels of functional and innovative products. Considering that leagile is a combination of lean and agile and that lean is more related to functional products and agile to innovative products (Fisher, 1997; Wagner, Grosse-Ruyken, & Erhun, 2012), the findings confirm the theory developed in previous studies. Thus, this group of firms is able to combine different strategies according to different needs.

The environment where firms in this cluster compete is characterized by high levels of munificence, that is, an environment that can support a sustained growth of the firms (Dess & Beard, 1984) and average levels of complexity and dynamism (well below agile but above lean and traditional strategies). To cope with this relative uncertainty, this group needs to be able to respond quickly to changes, which explains the need for a certain degree of agility.

Cluster 2, agile, is comprised of the firms that focus on flexibility and adaptability for changing market demands (Christopher & Towill, 2002). The results show a predominance of innovative, rather than functional products, among the firms in this group. This can be

explained by existing theory as an agile strategy is often linked to innovative products (Fisher, 1997; Wagner et al., 2012), and product characteristics can be considered one of the main antecedents to an SC strategy (Qi et al., 2009). Complexity and dynamism characterize the environment of these firms, which helps to explain their choice of this strategy, while munificence is relatively low.

Firms with a traditional SC strategy make up cluster 3. This group shows a relative balance between functional and innovative products, which may help to explain their apparent lack of focus (Qi et al., 2009). The environment where this group of firms competes is characterized by average munificence and low complexity and dynamism.

Cluster 4, lean, is made up of firms that prioritize efficiency and reduction of wastes (Guan & Ma, 2003; Qrunfleh & Tarafdar, 2014). There is a clear predominance of functional products among the firms in this group, rather than innovative products, confirming the theory that a lean strategy is related to functional products (Fisher, 1997). The environment of this group is characterized by low complexity and dynamism, which helps to understand the cluster's strategic choice, and relatively high munificence.

5.4.4 Impact of SC strategies on business performance and innovation performance

The impact of the adoption of the different SC strategies on business performance and innovation performance was also assessed by means of one-way analysis of variance, as presented in table 25.

Table 25 – Analysis of variance of performance by SC strategy clusters

	Cluster 1 – Leagile N = 90		**Cluster 2 – Agile N = 40**		**Cluster 3 – Traditional N = 74**		**Cluster 4 – Lean N = 125**		
	Mean*	SE	Mean*	SE	Mean*	SE	Mean*	SE	F Value
Commercial performance	3.71 (2,3,4)	0.06	3.41 (1)	0.11	3.36 (1)	0.07	3.45 (1)	0.06	4.92**
Economic and productivity performance	5.25 (2,3,4)	0.11	4.75 (1)	0.17	4.58 (1)	0.12	4.67 (1)	0.09	7.48**
Product innovation performance	4.88 (2,3,4)	0.10	4.49 (1)	0.10	4.26 (1)	0.13	4.34 (1)	0.09	7.49**
Process innovation performance	5.05 (2,3,4)	0.08	4.58 (1)	0.10	4.28 (1)	0.13	4.55 (1)	0.08	10.19**

SE = standard error; * Based on a seven-point Likert scale; ** $p<0.001$; Numbers in parentheses indicate the cluster from which this cluster is significantly different at 0.05 level of significance based on the Scheffe pairwise comparison.

These results show that firms with a leagile SC strategy achieve the best performance among the clusters in the four parameters analyzed (commercial, economic and productivity, product innovation and process innovation performance). It can be said that this group is the most well-prepared to face different types of environments, as they are able simultaneously, and depending on, different challenges, to reduce waste and improve efficiency and respond quickly to changes in demand (Qi et al., 2017).

Firms with an agile SC strategy present relatively high levels of economic and productivity performance, as well as product and process innovation performance, but a lower level of commercial performance. Firms that follow a lean paradigm presented higher levels of commercial, economic and productivity performance compared to innovation performance. The group of firms that adopt a traditional SC strategy has the lowest levels of performance in all the parameters observed. It is important to highlight that all the clusters present lower levels of commercial performance compared to economic and productivity performance.

5.5 Implications and conclusions

The aim of this chapter was to discuss and test the antecedents and consequences of the adoption of different SC strategies. An exploratory approach was applied to analyze data from Portuguese and Brazilian firms. The study replicated and confirmed previous studies (especially Qi et al., 2009) in some respects and added to the existing knowledge in others. RBV was used as the theoretical foundation for the study, following previous studies in the field (Fawcett, Jones, & Fawcett, 2012; Sjoerdsma & van Weele, 2015; Yan & Azadegan, 2017). An SC strategy was understood to be as strategic resources that must match firms' specific requirements (internal and external) and helps to explain a firm's results.

The hierarchical cluster analyses carried out in this study demonstrated that the four types of SC strategies observed by Qi et al (2009) in Chinese firms are also adopted by the firms analyzed in the Portuguese and Brazilian context. Significant differences among the clusters were found in a variety of aspects.

Product characteristics and environmental uncertainty were analyzed as antecedents of the adoption of SC strategies. The results confirmed previous studies regarding product characteristics, clearly showing that firms with primarily functional products tend to adopt a lean strategy, while those with primarily innovative products adopt an agile strategy. Firms with traditional and leagile SC strategies present both functional and innovative products to a similar degree, although leagile has higher levels of innovative products. These results confirm the model proposed by Qi et al. (2009), contributing to provide validity and credibility to this previously developed theory.

Environmental uncertainty was assessed with a view to adding to the present knowledge about the factors driving the adoption of SC strategies. According to the results, firms that compete in environments characterized by high levels of complexity and dynamism tend to adopt an agile SC strategy, while those in enviroments with higher munificence adopt leagile and lean strategies – although the results also supported the idea that environmental munificence presents a lower correlation with SC strategies, as the differences between clusters were less significative when compared with complexity and dynamism (Pan et al, 2018). These results help to explain the strategic choices made by firms, along with product characteristics, as the analysis was able to support and extend the theory regarding the relationship of the different SC strategies to the different internal and external features of firms, especially concerning the various aspects of uncertainty.

The results showed that the firms that adopt a leagile SC strategy present better economic, commercial and productivity performance, contrary to previous studies, especially Qi et al. (2009), who do not find significant differences among the performance of lean, agile and leagile ones. Moreover, the group using a leagile strategy also perform better in terms of innovation, which had not been tested before. According to the results, a traditional SC strategy leads to the worst results, confirming the results obtained by Qi et al. (2009). The similarity of the performance between lean and agile, also verified in previous studies, although agile performed slightly better regarding innovation, confirms the idea that there is no best SC strategy. The strategy has to fit the requirements of each firm (Lee, 2002).

This study makes a theoretical contribution to the literature on the characteristics of firms with a lean and agile SC strategy. A novel study, involving the antecedents to the adoption of an SC strategy, was empirically tested within the context of Portugal and Brazil. Moreover, this study includes the analyses of the impact of SC strategies on innovation performance, which has not been tested before. The replication and extention of previous studies in a different context, especially in countries which are not part of the main group of developed countries and which are not among the most common in empirical research, contributes to the generalizability, validity and relevance of the previous findings, while assessing the same subjects under different conditions (Goldsby & Autry, 2011).

This chapter also presents a variety of managerial implications. Firms need to adopt not only the right SC strategies related to their product characteristics, but also to the variety of features of their environment. The results can be used to guide managers in the adoption of their SC strategy as it clearly demonstrates that each strategy fits better with different characteristics of firms and environments, and produces different results.

While making significant contributions to SCM literature and having important implications in terms of theory and practice, some limitations and opportunities for future studies can be highlighted. Although this study provides interesting findings on the relationship between strategy, business conditions and performance, the limited sample size and geographical coverage of the sample means that any generalization of the conclusions should be made cautiously. Future research using data from different countries could contribute to discussing similarities and differences among different cultures further, following a logic of replication, as advocated by Goldsby and Autry (2011).

Considering the significative lower level of commercial performance compared with economic and productivity performance in all the clusters, future research could use different scales and metrics (such as primary data) to explore and discuss the reasons and effects of this characteristic. Moreover, besides analyzing other constructs, such as corporate strategies or trust among SC partners, future research could also analyze the antecedents and consequences of the adoption of SC strategies by means of different methods, either using survey data or case studies.

Finally, this study considers the link between SCM and innovation, a topic which has gained great relevance in the last years (Zimmermann et al., 2016), by including the impact of SC strategies on innovation performance, as well as the analysis of innovative products. In this sense, future research could analyze this link more profoundly by assessing the relationship between SC strategies and innovation strategies and/or innovation capabilities.

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CHAPTER 6 – HOW SUPPLY CHAIN STRATEGIES MODERATE THE INNOVATION CAPABILITIES-BUSINESS PERFORMANCE RELATIONSHIP[8]

Abstract:

The purpose of this chapter is to study how the fit between innovation capabilities and supply chain strategies affect business performance. An empirical study on a sample of 329 companies from Portugal and Brazil was conducted through a web-based survey and a theoretical model grounded on the resource-based view is presented. Linear and hierarchical regression analysis are used to test the hypotheses. The different combinations of core and supplementary innovation capabilities and lean and agile supply chain strategies are empirically tested and discussed. Evidences revealed that core and supplementary innovation capabilities positively impact business performance and that supply chain strategies moderate the relationship between innovation capabilities and business performance. The analysis also showed that the combination of agile supply chain strategy and supplementary innovation capabilities offers the greatest opportunities to increase business performance. Using the results of this study it is possible to improve the impact of innovation capabilities on business performance adopting the most appropriate SC strategy. The chapter contributes to the study of the consequences on business performance of adopting different innovation capabilities and supply chain strategies as previous research has studied the relationship between innovation and SC management or between innovation capabilities and business performance.

Keywords: supply chain strategies, innovation capabilities, business performance, fit, moderation.

6.1 Introduction

Innovation is recognized as an important source of competitive advantage (Porter, 1996; Teece, 2018) and its potential to generate performance improvements depends on a set of factors known as innovation capabilities (ICs), which result from the abilities to

[8] Under review in an ISI and Scopus indexed Journal when the thesis was delivered.

develop and explore new ideas successfully (Adler & Shenhar, 1990; Francis & Bessant, 2005; Guan & Ma, 2003; Teece, 1986). Many authors argue that ICs positively impact business performance (Borjesson & Elmquist, 2011; Calantone, Cavusgil, & Zhao, 2002; Mir, Casadesus, & Petnji, 2016; Saunila, Pekkola, & Ukko, 2014), but the factors and circumstances that favour or undermine this relationship are not well known (Saunila et al., 2014).

Considering this complexity, where the impact of ICs on business performance is influenced by several factors, this study looks at the relationship between ICs and supply chain (SC) management, which also plays an important role in firms' competitiveness. The link between innovation and SC has attracted more and more attention from academics in the last few years (Arlbjorn & Paulraj, 2013; Moreira, Ferreira, & Zimmermann, 2018; Sjoerdsma & van Weele, 2015; Zimmermann, Ferreira, & Moreira, 2016). An important part of SC management is expressed on the SC strategy, which refers to a pattern of decisions related to sourcing products, capacity planning, conversion of raw materials, demand management, communication with SC actors, and delivery of products and services (Arora, Arora, & Sivakumar, 2016).

The relationship between two or more areas, functions, processes, units, strategies or capacities can be studied through the lens of the concept of fit (Porter, 1996; Venkatraman & Camillus, 1984). Fit expresses the adjustment of one or more variables in relation to another and a good fit is believed to have a positive impact on performance (Peng, Schroeder, & Shah, 2011; Venkatraman & Camillus, 1984; Wu, Wu, Chen, & Goh, 2014). Fit as moderation is related to the impact of a moderator variable on the relationship between a predictor variable and a criterion variable (Venkatraman, 1989).

In light of this scenario, this chapter aims to study how fit (as moderation) between innovation capabilities and SC strategies affects business performance. The following research question is addressed: how SC strategies moderate the relationship between innovation capabilities and business performance?

In an attempt toward building a better understanding of the relationship between innovation and SCM, this study contributes to the literature in several ways. The empirical test of the relationship between ICs and SC strategies and its effects on business

performance represents a contribution to theory and practice, bringing a new perspective to the topic. By focusing on the strategic view of SC strategies and ICs, the chapter enhances the understanding of the importance of the two areas – and their relationship – for business performance and extends prior literature on the relationship between innovation and SCM. This chapter also offers practical implications for firms seeking to improve their overall performance, discussing the importance of aligning SC strategies and ICs.

The remaining of the chapter is organized as follows. Section 2 provides a literature review that helps to develop the theoretical model and presents the hypotheses to be tested. Research methodology is presented in Section 3. Results and discussions are given in Section 4, followed by the conclusions and implications of the study.

6.2 Literature review and theoretical development

The present study is based on the concept of fit as moderation and on the principles of Resource-based View (RBV). The concept of fit has gained ground in the literature over the last few years (Acur, Kandemir, & Boer, 2012; Wu et al., 2014) and indicates consistency and harmony between two or more variables. It is believed that the better the fit, the better the impact on performance (Peng et al., 2011; Venkatraman, 1989). Peng et al. (2011, p. 486) state that "*researchers adopting a fit perspective investigate consistency among subsystems (areas, processes, strategies) within a firm (internal fit) or fit among the organizational structure, strategy and the external environment (external fit).*"

To the moderation perspective of fit, the impact that a predictor variable has on a criterion variable is dependent on the level of a third variable, known as moderator. Thus, the fit between the predictor and the moderator is the primary determinant of the criterion variable (Venkatraman, 1989). This perspective is used when the theory specifies that the impact of the predictor varies across the different levels of the moderator, which can be viewed categorically (types of environment, stages of product life cycle, organizational types) or characteristically (degree of business-relatedness, degree of competitive intensity). The type of moderation affects the direction or the strength of the impact on the dependent variable (e.g., performance) (Venkatraman, 1989).

The RBV supports this study as it provides the foundation for the assertion that ICs and SC strategies are strategic resources that influence key outcomes, such as business performance (Craighead, Hult, & Ketchen Jr, 2009). The RBV has been one of the most promising theories to evolve in the strategic management field and is able to bring a more systematic approach to firm-level analysis by characterizing the firm as a collection of resources and capabilities. "*RBV assumes that performance differences across firms are due to differences arising from valuable, rent-generating, firm specific resources and capabilities that cannot be easily imitated or substituted*" (Lawson & Samson, 2001, p. 379).

6.2.1 Innovation capabilities

Firms' capabilities are usually described as what firms are able (or unable) to do (Borjesson & Elmquist, 2011) and are often seen as the ability to apply available resources to achieve the expected results (Yang, 2012). ICs, which have received increasing attention from researchers in the last few years (Calantone et al., 2002; Guan & Ma, 2003; Mir et al., 2016; Ngo & O'Cass, 2012; Oura, Zilber, & Lopes, 2016), result from the abilities to develop and explore new ideas successfully and are determinant factors in generating competitive advantages (Guan & Ma, 2003; Menguc, Auh, & Yannopoulos, 2014). To Borjesson & Elmquist (2011, p. 174), "*IC are characteristics of the firm's preparedness and its development of the 'muscles for innovation'*."

The concept of IC emerged from the need to understand why innovating firms often fail to obtain significant economic benefits (Teece, 1986). Teece (1986) discussed the importance of having different assets and competencies to take advantage of innovating and argued that innovators will fail if they do not have the set of capabilities that allow not only to develop new products, but also to successfully implement them. Research indicates that established product development processes do not necessarily result in innovative products and economic benefits (Borjesson & Elmquist, 2011; Lisboa, Skarmeas, & Lages, 2011; Mir et al., 2016), showing that firms need much more than a process to take advantage of innovation. Moreover, ICs must be defined according to the specificities of each firm, accommodating the special conditions and competition environment characteristics (Guan & Ma, 2003; Lisboa et al., 2011).

Innovation brings a certain degree of uncertainty to firms, as it requires the coexistence of different interests, often contrasting. Lawson and Samson (2001, p. 381) discuss the paradox of managing daily operations while also cultivating innovation referring that "*the need to manage mainstream competencies efficiently is often seen as hampering the development of successful innovation*." (Lawson & Samson, 2001, p. 381) Mainstream activities like manufacturing and marketing are usually seen as the key to firms' success and organizational processes are built around stability, efficiency and profitability. On the other hand, innovation requires long-term vision and flexibility (Lawson & Samson, 2001), making this balance a challenge to managers. The development of a set of capabilities suitable to firms needs helps to minimize this instability.

Guan and Ma (2003) identified seven dimensions of ICs based on the need of firms to transform knowledge and ideas into new products, processes and systems and to succeed in its implementation (Lin, 2007), balancing the different needs and interests: (1) research and development (R&D) capability; (2) manufacturing capability; (3) marketing capability; (4) learning capability; (5) organizational capability; (6) resource exploiting capability; and (7) strategic capability.

R&D capability is related to firms that have a formal R&D process (represented by an area or department) but is not exclusive to this group. Firms without a formal R&D process can present this capability if they are able to embrace novel technologies and approaches when developing new products or processes (Guan & Ma, 2003). Manufacturing capability, in turns, refers to the ability to transform R&D results into products, which meet market needs, in accordance with design request, while marketing capability indicates the capacity to publicize and sell the products on the basis of understanding consumers' current and future needs, customers' access approaches, and competitors' knowledge (Guan & Ma, 2003).

Learning capability refers to the capacity to identify, assimilate, and exploit new knowledge (Guan & Ma, 2003). Research on innovation often identifies learning as a critical capability for innovative firms and consider it a crucial aspect in the development of organizational capabilities (Borjesson & Elmquist, 2011). Learning encompasses sharing

and transfer of knowledge internally, learning from previous experiences and collaborating with external firms.

Organizational capability is the capacity to constitute a well-established organizational structure, coordinate the work of all activities towards shared objectives, and influence the speed of innovative processes (Guan & Ma, 2003). Resource exploiting capability represents the firm's ability to mobilize and expand its resource base (technological, human and financial). Organizational and resource exploiting capabilities play an important role in balancing the contrasting interests related to mainstream activities and innovation (Lawson & Samson, 2001).

Strategic capability is the capacity to adopt different types of strategies that can adapt to environment changes for the excelling in the highly competitive environment (Guan & Ma, 2003). This capability represents, on one hand, the long-term view needed to develop and invest in innovation and, on the other hand, the flexibility to turn directions whenever necessary.

According to Guan and Ma (2003) and following the conclusions of Teece (1986), the seven dimensions can be divided into two groups: core ICs, composed by R&D, manufacturing and marketing capabilities; and supplementary ICs, composed by learning, organizational, resource-exploiting and strategic capabilities. This division is similar to Lawson and Samson's (2001), who classified activities or processes in mainstream and newstream. Capabilities could also be distinguished based on the type of knowledge they contain (Verona, 1999), as (1) functional capabilities, that allow a firm to develop its technical knowledge; and (2) integrative capabilities, which allow firms to absorb knowledge from external sources and blend the different technical competencies developed in various company departments (Cohen & Levinthal, 1990; Lawson & Samson, 2001; Teece, Pisano, & Shuen, 1997). Understanding the differences between these groups of capabilities or activities is fundamental to manage their different needs and to be successful in a dynamic and turbulent environment (Guan & Ma, 2003; Lawson & Samson, 2001).

Core ICs are more related to intellectual property (Teece, 1986) and knowledge management (Swink, 2006) and are understood as the ability to transform innovation

ideas through R&D, manufacturing and marketing process (Guan & Ma, 2003). Understanding R&D as a process (as well as manufacturing and marketing) core capabilities represent the mainstream activities. On the other hand, supplementary ICs are key determinants for firm performance in markets where barriers to imitation and entrance of new competitors are smaller (Teece, 1986). According to Teece (1986, p. 285), "*when imitation is easy, markets don't work well, and the profits from innovation may accrue to the owners of certain complementary assets, rather than to the developers of the intellectual property*." Guan and Ma (2003) highlight the role of supplementary capabilities to support and harmonize core ICs, improving their effectiveness.

In this sense, even though core ICs include R&D, manufacturing and marketing, their existence is no guarantee of successful innovation nor financial return (Mir et al., 2016; Teece, 1986). Supplementary capabilities are important determinants to balance and integrate different interests within the firm and allow the sustainability of innovation over time. Organizations possessing a balanced set of ICs have the ability to integrate key capabilities and resources of their firm to successfully stimulate innovation (Lawson & Samson, 2001).

The ICs impact on the intensity and depth of innovation (Lisboa et al., 2011), can be understood through the concepts of exploration and exploitation. Exploration refers to the firms' capacity to find completely new knowledge, competences, and opportunities. It is closely connected to creativity and innovation and includes characteristics such as search, variation, risk taking, experimentation, flexibility and discovery (March, 1991; Uotila, 2017). On the other hand, exploitation is the ability to refine and utilize the firms' existing knowledge, competences and opportunities. It is linked to efficiency and productivity and encompasses refinement, choice, selection, implementation, and execution (March, 1991; Uotila, 2017).

6.2.2 SC strategies

SC environments have become increasingly more dynamic and unpredictable, influenced by characteristics like product demand, product variety and product life-cycle (Hallavo, 2015). As such, firms need to deploy their SC strategies to overcome volatile

environments, in order to enhance their competitiveness in the market (Abdollahi, Arvan, & Razmi, 2015; Stentoft & Rajkumar, 2018).

Although SC management is a recurring topic in strategic plans, firms often do not clearly define their strategies (Qi, Boyer, & Zhao, 2009; Qrunfleh & Tarafdar, 2014; Sharifi, Ismail, Qiu, & Tavani, 2013). How firms achieve and maintain competitive advantage is one of the main questions in the field of strategic management (Pisano, 2015; Porter, 1996; Teece et al., 1997). Strategic positioning is based on carrying out activities different from those of competitors or carrying out similar activities in a different way (Porter, 1996). In this sense, a strategy is a commitment to a set of activities, policies and behaviours, which are coherent and mutually supportive, seeking to achieve objectives that contribute to the competitiveness of the firms. For Pisano (2015), good strategies encourage alignment between the different functional / business areas of the organization, clarify objectives and help maintain the focus on the stated priorities.

SC strategies reflect the nature of the SC and lay down their objectives and goals (Lee, 2002; Qrunfleh & Tarafdar, 2014). Moreover, they should be aligned with the product's characteristics, with the adopted competitive strategy and with the environment where the firms compete. For Arora et al. (2016, p. 206), "*SC strategy describes a pattern of decisions related to sourcing products, capacity planning, conversion of raw materials, demand management, communication across the SC, and delivery of products and services and thereby links SCM strategy to business and corporate-level strategy*." In this sense, SC strategy is often understood as an extension of the operations strategy and represents a set of choices that firms need to make to match the environmental contingencies they confront (Lo & Power, 2010).

By the lens of SC management, the purpose of achieving and sustaining a competitive position in the market can be obtained essentially by two ways: increasing efficiency or responding quickly to market needs. In this sense, the model proposed by Marshall Fisher in his important and influential article published in the Harvard Business Review in 1997 (Fisher, 1997) led many authors to adopt two types of SC strategy: lean – equivalent to Fisher's Efficient strategy, and agile – equivalent to Fisher's Market-

responsive strategy (Abdollahi et al., 2015; Christopher & Towill, 2002; Qi, Zhao, & Sheu, 2011; Qrunfleh & Tarafdar, 2014).

Firms that adopt a lean "thinking" perspective seek to improve the efficiency of their business processes (Mason-Jones, Naylor, & Towill, 2000). This kind of strategy is linked to elimination of waste, cost efficiency and lead-time reduction. An agile SC, on the other hand, seeks to have the capacity to be responsive and flexible to changing and unpredictable demands of customers (Abdollahi et al., 2015; Lee, 2002). While Lean tends to perform better in high volume, low variety and predictable environments, agile is more adaptable to less predictable environments where the demand varies considerably (Christopher, 2000).

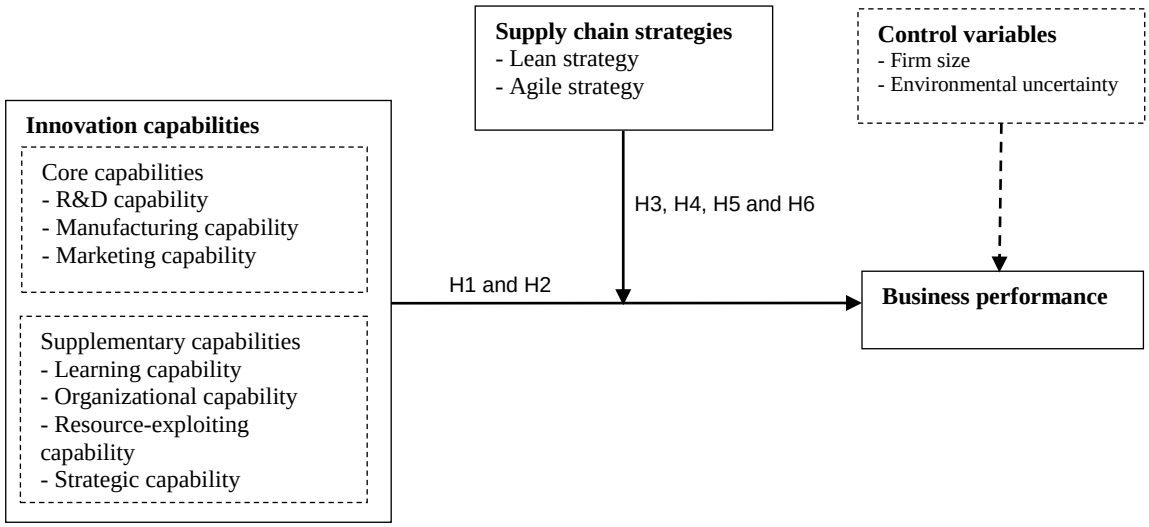
Some authors have adopted other strategies in their studies, especially lean/agile, or leagile (Bruce, Daly, & Towers, 2004; Mason-Jones et al., 2000; Naylor, Naim, & Berry, 1999), which is a combination of the lean and agile approaches.

The model proposed by Fisher, as well as the models derived from it, considers the characteristics of products to determine SC strategy. In these models, lean or efficient SC matches with functional products, while agile or responsive SC matches with innovative products (Fisher, 1997; Lo & Power, 2010; Qrunfleh & Tarafdar, 2014). However, being SC management a process that goes through constant changes, the choice of SC strategy is also a dynamic process that has to be adapted whenever it is needed. As Christopher and Towill (2002) state, Lean and Agile are not opposing philosophies, they are just better suited to different contexts. As Lee (2002, p. 106) states, "*strategies that are based on a one-size-fits-all or try-everything mentality, will fail*."

6.2.3 Theoretical model and hypotheses development

This chapter is developed according to the model presented in figure 17, that represents the relationship between ICs, SC strategies and business performance, complemented by the influence of firm size and environmental uncertainty as control variables. The model reflects the concept of fit as moderation, where ICs are the predictor variables, business performance is the criterion variable and SC strategies are the moderator variables.

Figure 17 - Theoretical model



The relationship between ICs and business performance is not new as many authors have argued that ICs positively impact business performance (Borjesson & Elmquist, 2011; Calantone et al., 2002; Mir et al., 2016; Saunila et al., 2014). However, the characteristics of this relation and the circumstances that influence it have not been broadly studied yet. In this sense, testing the effect of the ICs separately, in this case core and supplementary, is a new approach and is central to initiating an understanding of the overall context of this chapter. In other words, besides knowing the impact of ICs as a whole, it is important to know if the different characteristics of core and supplementary ICs lead to different results in terms of business performance. Thus, hypotheses H1 and H2 are as follow:

H1 Core ICs positively impact business performance.
H2 Supplementary ICs positively impact business performance.

As discussed earlier, due to the complexity of the innovation process, to the growing importance of SCM and to the intrinsic relation between innovation and SC, it is expected that SC strategies impact the relationship between ICs and business performance. Considering the characteristics of each type of innovation capability and SC strategy, four different combinations are discussed below: (1) core ICs and lean SC strategy; (2) core ICs and agile SC strategy; (3) supplementary ICs and lean SC strategy; and (4) supplementary ICs and agile SC strategy.

6.2.3.1 Core ICs and Lean SC strategy

Core ICs and lean SC strategy share a set of characteristics and principles, as both represents a certain degree of stability and continuity of the status quo within firms. Lean strategies aim to create efficient supply chains, in terms of costs, focusing on the improvement of the efficiency of processes and on the elimination of waste. This strategy fits well with stable and predictable demand with products and processes streamlined to enable the organization to satisfy current customers' needs (Christopher & Towill, 2002; Qi et al., 2009; Qrunfleh & Tarafdar, 2014).

Core ICs are represented by marketing, manufacturing and R&D capabilities. Manufacturing capabilities are related to the consistency of the manufactured product quality and the employment of advanced technologies compared to competitors (Guan & Ma, 2003). The fit between manufacturing capabilities and a lean SC can favour the development of exploitation innovation activities, as both can focus on incremental improvements for existing products and processes, which also generates a positive effect on business performance.

Marketing capabilities indicate the firms' capacity to segment and target specific markets and to utilize marketing tools (product design, pricing, advertising) to differentiate products on the basis of understanding consumers' current and future needs, customers' access approaches, and competitors' knowledge. Firms tuned to exploitation innovation activities in which market needs can lead to incremental improvements in products and processes tend to favour lean SC strategies.

Although R&D capability is related to innovation, it also works as a process that requires stability and represents the mainstream activities. It is expected that R&D capabilities are tuned to lean SC strategy when firms favour the development of products and processes that need to be adapted to the constant changes of the demand. As such, firms' exploitation of innovative activities is more tuned to firms deploying lean SC strategies.

In this sense, it is expected that lean SC strategy moderate the relationship between core ICs and business performance, especially when it comes to exploitation of innovative activities. Thus, H3 is as follows:

H3 Lean SC strategies positively moderate the relationship between core ICs and business performance.

6.2.3.2 Core ICs and Agile SC strategy

Agile SC strategies' main goal is to guarantee the flexibility and adaptability of the SC given the constant changes of customers' needs and of the competitive environment, using rapid, dynamic and continuous responses (Christopher & Towill, 2002; Qi et al., 2009; Qrunfleh & Tarafdar, 2014). This type of strategy seeks to adapt the organization, developing new products and processes to unique market characteristics, in order to generate and retain new competitive advantages based on constantly changing environments. The reduction in the life cycles of products leads to an increase in pressure on the SC to provide products and services quicker and in a more responsive way (Qi et al., 2009).

On the other hand, core ICs represent mainstream activities within a firm, meaning that they require (or at least fit better with) stability and short-term vision. Contrary to agile SC strategy, which is prone to adapt better to exploration of innovation activities, the adoption of core ICs favour the development of exploitation innovation activities. Thus, the fourth hypothesis is:

H4 The relationship between core ICs and business performance will not be strengthened by agile SC strategies.

6.2.3.3 Supplementary ICs and lean SC strategy

Supplementary ICs are composed by learning, resource-exploiting, organizational and strategic capabilities. Learning capabilities are related to the promotion of a learning culture that allows the identification and assimilation of new knowledge essential to the competitive success of the firm, which is reflected in the identification and application of trends within the industry and the development and acquisition of the new and necessary skills or technologies to develop new products (Guan & Ma, 2003).

Resource exploiting capabilities represent the firms' ability to mobilize and expand their technological, human and financial resources, by combining internally and externally

developed technologies while maintaining a continuous flow of financial resources for the introduction of new products on the market, also being skilled in the allocation of personnel and continually striving to improve products and processes.

Organizational capability is the capacity to constitute a well-established organizational structure; coordinate the work of all activities towards shared objectives; and influence the speed of innovation processes throughout the organization. It includes the implementation of new management techniques to improve routines and work practices and to facilitate the use and exchange of information, knowledge and skills within the company and the implementation of new organizational methods for work to better distribute responsibilities and decision-making tasks.

Strategic capability is the capacity to adopt different types of strategies that can adapt to changes in the business environment in order to excel in today's highly competitive environments. Firms with these capabilities shape their strategy formulation by a strong entrepreneurial vision and senior managers are highly capable of understanding external factors that may affect business operations and can quickly anticipate the movements of outstanding competitors and adjust strategies to these changes.

In this sense, supplementary ICs and lean SC strategy represent contrasting interests within firms and it is believed that the fit between them do not impact business performance. Thus, the following hypothesis is proposed:

H5 The relationship between supplementary ICs and business performance will not be strengthened by lean SC strategies.

6.2.3.4 Supplementary ICs and Agile SC strategy

Supplementary ICs and agile SC strategies share the same characteristics and principles as they represent the "newstream" and require flexibility and adaptability. It is expected that learning capabilities will have a good fit with agile SC strategies, as they presuppose understanding and adapting to customer requirements and need a certain degree of flexibility. Innovation exploration activities are more tuned to develop unique products and processes based on constantly changing environments, which require firms

to be tuned to an outward, opportunity-based perspective in order to keep abreast of future market perspectives.

Resource exploiting capabilities contribute to continually striving to improve products and processes. Exploration innovation activities are riskier than exploitation innovation activities as the former are tuned to the firm capacity to generate new competitive advantages for the future market needs, which involve long-term, riskier partnerships and technologies.

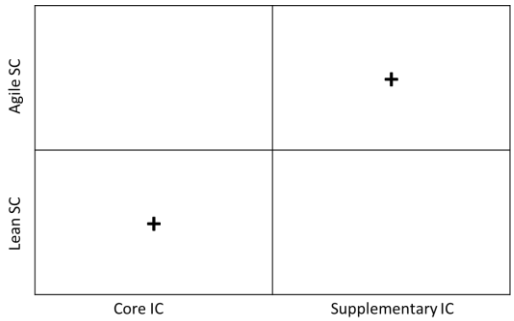
Organizational capabilities include the adoption of a flexible organizational structure to adjust to new projects focused on product or process innovation; managers' autonomy in the innovation process; strong coordination between technical (e.g., engineering, projects), sales and manufacturing departments. In this sense, flexibility and adaptability tend to be key organizational capabilities among successful firms that adopt agile SC strategies.

Strategic capabilities allow firms to shape their strategy formulation by a strong entrepreneurial vision and senior managers are highly capable of understanding external factors that may affect business operations and can quickly anticipate the movements of outstanding competitors and adjust strategies to these changes. Outwardly, innovation seeking firms have a strong connection between innovation and customers' value recognition. Thus, it is expected that strategic capabilities have a good fit with an agile SC strategy, as both presuppose a solid understanding of customers' evolving requirements and the capacity to face external environmental changes. Thus, the last hypothesis proposed represents what is expected to be the strongest moderator effect between ICs and SC strategies:

H6 Agile SC strategies positively moderate the relationship between supplementary ICs and business performance.

Due to the characteristics of each one of the ICs capabilities and SC strategies discussed above, among the four possible combinations presented, as shown in Figure 18, two are expected to impact business performance – core and lean; supplementary and agile, and two are expected to not impact business performance – core and agile; supplementary and lean.

Figure 18 - Different combination of ICs and SC strategies



6.3 Research methodology

6.3.1 Questionnaire development

A survey instrument was developed to test the research model. Krause et al. (2018) highlight the use of survey research when theory testing is the primary goal of SCM operations management researchers. To ensure its reliability, the first version of the questionnaire was developed and reviewed by knowledgeable researchers of operations management and SCM. Two potential respondents were also interviewed to ground the research and provide appropriate focus for survey development. This version, designed in English, was translated into Portuguese, and then translated back to English. The back-translated English version was then checked against the original English version.

The questionnaire was then pilot-tested in five companies in Portugal and five companies in Brazil – although the items and questions in the questionnaire were adopted from previous published studies, the pilot-test is considered an important part of the process. The respondents were asked to complete the questionnaire and provide comments on the understandability and clarity of the items. Some of the minor modifications suggested by the respondents were made based on this pilot study. After these changes, the final version was reviewed by two academic experts and was ready to be sent in a large sample for data collection.

The combination of the two interviews, specialists review, the translation to Portuguese, back translation to English, and pilot testing provides important evidence to support reliability and validity of measurement in research (Zhao, Flynn, & Roth, 2007).

A set of items – divided in dependent variables, independent and moderator variables and control variables – was identified from the literature for measuring the constructs of the research model.

6.3.1.1 Dependent variable

Business performance was measured following Gonzalez-Benito (2007). Five items were included to measure the commercial success of the firm and three items refer to ratios based on accounting data and related to the economic benefits and productivity of the company. The respondents were asked to value company performance in comparison with their competitors for each of the aspects on a seven-point Likert scale (1 = lower, 4 = equal, 7 = higher). The items measured were: sales growth, reputation and image, customer satisfaction, market share (of the main product), success of new product launches (commercial success), return on investment (ROI), profits as percent of sales, and labour productivity (economic and productivity performance).

6.3.1.2 Independent and moderator variables

ICs were based on the seven capabilities proposed by Guan and Ma (2009). Core and supplementary capabilities were analysed as second order constructs: R&D capabilities, marketing capabilities, manufacturing capabilities (core ICs), learning capabilities, resource exploiting capabilities, organizational capabilities, and strategic capabilities (supplementary ICs). The questions were based on the items proposed by Guan and Ma (2009) and Oura, Zilber and Lopes (2016). The respondents were asked to classify each of the statements in a seven-point Likert scale with 1 = strongly disagree and 7 = strongly agree.

SC strategies (moderator variable) were measured adapting the items used by Qi et al. (2009) which, in turn, are based on a variety of sources, including Katayama and Bennett (1996), Yusuf et al. (1999), Naylor, Naim and Berry (1999), Christopher (2000), Mason-Jones et al. (2000), and Heikkial (2002). Several statements that describe the characteristics of lean and agile supply chain were listed and the respondents were asked to answer the question: "to what extent do you agree that the supply chain of your company's major product/product mix has the following characteristics?" The

measurement scales employ a seven-point Likert scale with 1 = strongly disagree and 7 = strongly agree.

6.3.1.3 Control variables

Firm size and environmental uncertainty were considered the control variables. Firm size (number of employees) can impact the resources a firm has available for implementing initiatives, as well as the firm's profitability (Gligor, 2016). Previous research has also found that innovation performance and business performance might benefit from economies of scale and scope (Fosfuri & Tribo, 2008).

Environmental uncertainty was measured as proposed by Dess and Beard (1984). Environmental uncertainty helps to understand the impact of business environment on the context of SC and innovation – and consequently on the fit between them. It is expected that the greater the uncertainty of the environment (reflected in environmental munificence, environmental dynamism, and environmental complexity), the greater the influence of SC strategies over the relationship. Aldrich (1979) and Dess and Beard (1984) classify environmental uncertainty in three dimensions: environmental munificence, environmental dynamism, and environmental complexity. Environmental munificence refers to the extent to which the environment can support sustained growth. Environmental dynamism refers to the extent that the environment in which the firm competes is characterized by changes that are hard to predict and that heighten uncertainty for key organizational members. Environmental complexity refers to the complexity of the environment, measured by the extent that the environment in which the firm competes is characterized by great uncertainty and a great information-processing requirement (Dess & Beard, 1984). The respondents were asked to indicate their opinion on the statements concerning the business condition of the company in a seven-point Likert scale with 1 = strongly disagree and 7 = strongly agree.

6.3.2 Universe of the research - target sample

The sample population was composed by firms operating in Portugal and Brazil. The choice of the two countries aimed to enrich the analysis and was based on the distinct characteristics of these economies. The same approach is used by Mani and Gunasekaran

(2018) and Gimenez, Van der Vaart and Van Donk (2012). Brazilian firms were selected from two of the most industrialized states – São Paulo and Santa Catarina.

The data bases provided by Neoway in Brazil and Bureau Van Dijk in Portugal (both big data companies which collect and provide information from firms) were used to randomly select the final sample (to whom the questionnaire was sent), composed by 1.000 firms in Portugal and 1.000 firms in Brazil. The sample encompasses firms from various sectors, including automotive, construction and materials, electronic and electrical equipment, food and beverages, machinery and plant construction, pharmaceuticals and biotechnology and textiles and apparel.

6.3.3 Data collection

The questionnaire was introduced in the online platform Lime Survey. To determine the most appropriate respondents, the researchers identified (by e-mail and/or phone calls) the managers who would be most knowledgeable about the firm's SC strategies and ICs. Following the guidelines proposed by Boyer and Verma (2000) and Craighead, Ketchen Jr. and Dunn (2011) and the principles discussed by Krause, Luzzini and Lawson (2018) and Flynn, Pagell and Fugate (2018), the questionnaire was designed to be answered by two respondents in each firm: the first part by a SC manager, the second part by an innovation manager and the third part (related to business performance) by both. The firms which had uncompleted answers were discarded. The most common functional responsibilities of the respondents included: operations director/manager; purchasing director/manager; supply-chain director/manager; and innovation and new product development director/manager.

An email inviting the selected respondents to answer was sent with a cover letter explaining the purpose and intention of the survey and promising anonymity as a way to increase participation. Follow-up emails and phone calls were done to improve the response rate. The data collection took five months, from September 2017 to January 2018 and totalized 329 responses – 179 from Portugal and 150 from Brazil. The return rate was 16.5% (17.9% in Portugal and 15.0% in Brazil). Specifics of samples composition are presented in Table 26.

Table 26 – Sample composition

Variable	Portugal		Brazil		Total	
	Number	**%**	**Number**	**%**	**Number**	**%**
Number of responses	179	54.2%	150	45.5%	329	100.0%
Response rate	17.9%		15.0%		16.5%	
Number of employees	**Number**	**%**	**Number**	**%**	**Number**	**%**
< 50	10	5.6%	10	6.7%	20	6.1%
50 – 100	19	10.6%	27	18.0%	46	14.0%
101 – 500	69	38.5%	68	45.3%	137	41.6%
501 - 1000	43	24.0%	19	12.7%	62	18.8%
> 1000	38	21.2%	26	17.3%	64	19.5%
Total	179	100.0%	150	100.0%	329	100.0%
Industrial Sector	**Number**	**%**	**Number**	**%**	**Number**	**%**
Food and beverages	42	23.5%	26	17.3%	68	20.7%
Automotive and parts	40	22.3%	15	10.0%	55	16.7%
Construction and materials	17	9.5%	14	9.3%	31	9.4%
Machinery and plant construction	8	4.5%	15	10.0%	23	7.0%
Industrial metals	9	5.0%	13	8.7%	22	6.7%
Textiles and apparel	10	5.6%	11	7.3%	21	6.4%
Household goods and personal care	9	5.0%	11	7.3%	20	6.1%
Chemical	9	5.0%	10	6.7%	19	5.8%
Electronic and electrical equipment	7	3.9%	8	5.3%	15	4.6%
Forestry and paper	6	3.4%	5	3.3%	11	3.3%
Pharmaceuticals and biotechnology	6	3.4%	5	3.3%	11	3.3%
Electricity	5	2.8%	5	3.3%	10	3.0%
Oil and gas	4	2.2%	4	2.7%	8	2.4%
Medical equipment	1	0.6%	3	2.0%	4	1.2%
Mining	2	1.1%	2	1.3%	4	1.2%
Technology hardware and equipment	2	1.1%	2	1.3%	4	1.2%
Aerospace	2	1.1%	1	0.7%	3	0.9%
Total	179	100.0%	150	100.0%	329	100.0%

6.3.4 Nonresponse and common-method bias

Following Mentzer and Flint (1997), nonresponse bias was assessed by contacting a random sample of 30 nonrespondents (15 in Portugal and 15 in Brazil) and asking them to respond a set of non-demographic questions. No statistical difference was found between the answers of respondents and nonrespondents. Nonresponse bias was also tested by

examining the differences between early (n = 198) and late respondents (n = 131), based on the premise that late respondents are similar to nonrespondents, because their replies took the most effort and the longest time. The differences in the means and factor loadings were not significant for the constructs analysed. These results indicate that nonresponse bias does not appear to be a concern in the present study.

To minimize potential common-method bias, some procedural and statistical methods were implemented. As procedural method, the questionnaire was answered by two respondents in each firm. SC managers were asked to answer the questions related to SC strategies and innovation managers the questions related to ICs. Both SC and innovation managers were asked to answer the questions related to business performance (part 3 of the questionnaire). Afterwards, the answers of part 3 were compared, ensuring the reliability of the information. When huge differences between the answers were find, the respondents were contacted again. Secondary data were used to triangulate survey data – this approach limit the risk of common method bias and enhance causal inference by reducing the likelihood of rival method-based explanations (Montabon, Daugherty, & Chen, 2017). Bureau Van Dijk and Neoway databases (in Portugal and Brazil respectively), as well as sectorial and firms' websites (when available) were used to collect archival data on the firms in the sample. The results showed no significant difference in demographic information among all participating firms.

Complementarily, the respondents' anonymity was protected, the respondents were assured that there were no right or wrong answers and items ambiguity were reduced during the pilot test.

6.4 Results and discussion

6.4.1 Measurement properties

Reliability and validity were assessed by means of the evaluation of the measurement models. Construct reliability was measured by using Cronbach's α and composite reliability. The average variance extracted (AVE) criterion was used to evaluate convergent validity. Table 27 shows that most of the item loadings were greater than 0.7, apart from eight items where loadings were >0.6, which were also accepted (Hair, Black,

Babin, & Anderson, 2010). The values of Cronbach's α and composite reliability (ρ) exceeded 0.8 in all constructs, indicating acceptable construct reliability (Hair et al., 2010; Peng & Lai, 2012). All AVE values were above the recommended value of 0.5, indicating convergent validity at the construct level (Peng & Lai, 2012).

Table 27 - Confirmatory factor analysis and reliability and validity of the constructs

Supply chain strategies			**Mean**	**Standard deviation**	**Factor loading**	**Cronbach's α**
Lean		AL1	4.980	1.680	0.762	
		AL2	4.870	1.624	0.719	
		AL3	4.840	1.643	0.794	
		AL4	5.120	1.733	0.788	0.837
		AL5	4.680	1.680	0.615	
		AL6	5.640	1.219	0.697	
		AL7	4.730	1.456	0.601	
Agile		AA8	4.890	1.498	0.672	
		AA9	4.770	1.337	0.764	
		AA10	4.610	1.403	0.641	
		AA11	4.880	1.660	0.740	0.849
		AA12	4.860	1.336	0.760	
		AA13	4.640	1.546	0.757	
		AA14	4.060	1.572	0.744	
Innovation capabilities			Mean	Standard deviation	Factor loading	Cronbach's α
Core	R&D	BR1	4.960	1.756	0.815	
		BR2	5.380	1.325	0.779	
		BR3	5.060	1.502	0.848	
		BR4	4.630	1.683	0.810	
	Marketing	BMK5	5.440	1.313	0.609	
		BMK6	4.790	1.807	0.729	
		BMK7	4.280	1.670	0.851	0.880
		BMK8	4.080	1.805	0.855	
		BMK9	3.820	1.784	0.892	
	Manufacturing	BM10	5.960	1.084	0.804	
		BM11	5.220	1.686	0.652	
		BM12	5.750	1.224	0.702	
		BM13	4.670	1.545	0.641	
Supplementary	Learning	BL14	5.220	1.394	0.765	
		BL15	5.200	1.404	0.864	
		BL16	4.990	1.294	0.892	
		BL17	5.030	1.274	0.870	
		BL18	4.910	1.277	0.867	
	Organizational	BO19	5.050	1.341	0.719	
		BO20	5.000	1.455	0.809	
		BO21	4.990	1.450	0.828	0.950
		BO22	5.120	1.345	0.865	
		BO23	5.090	1.325	0.860	
	Resource exploiting	BRE24	5.080	1.321	0.721	
		BRE25	5.260	1.440	0.588	
		BRE26	4.990	1.391	0.832	
		BRE27	5.570	1.025	0.839	

Supply chain strategies			**Mean**	**Standard deviation**	**Factor loading**	**Cronbach's α**
		BRE28	5.460	1.173	0.803	
	Strategic	BS29	5.350	1.337	0.864	
		BS30	5.530	1.302	0.870	
		BS31	5.140	1.360	0.878	
		BS32	5.150	1.310	0.806	
Business performance			Mean	Standard deviation	Factor loading	Cronbach's α
Commercial		DC1	4.820	1.118	0.725	
		DC2	5.500	1.228	0.859	
		DC3	5.400	1.124	0.764	0.803
		DC4	4.900	1.457	0.730	
		DC5	4.760	1.262	0.679	
Economic and productivity		DF6	4.650	1.289	0.894	
		DF7	4.580	1.259	0.897	0.806
		DF8	4.770	1.221	0.751	

Convergent and discriminant validity									
	CR	**AVE**	**MSV**	**MaxR(H)**	**1**	**2**	**3**	**4**	**5**
BusPerf (1)	0.929	0.883	0.099	1.604	**0.940**				
Lean (2)	0.812	0.590	0.104	0.814	0.121	**0.768**			
Agile (3)	0.811	0.518	0.129	0.814	0.138	0.323	**0.720**		
Core (4)	0.894	0.745	0.593	0.994	0.230	0.042	0.326	**0.863**	
Supplementary (5)	0.912	0.724	0.593	0.926	0.315	0.110	0.359	0.770	**0.851**

Note: n = 329, Reliability coefficients are presented along the diagonal.

The fit indices of the structural model are satisfactory ($p < 0.001$, IFI = 0.916, TLI = 0.908, CFI = 0.915 and RMSEA = 0.055), providing support for the nomological validity of the hypothesized structural model.

Moreover, as two different samples were collected, one from Portugal and other from Brazil, Schuirmann's two one-sided tests (TOST) for equivalence (Schuirmann, 1987) was applied and showed that there was no significant difference in their means.

6.4.2 Hypotheses testing

Linear regression analysis was used to test hypothesis H1 and H2. According to the findings, ICs have a positive effect on business performance. The results obtained supported hypothesis H1 ($\beta = 0.20$; $p < 0.001$), that core ICs positively impact business performance, and H2 ($\beta = 0.29$; $p < 0.001$), that supplementary ICs positively impact business performance.

Hierarchical regression analysis (Aguinis & Gottfredson, 2010; Arnold, 1982; Gonzalez-Benito, Lannelongue, Ferreira, & Gonzalez-Zapatero, 2016; Sharma, Durand, & Gurarie, 1981) was used to test hypotheses H3 to H6, which concern the four possible moderator effects of SC strategies over the relationship between ICs and business performance (models 3 to model 6). The interpretation for the overall relationships tested in the hypotheses focused on the change in R^2 in the last block – when adding the interaction effect. If change in R^2 is statistically significant, the overall relationship for all independent variables will be significant as well.

Business performance was considered the dependent variable. The control variables firm size and environmental uncertainty (environmental munificence, environmental dynamism, and environmental complexity) were placed as independent variables (predictors) in blocks one and two respectively. ICs and SC strategies were added in block three, alternating the different combinations – core x lean; core x agile; supplementary x lean; supplementary x agile. Finally, the interaction effect was added in block four (again according to each combination of ICs and SC strategies).

Model 3 tested the effect of lean SC strategy on the relationship between core ICs and business performance. The change in R^2 was not significant (0.375) when adding the interaction effect, meaning that hypothesis H3, that lean SC strategy positively moderate the relationship between core ICs and business performance, was not statistically supported by the data.

The data supported H4 (significance of change in R^2 = 0.197), which means that there are no evidences that agile SC strategy moderate the relationship between core ICs and business performance, and H5, that lean SC strategy do not moderate the relationship between supplementary ICs and business performance (significance of change in R^2 = 0.259).

On the other hand, when adding the effect of interaction between supplementary ICs and agile SC strategy to the model, an improvement in business performance is observed, supporting H6 (significance of change in R^2 = 0.034). Table 28 presents a summary of the results.

Table 28 – Summary of the regression analysis and hierarchical regression analysis

Variables	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**
Firm size	0.000	0.000	0.000	0.000	0.000	0.000
Env. munificence	0.065**	0.022**	0.460**	0.059**	0.022**	0.026**
Env. dynamism	0.001	0.019	0.003	0.002	-0.001	-0.002
Env. complexity	-0.007	0.019	-0.008	-0.033	-0.002	-0.022
Core	0.196*		0.178*	0.179*		
Supplementary		0.290*			0.228*	0.248*
Lean			0.115*		0.103*	
Agile				0.077*		0.052*
Core x Lean			-0.019			
Core x Agile				0.026***		
Supp. x Lean					-0.023	
Supp. x Agile						0.041***
R^2	*0.233*	*0.300*	*0.302*	*0.253*	*0.356*	*0.316*
Adjusted R^2	*0.221*	*0.289*	*0.286*	*0.237*	*0.341*	*0.301*
Change in R^2			*0.002*	*0.004*	*0.003*	*0.010*
Sig. change in R^2			*0.375*	*0.197*	*0.259*	*0.034*

Notes: n = 329; Unstandardized regression coefficients are reported; Change in R^2 reports results of the last block, after the inclusion of the interaction effect. *p < 0.001; **p<0.01; *** p<0.05

Among the control variables, environmental munificence has proven to be the most significant in the six models. The results do not show that the other control variables – firm size, environmental dynamism and environmental complexity – influence the relationships tested.

6.4.3 Discussion

H1 and H2 were supported through regression analysis. The findings confirm previous studies on the impact of ICs on business performance (Borjesson & Elmquist, 2011; Calantone et al., 2002; Mir et al., 2016; Saunila et al., 2014), and contribute to deepen the knowledge through the test of the impact of core and supplementary ICs separately. According to the results, supplementary ICs have a slightly higher impact on business performance than core ICs (β = 0,29 and 0,20 respectively), although the findings are robust in both cases.

Core ICs are more related to exploitation and supplementary ICs are more related to exploration. The differences in the results of supplementary ICs' impact on business performance compared to core ICs' can be explained: by the often greater potential of exploration activities to positively impact business performance (Kavin & Narasimhan, 2018; Wang, Van de Vrande, & Jansen, 2017); and by a greater contribution of supplementary ICs to exploitation, compared to the contribution of core ICs to exploration. As exploitation refers to incremental improvement made to existing products or processes using currently available technologies or competencies (March, 1991; Uotila, 2017), the existence of some of the supplementary ICs can help to achieve this aim, especially learning capabilities (Guan & Ma, 2003), which contribute to refining existing business activities. On the other hand, exploration concerns the capacity to meet completely new knowledge and opportunities (March, 1991; Uotila, 2017), requiring flexibility and adaptability, characteristics weakly related (or even unrelated) to core ICs (Swink, 2006).

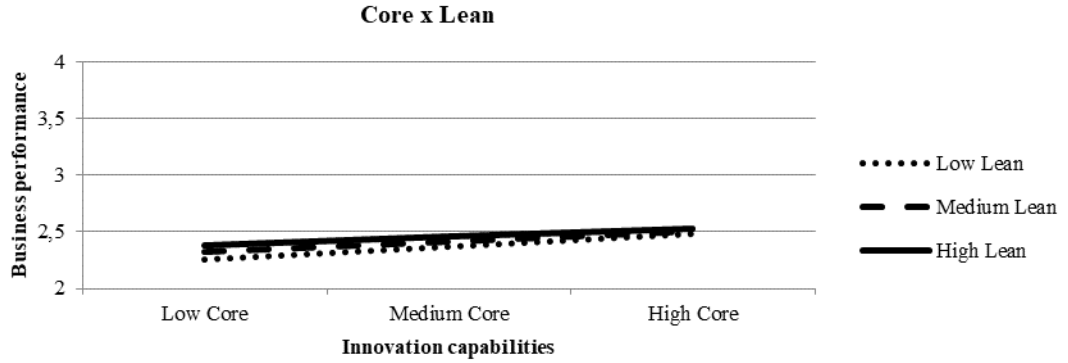
These results can also be explained by the lens of RBV, to which different resources generate different results. According to RBV, firms must seek to develop a set of characteristics that are valuable, rare, inimitable and no substitutable (Barney, 1991; Hong,

Doll, Revilla, & Nahm, 2011; Laosirihongthong, Prajogo, & Adebanjo, 2014), which are characteristics more easily related to supplementary ICs than core ICs.

When it comes to the moderator effect of SC strategies on the relationship between ICs and business performance, H3, H4, H5 and H6 were tested. As discussed in the literature review section, the relationship between core ICs and lean SC strategies was expected to impact business performance (H3) as they share some characteristics and principles. Both require stability and consistency and match with stable and predictable environments (Guan & Ma, 2003; Qrunfleh & Tarafdar, 2014) and are much more suitable for exploitation than exploration.

However, H3 was not supported by the data. This can be explained by the different degree of stability of markets and technologies they need. While core ICs, especially R&D, admit – and even can be favoured by – some degree of "novelty", lean SC strategies hardly adapt to turbulence (Christopher & Towill, 2002). Moreover, firms that focus on lean strategy aim to increase the efficiency (Qi et al., 2009) and, at same time, tend to present relatively low levels of ICs compared to firms that adopt agile SC strategy. That supports the idea that innovation (especially explorative innovation activities/radical innovation) is not treated as a priority for this group and that an improvement on the level of lean SC strategy (low, medium or high) does not strengthen significantly the positive relationship between core ICs and business performance, as shown in figure 19.

Figure 19 - Impact of lean SC strategy on the relationship between core ICs and business performance

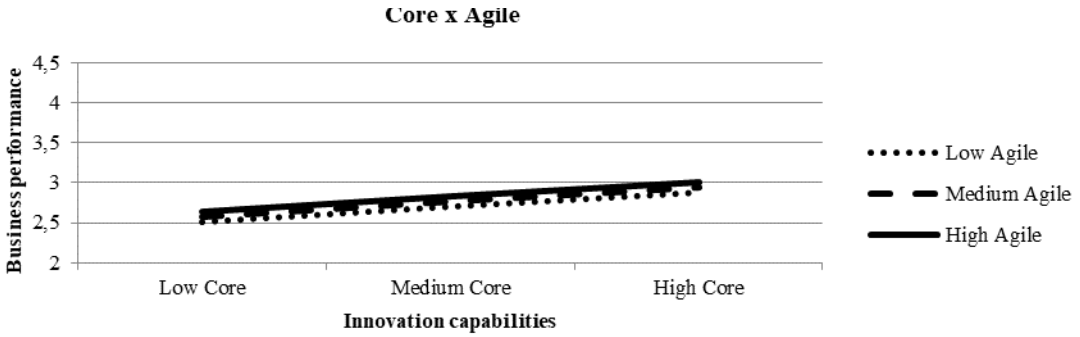


On the other hand, firms where agile SC strategy is employed value flexibility and adaptability aiming to adapt the organization, developing new products and processes to

unique market characteristics, to generate and retain new competitive advantages based on constantly changing environments (Qi et al., 2009; Qrunfleh & Tarafdar, 2014). Based on the literature review, it was expected that the relationship between core ICs and business performance would not be strengthened by agile SC strategies (H4), as their characteristics represent contrasting interests and priorities, which was supported by the data.

It can also be argued that core ICs are the costliest capacities to be created and developed as they are strongly related to important functions and areas within firms (Guan & Ma, 2003). Similarly, the adoption of agile SC strategy requires a high level of commitment by the different areas and functions within a firm. Thus, in a sense, core ICs and agile SC strategy compete for the same resources within a firm, which are finite. Figure 20 shows that agile SC strategy does not impact significantly the relationship between core ICs and business performance, as the three lines (low, medium and agile) are very close and present very similar behaviour.

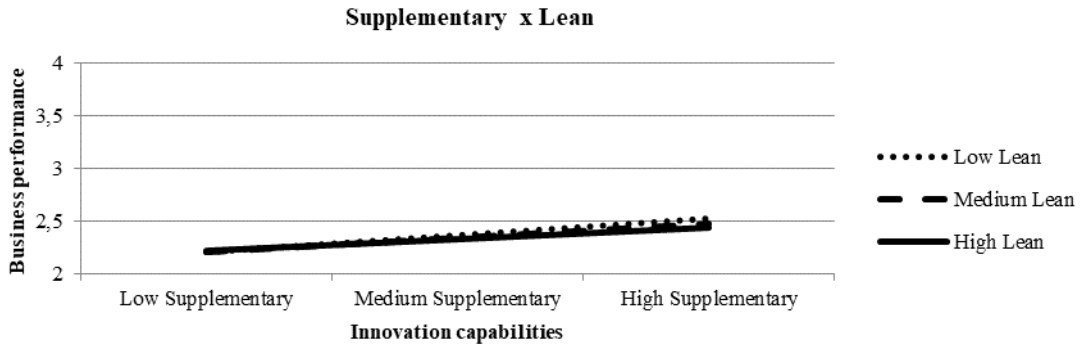
Figure 20 - Impact of agile SC strategy on the relationship between core ICs and business performance



H5 deals with the impact of lean SC strategy on the relationship between supplementary IC and business performance. Similarly to H4, supplementary ICs and lean SC strategy represent conflicting interests within firms. On one hand, supplementary ICs require flexibility and adaptability (Guan & Ma, 2003) and, on the other, lean SC strategy asks for stability and predictability (Qi et al., 2009). The data support H5, meaning that lower or higher degree of lean SC strategy does not generate significantly different results in the relationship between supplementary ICs and business performance. Figure 21 shows

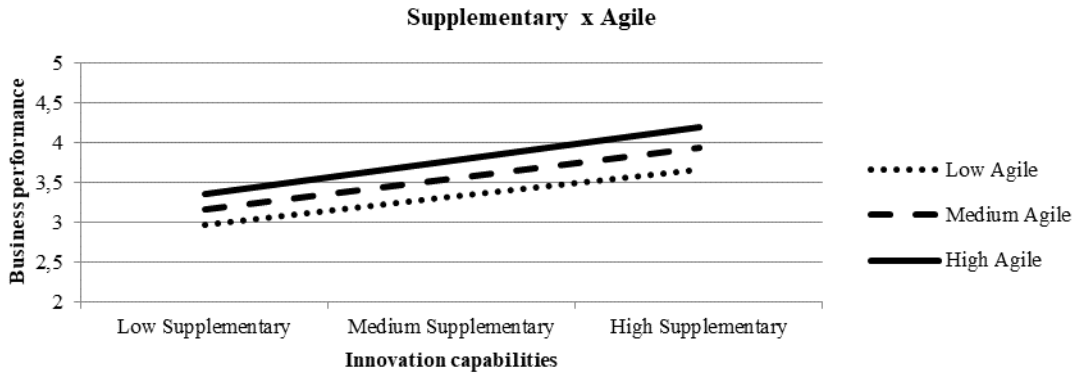
that the three lines representing different levels of lean have practically the same behaviour.

Figure 21 - Impact of lean SC strategy on the relationship between supplementary ICs and business performance



Finally, as expected and discussed in the literature review, the tests supported H6, highlighting that agile SC strategies strengthen the positive relationship between supplementary ICs and business performance. It can be said that supplementary ICs and agile SC strategy require the same kind of organizational culture, what makes the relationship between them natural. Both are related to "newstream" activities or processes, favouring flexibility, adaptability and innovation (Guan & Ma, 2003; Qi et al., 2009; Qrunfleh & Tarafdar, 2014). Figure 22 shows that a higher level of agile SC strategy contributes to higher business performance.

Figure 22 - Impact of agile SC strategy on the relationship between supplementary ICs and business performance



6.5 Implication and conclusions

Grounded on RBV, the main objective of this study was to understand how SC strategies affect the relationship between ICs and business performance. RBV supports the discussion due to its potential to help to: (1) understand the characteristics that lead to better business performance; (2) compare business performance based on observable characteristics; and (3) explain the antecedents of innovation (Prajogo, 2016). The chapter offers several theoretical and managerial contributions.

The study expands the knowledge on the impact of ICs on business performance, previously approached by several authors (Borjesson & Elmquist, 2011; Calantone et al., 2002; Mir et al., 2016; Saunila et al., 2014), by analysing the effects of core and supplementary ICs separately. The data analysed supported the hypotheses that both types of ICs have positive effect on business performance, even though supplementary presented a slightly superior impact. The circumstances and consequences of having different types of ICs capabilities have not been studied before.

The relationship between the different types of ICs and SC strategies and the effects of their interactions on business performance was assessed and discussed using data from an empirical study on a sample of 329 companies from Portugal and Brazil. Results obtained from hierarchical regression analysis method confirmed three of the four hypotheses tested, showing that the relationship between supplementary ICs and agile SC strategy (H6) produces the main positive effect on business performance. As hypothesized, the relationship between the most contrasting ICs and SC strategy – namely core x agile (H4); and supplementary x lean (H5) – do not impact business performance, once they represent conflicting characteristics, interests and priorities. As showed in figures 4 and 5, in these cases, the level of SC strategies (low, medium or high) is practically indifferent in what concerns the relationship between ICs and business performance. Finally, contrary to previous expectations, the moderator effect of lean SC strategy on the relationship between core ICs and business performance (H3) was not supported by the data. It can be explained by the different degree of stability of markets and technologies they need and by the relative low priority of innovation activities among firms with lean SC strategies.

While making significant contributions to research and practice, there are several limitations of the study and future research directions that worth mentioning. The study presents some limitations related to the method used. The results are based on survey research with a limited sample size of 329 respondents and geographic coverage (Portugal and Brazil), which may limit the interpretation and generalization of the results and conclusions. In future researches this study could be extended to other countries. To minimize limitations related to the development and validity of the measurement procedures and to nonresponse and common-method bias, the authors adopted a set of rigorous methods.

The research scope is limited to investigating the influence of SC strategies on the relationship between ICs and business performance, leaving opportunities for further research adding new features such as innovation strategies (as independent variables), product characteristics, supply chain fit (as moderators) and innovation performance (as dependent variables). The importance of cultural characteristics and the role of ambidexterity are two other topics which can also be studied in the future, helping to improve the understanding of the circumstances that lead to a better or worst fit between ICs and SC strategies.

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CONCLUSIONS

This section aims to present the main conclusions of the thesis as well as the contributions to theory and practice, the limitation of the study and some recommendations for future research.

Innovation and supply chain management are two important topics which have attracted considerable attention from managers and researchers recently – separately and together. At the same time that both fields are becoming more and more relevant, the perception of the importance of the link between them has increased in the last few years. This study started by exploring this relationship, aiming to understand the aspects that are part of this complex relation. The literature on this relationship was thoroughly analysed in chapter one and two, allowing a new perspective on the topic.

The systematic literature review presented in chapter 1 and the analysis of the intellectual structure of the topic presented in chapter 2 demonstrated the complexity of the relationship between innovation and supply chain and highlighted the timeliness and the embracing character of the topic. The collaborative nature of the innovative process, that encompass internal and external aspects of the organisation, as well as the increasing complexity of business environments, help to explain the growing number of studies regarding the relationship between innovation and supply chains. As mentioned in chapters 1 and 2, the main reason to collaborate with other supply chain actors is to gain access to resources not available internally, in particular knowledge, making the relationships among actors of the supply chain a potentially facilitators of innovation.

From the systematic literature review, a set of facilitators to the innovation process was identified: building trust relationships, facility and/or frequency of information sharing, shared decision-making, integration of information systems, compatibility of technologies used by partners, cooperative behaviour of all actors and the efficient management of supply chains, including their resilience. Moreover, five innovation strategies were detected regarding the way firms manage the innovation process throughout the supply chain: (1) partnerships for specific purposes; (2) projects coordinated by the client firm; (3) the integration of both – new products and processes development between actors in the supply chain; (4) the strategic alignment between

actors in the supply chain and (5) open innovation strategy. The analysis of previous studies indicated that the integration for the development of new products and processes, the strategic alignment and open innovation are the three strategies that tend to lead the best performance.

Chapter 2 complemented chapter 1 showing the different ways that the relationship between innovation and supply chain management is approached in the literature. The intellectual base of the field was identified, composed by 35 studies that can be divided in four clusters regarding their main focus: (1) the structural characteristics of the supply chain network; (2) supply chain trust and collaborative advantage; (3) the importance of supplier and customer long term integration; and (4) new trends on the topic.

Moreover, from the conclusions of part 1, it was also possible to recognize the importance of the alignment between the processes of innovation and supply chain management within firms. A set of internal features of firms that are important to potentiate innovation were identified: absorptive capacity, supply chain strategy, innovation strategy, innovation capabilities and information systems capacity. From this perception, supply chain strategy, innovation strategy and innovation capabilities were addressed in the later chapters in a strategic fit perspective.

The second part of the thesis aimed to develop theory on the link between supply chain strategies and innovation strategies (chapter 3) and between supply chain strategies and innovation capabilities (chapter 4), providing research propositions and the theoretical model to orientate the empirical part of the study. Both chapters theoretically indicate the importance of aligning supply chain and innovation features as a way to improve performance.

In chapter 3, the discussion on the possible combinations of innovation and supply chain strategies suggested that the adoption of the various types of innovation strategies influence business performance, suggesting that the two areas are more interrelated than originally thought. Moreover, the discussion also suggests that supply chain strategies moderate the relationship between innovation strategy and business performance. Similarly, the possible combinations between innovation capabilities and supply chain strategies and the expected effects of these combinations were analysed in chapter 4. The

discussion suggested that different combinations of innovation capabilities and supply chain strategies lead to different business performance. The chapter presented a set of research propositions and a theoretical model.

The complex and dynamic nature of both processes was also discussed in part two, showing that innovation strategies/capabilities and supply chain strategies must be constantly re-evaluated according to internal and external changes. Considering the uncertainties that characterise the business conditions and the variety of processes and products within firms, it was also possible to conclude that different strategies and capabilities can coexist in a single firm. The resource-based view and the contingency theory were used in this part of the thesis to provide theoretical foundations to the discussion and to the development of theory related to the effect of SC strategies on the relationship between innovation strategies/capabilities and business performance.

The conclusions of parts one and two guided the development of the empirical part of the thesis. The choice of innovation capabilities in this phase, rather than innovation strategies, was mainly due to the perception that the concept of innovation capabilities is more clearly established in the literature, providing more references to its test. Moreover, innovation capability is a more complex concept, allowing deepest and more interesting discussion and findings.

However, before testing its moderator effect on the relationship between innovation capabilities and business performance, it was important to explore the nature and the implications of the different supply chain strategies according to different conditions. The results of the cluster analysis developed confirmed previous studies (especially Qi et al., 2009), showing that four types of strategies are adopted by the firms: lean, agile, leagile and traditional. Different characteristics of each type of strategy were empirically tested and discussed, highlighting that: firms with functional products tend to adopt a lean strategy and firms with innovative products adopt an agile strategy; firms with traditional and leagile SC strategy present both functional and innovative products in a similar degree; firms that compete in more dynamic and complex environments tend to adopt an agile supply chain strategy, while environmental munificence does not influence the supply chain strategy choice; firms that adopt a leagile SC strategy present better financial,

commercial and productivity and innovation performance, while traditional SC strategy leads to the worst results.

The results of chapter 5 provided the necessary background that allowed the development of the final research model in chapter 6, where SC strategies act as moderators of the relationship between innovation capabilities and business performance. First, the results showed that innovation capabilities – core and supplementary – positively impact business performance, deepening the knowledge on the topic by analysing both capabilities separately. Then, the combinations of core and supplementary innovation capabilities with lean and agile SC strategies were analysed by means of hierarchical regression analysis. The results demonstrate that: the relationship between supplementary innovation capabilities and agile SC strategy tend to produce the main positive effect on business performance; the relationship between the most contrasting innovation capabilities and SC strategy – core x agile; and supplementary x lean – do not impact business performance, once they represent conflicting characteristics, interests and priorities; lean supply chain strategy does not moderate the relationship between core innovation capabilities and business performance (contrary to the expectations).

In short, the main conclusions of the thesis can be divided into three aspects:

(1) From the literature review and from the conceptual theory building it was possible to understand the complexity, the importance and the dynamic nature of the relationship between innovation and supply chain management and to demonstrate the different ways that this relation is managed within firms and is addressed in the literature;

(2) Supply chain strategies are important features within firms that are influenced by several aspects (such as products' characteristics and environmental uncertainty) and have great potential to contribute to performance improvement when "correctly" chosen; and

(3) Supply chain strategies moderate the (positive) relationship between innovation capabilities and business performance in different ways, according to the different characteristics of firms.

a. Contributions to theory

This study presents several contributions to theory as it addresses topics, uses methods and test hypotheses that have not been approached before. The first part of the

thesis contributes to the literature since it clearly presents what is known and what is not known about the relationship between supply chain and innovation, providing a clear "picture" of the topic. The systematic literature review, as well as the analysis of the intellectual structure of the topic, reveals several aspects of the link between the two areas still not widely explored, such as the main theories used as the basis for the studies in the area, the facilitators and barriers of the innovation process, the strategies applied to manage innovation throughout supply chains and the ways that this relation is addressed in the literature.

By conducting conceptual theory building on the fit between innovation strategies and supply chain strategies and between innovation capabilities and supply chain strategies, this thesis contributes for a strategic view of the relationship between innovation and SC, as prior studies have focused mainly on a more operational perspective. The propositions and the theoretical models that have emerged from chapters 3 and 4 contribute to theory providing new perspectives on the topic.

Chapter 5 makes a contribution to the literature on the characteristics of firms that adopt the different supply chain strategies. Although following the study of Qi et al. (2009), partially in a "replication" perspective, a combination of antecedents of supply chain strategy adoption that had not been addressed before was empirically tested considering the reality of Portugal and Brazil. This issue has been explored mainly in developed countries, especially in the United States of America, and there is no consensus on the aspects that influence the adoption of the SC strategies nor on its effects on performance. Some of the results confirmed previous studies on the topic – especially the relationship between product characteristics and SC strategies – and some added new perspectives, such as the role of environmental uncertainty and the higher performance of firms that adopt a leagile supply chain strategy.

Chapter 6 provides several contributions to theory, as it empirically addresses the topics studied before. It expands the knowledge on the impact of innovation capabilities on business performance, which was analysed before by several authors (Borjesson & Elmquist, 2011; Calantone et al., 2002; Mir et al., 2016; Saunila et al., 2014), by analysing the effects of core and supplementary innovation capabilities separately. Finally, the thesis

contributes to the theory regarding the moderator effect of supply chain strategies on the relationship between innovation capabilities and business performance, providing a new perspective on the topic. The results highlighted the relationship between supplementary innovation capabilities and agile SC strategy as the potentially most "fruitful" relation.

b. Contributions to practice

This thesis has its origins in practical issues identified by the author in his previous professional experiences, namely the difficulty that firms face in order to innovate and build sustainable competitive advantage. Therefore, the concern to contribute to practice was a constant commitment throughout the period of the development of this study.

From the analysis of the literature on the relationship between innovation and SCM, the first part of the thesis contributes to practice by identifying and presenting a set of facilitators and barriers to innovation in the context of SC and providing some ideas to stimulate this relationship and improve performance. Thus, it can be said that part one offers a framework to managers which can help to boost innovation and business performance within firms.

Based on the most important research on the field, a set of practices and strategies that can be adopted by firms and has great potential to increase performance was identified in chapter 1. Chapter 2 contributes to practice as it identified the different ways that the relationship between innovation and SCM is addressed in the literature and presented a set of ideas on how to deal with the relationship between innovation and supply chain, giving valuable information for manager in decision making regarding the adoption of practices and strategies and in the development of capabilities.

Part II aimed to develop theory focused on the internal relationship between the processes of innovation and SCM, rather than the role of SC in the innovation process, providing insights for managers regarding the alignment between innovation strategies/innovation capabilities and SC strategies. The propositions that have emerged from chapters 3 and 4 have the potential to be used as a guide by managers for decision making in the adoption of innovation strategies/capabilities and SC strategies, as well as to encourage alignment between different functional areas (besides innovation and SCM).

Thus, part II provides some insights for both innovation and SC managers who are looking to improve the global performance of their organisations.

The results of chapter 5 can be used to guide managers in the adoption of the "right" SC strategy, as it clearly demonstrates that each strategy presents a better fit with different firms' and environments' characteristics and produces different results. In this sense, firms need to adopt the proper SC strategies considering a group of features, including product characteristics and environmental uncertainty. The results show that complexity and dynamism are related to agility, while munificence is related to leanness, although in a lower degree.

Chapter 6 provide information that can help managers in the choice and development of innovation capabilities and supply chain strategies. Knowing the effects of the fit on business performance allow managers to better prioritize among the different strategies and capabilities. In this sense, managers can choose among the different capabilities according to the business conditions and according to the capabilities and strategies already developed. For instance, firms that adopt an agile approach in their supply chain can develop learning or strategic capabilities to take advantage of a better fit and, consequently, achieve better performance.

c. Limitations

The thesis presents some limitations, especially related to the methods adopted. The main limitation of part one concerns the subjectivity of the selection of works to be analysed. Although the method applied – a systematic literature review – tried to minimize this limitation, the assessment of each article is still a subjective process. The ISI Web of Science database was used to identify the most important studies on the field. Although it is one of the most important databases on the field and this criterion has been used in previous studies, it is possible that some important works may not have been included. Considering the relatively time-consuming process for publication of studies in scientific journals, studies on themes which are in vogue at the moment, such as new technologies – the Internet of Things, virtual reality, autonomous vehicles and drones – and their importance for supply chains and innovation, may not have been included as well. Moreover, considering that the cluster analysis conducted in chapter 2 was based on the

co-citation of the papers, the newest studies in the area are not included in any cluster because they were not yet co-cited at the time the analysis was conducted.

The main limitation of the second part of the thesis is related to the nature of the work, namely carrying out a literature review with the goal of developing conceptual studies. This limitation has been overcome regarding chapter 4, as the theoretical model put forward was empirically tested later.

Looking to the empirical part of the thesis, the main limitations concern the methods applied, especially in the collection of data. The survey presents a limited sample size of 329 respondents and a geographic coverage of Portugal and Brazil, which may limit the interpretation and generalization of the results and conclusions. To minimize limitations related to the development and validity of the measurement procedures and to nonresponse and common-method bias, the authors adopted a set of rigorous methods.

d. Recommendations for future research

Several recommendations for future research emerge from this thesis derived from the different chapters. The development of in-depth empirical studies about the use of different strategies and approaches to innovation applied to supply chains and about the facilitators and barriers to the innovation process is recommended from the conclusions of chapter 1. The influence of supply chains on different types of innovation (product or process, radical or incremental, etc) is also recommended for future research as it is rarely addressed in the literature. The influence of supply chains in the different phases of the innovation process has not been broadly studied yet, as well as the particularities of service companies and SMEs.

From the second part of the thesis, as the main recommendation for future research, it is possible to highlight the need of the empirical test of the research propositions provided in chapter 3 (the propositions proposed in chapter 4 were tested in chapter 6). From part III, it is possible to highlight the replication of the studies in different countries, extending the coverage of the conclusions and findings. Moreover, the inclusion of additional constructs – both in the analysis of the antecedents to the adoption of supply chain strategies and in the analysis of fit and the effect on performance – is recommended in future research.

Finally, some topics that can help to improve the understanding about the role of supply chain strategies and the circumstances that lead to a better or worst fit between innovation capabilities and SC strategies can be studied in the future, such as: ambidexterity and the trade-off between exploration and exploitation; supply chain fit (which encompasses supply and demand uncertainty and supply chain responsiveness); new technologies and their effects on SCM; global supply chain networks; among others.

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APPENDIX

APPENDIX 1

Table 29 – Appendix 1 - Articles analysed in chapter 1

Authors	Year	Journal	Theory	Factors		Approach					Context				Method					Type of Innovation		
				Facilit	Bar	PSP	PCCC	INPDP	SA	OI	Ind	Serv	Gen	SME	EQt	CS	EQl	LR	Conc	Prod	Proc	MP
Bruce, M; Moger ST	1999	Technol Anal Strateg	Not mentioned	x	x	x					x						x			x		
Kim, B	2000	Eur J Oper Res	Optimal control theory	x			x				x								x	x		
Sobrero, M; Roberts EB	2002	Res Policy	Transaction cost economics	x					x		x					x				X		
Roy S; Sivakumar K; Wilkinson IF	2004	J Acad Market Sci	Network theory and Relational view theory	x					x				x						x	x	x	
McIvor R, Humphreys P	2004	Omega	Not mentioned	x				x			x					x				x		
Kim B, Oh H	2005	Supply Chain Manag	Contingency theory	x					x		x					x				x		
Petersen K, et al	2005	J Oper Manag	Transact. cost econ, relational view theory	x				x			x				x					x	x	
Ettlie JE, Pavlou PA	2006	Decision Sci	Not mentioned	x				x			x				x					x		
Choi TY, Krause DR	2006	J Oper Manag	Transaction cost economics	x			x						x						x	x	x	x
Lau AKW, Yam RCM, Tang EPY	2007	Ind Manage Data Syst	Resource-based view	x					x		x				x					x		
Koufteros XA, Cheng TCE, Lai KH	2007	J Oper Manag	Social network theory	x				x			x				x					x		
Soosay CA, Hyland PW, Ferrer M	2008	Supply Chain Manag	Theory building process	x					x				x			x				x	x	
Tether BS, Tajar A	2008	Res Policy	Relational view theory	x				x				x			x					x	x	
Lee J, Veloso FM	2008	J Prod Innov Manag	Knowledge-based view	x				x			x				x					x		
Craighead CW, Hult GTM, Ketchen Jr DJ	2009	J Oper Manag	Resource-based view,	x					x		x				x					x		

Authors	Year	Journal	Theory	Factors		Approach					Context					Method					Type of Innovation		
				Facilit	Bar	PSP	PCCC	INPDP	SA	OI	Ind	Serv	Gen	SME		EQt	CS	EQl	LR	Conc	Prod	Proc	MP
			knowledge-based view																				
Bhaskaran RS, Krishnan V	2009	Manage Sci	Not mentioned	x	x				x		x						x				x		
Bakhshi H, McVittie E	2009	Innov:Manag Policy P	Not mentioned	x				x			x					x					x		
Panayides P, Lun Y	2009	Int J Prod Econ	Social capital theory	x				x			x					x					X		
Modi SB, Mabert VA	2010	J Supply Chain Manag	Not mentioned	x					x		x					x					x		
Pero M, et al.	2010	Supply Chain Manag	Transaction cost economics	x				x			x						x				x		
Wynstra F, et al.	2010	J Prod Innov Manag	Not mentioned Not mentioned	x				x			x					x				x	x		
Lin Y, Wang Y, Yu C	2010	Int J Prod Econ	Resource-based view	x					x		x					x					x		
Roy S, Sivakumar K	2010	J Bus Res	Knowledge-based view	x					x				x							x	x	x	x
Cao M, Zhang Q	2010	Int J Prod Econ	Relational view theory	x					x		x					x					x		
Sun H, Yau H, Suen E	2010	J. Technol. Manag. Innov	Collaboration theory	x				x			x					x					x		
Hilletofth P, Eriksson D	2011	Ind Manage Data Syst	Not mentioned	x				x			x						x		x		x		
Chong AYL, et al.	2011	Ind Manage Data Syst	Not mentioned	x					x				x			x					x		
Lau AKW	2011	Ind Manage Data Syst	Contingency theory, org learning theory, trans cost economics	x				x			x					x					x		
Johnsen TE	2011	Int J Oper Prod Man	Organisational behaviour theory	x				x			x						x				x		
Zolghadri M, et al.	2011	Int J Comput Integ M	System theory	x	x			x					x							x	x		
Wang LW, Yeung JHY, Zhang M	2011	Int J Prod Econ	Contingency theory	x	x				x		x					x					x		
Bouncken RB	2011	EMJ-Eng Manag J	Not mentioned	x				x			x					x					x	x	x

Authors	Year	Journal	Theory	Factors		Approach					Context				Method					Type of Innovation		
				Facilit	Bar	PSP	PCCC	INPDP	SA	OI	Ind	Serv	Gen	SME	EQt	CS	EQl	LR	Conc	Prod	Proc	MP
Hernández-Espallardo M, et al.	2011	Technovation	Knowledge-based view	x				x			x				x					x		
Lee KH, Kim JW	2011	Bus Strateg Environ	Not mentioned	x				x			x					x				x		
Koufteros X, Vickery SK, Droge C	2012	J Supply Chain Manag	Resource-based view	x				x			x				x					x		
Berghman L, et al.	2012	Ind Market manag	Organisational learning theory	x					x		x				x					x		
Fawcett SE, Jones SL, Fawcett AM	2012	Bus Horizons	Resource-based view and rel view theory	x					x				x				x			x		
Caridi M, et al.	2012	Int J Prod Econ	Not mentioned	x				x			x				x					x		
Hsieh KN, Tidd J	2012	Technovation	Contingency theory	x						x		x			x					x		
Jean RJ, Kim D, Sinkovics RR	2012	Decision Sci	Resource dep. theory and network theory	x					x		x				x					x	x	x
Langenberg K, et al.	2012	Int J Prod Econ	Not mentioned	x					x		x								x	x		
Hazen BT, Overstreet RE, Cegielski CG	2012	Int J Logist Manag	Diffusion of innovation theory	x					x				x						x	x		
Machikita T, Ueki Y	2012	Asian J Techol Inno	Not mentioned	x					x		x				x					x		
Bendoly E, Bharadwaj A	2012	Prod Oper Manag	Theory of complementarity	x				x			x				x					x		
Didonet SR, Díaz G	2012	J Technol Manag Innov	Not mentioned	x				x			x			x	x					x		
Salvador F, Villena V	2013	J Supply Chain Manag	Theory of modular systems	x				x			x				x					x		
Kuhne B, Gellynck X, Weaver RD	2013	Supply Chain Manag	Not mentioned	x					x		x				x					x		
Golgeci I, Ponomarov SY	2013	Supply Chain Manag	Dynamic capabilities theory	x					x		x				x		x			x	x	x
Tomlinson P, Fai F	2013	Int J Prod Econ	Network theory	x						x	x			x	x					x	x	
Peitz M, Shin D	2013	J Econ Behav Organ	Not mentioned	x				x			x						x			x	x	
Fitjar RD, Rodriguez-Pose A	2013	Res Policy	Not mentioned	x					x				x		x					x	x	x

Authors	Year	Journal	Theory	Factors		Approach					Context				Method					Type of Innovation		
				Facilit	Bar	PSP	PCCC	INPDP	SA	OI	Ind	Serv	Gen	SME	EQt	CS	EQl	LR	Conc	Prod	Proc	MP
Cabigiosu A, Zirpoli F, Camuffo A	2013	Res Policy	Theory of modular systems	x				x			x					x				x		
Jayaram J, Pathak S	2013	Int J Prod Res	Knowledge-based view	x				x			x				x					x		
Tracey M, Neuhaus R	2013	J Purch Supply Manag	Not mentioned	x			x				x					x				x	x	
Peng DX, et al.	2013	J Supply Chain Manag	Org. information-processing theory	x					x		x				x							
Narasimhan R, Narayanan S	2013	J Supply Chain Manag	Network theory and complexity theory	x					x				x						x	x	x	x
Oke A, Prajogo DI, Jayaram J	2013	J Supply Chain Manag	Resource dep theory, knowledge-based view	x					x		x				x					x		
Blome C, Schoenherr T, Kaesser M	2013	J Supply Chain Manag	Complementarity Theory	x					x		x				x					x		
Vickery SK, Koufteros X, Droge C	2013	IEEE T Eng Manage	Dynamic capabilities theory	x				x			x				x					x		
Wong CWY, et al.	2013	Int J Prod Econ	Ambidexterity theory	x					x		x				x					x		
Billington C, Davidson R	2013	Prod Oper Manag	Knowledge transfer theory	x						x	x					x				x	x	
Fox GL, et al.	2013	Int J Oper Prod Man	Social network theory	x				x			x				x					x		
Ganotakis P, Hsieh WL, Love JH	2013	Prod Plan Control	Not mentioned	x				x			x				x					x	x	x
Germani M, et al.	2013	Int J Comput Integ M	Process view	x	x			x					x				x			x		
Cheng JH, Chen MC, Huang CM	2014	Supply Chain Manag	Institutional theory	x					x		x				x					x		
He YQ, et al.	2014	Int J Prod Econ	Trust theory	x				x			x				x					x		
Jean RJ, Sinkovics	2014	J Prod Innov Manag	Knowledge-	x					x		x			x						x		

Authors	Year	Journal	Theory	Factors		Approach					Context					Method					Type of Innovation		
				Facilit	Bar	PSP	PCCC	INPDP	SA	OI	Ind	Serv	Gen	SME		EQt	CS	EQl	LR	Conc	Prod	Proc	MP
RR, Hiebaum TP			based view and tran cost econ																				
Wagner SM, Bode C	2014	J Oper Manag	Transaction cost economics	x					x		x					x					x	x	x
Yeniyurt S, et al.	2014	J Acad Market Sci	Social exchange theory	x				x			x					x					x		
Ge ZH, Hu QY, Xia YS	2014	Prod Oper Manag	Not mentioned	x				x			x						x				x		
Schoenherr T, Griffith D, Chandra A	2014	Int J Prod Res	Resource-advantage theory	x				x			x			x		x					x	x	x
Tan YC, Ndubisi NO	2014	J Bus Ind Mark	Resource-based view	x				x			x					x					x		
Seo YJ, Dinwoodie J, Kwak DW	2014	Supply Chain Manag	Not mentioned	x				x			x					x					x		
Storer M, et al.	2014	Int J Logist Manag	Resource-based view and rel view theo	x					x		x					x					x		
Wu GD	2014	Int j simul model	Social exchange theory	x						x			x							x	x		
Jafarian M, Bashiri M	2014	Appl Math Model	Not mentioned	x				x					x					x			x		
Saenz MJ, Revilla M, Knoppen D	2014	J Supply Chain Manag	Dynamic capabilities theory	x					x		x					x					x		
von Massow M, Canbolat M	2014	Int J Prod Res	Not mentioned	x				x					x							x	x		
Gualandris J, Kalchschmidt M	2014	J Purch Supply Manag	Stakeholder theory, resource-based view	x				x			x					x					x		
Ma XF, Kaldenbach M, Katzy B	2014	Technol Anal Strateg	Institutional theory		x			x			x							x			x		
Pulles NJ, et al.	2014	J Supply Chain Manag	Social exchange theory	x					x		x					x					x		
Hernández JE, et al.	2014	Prod Plan Control	Not mentioned	x					x		x						x				x		
Chong AYL, Zhou L	2014	Int J Prod Econ	Not mentioned	x				x				x									x		

Authors	Year	Journal	Theory	Factors		Approach					Context				Method					Type of Innovation		
				Facilit	Bar	PSP	PCCC	INPDP	SA	OI	Ind	Serv	Gen	SME	EQt	CS	EQl	LR	Conc	Prod	Proc	MP
Bellamy MA, Ghosh S, Hora M	2014	J Oper Manag	Social network theory	x					x		x				x					x		
Liao SH, Kuo FI	2014	Int J Prod Econ	Resource-based view	x					x		x				x					x		
Singh PJ, Power D	2014	Int J Prod Res	Knowledge-based view	x					x		x				x					x		
Lee VH, et al.	2014	Expert Syst Appl	Not mentioned	x				x			x				x					x		
Lefebvre VM, et al	2014	Creat Innov Manag	Resource-based view	x					x					x	x					x		
Manasakis C, et al.	2014	South Econ J	Not mentioned	x				x					x						x	x		
Piening EP, Salge TO	2015	Journal of Product Innovation Management	Dynamic capabilities theory	x					x		x	x			x						x	
Ren S, Eisingerich AB, Tsai H	2015	Journal of Business Research	Organizational learning theory and relationship governance theory	x					x					x	x					x		
Wang J, Shin H	2015	Production and Operations Management	Not mentioned					x					x						x	x		
Golgeci I, Ponomarov SY	2015	Technology Analysis & Strategic Management	Relational view theory and network theory	x					x		x				x					x		
Arsenyan J, Büyüközkan G, Feyzioglu O	2015	Expert Systems with Applications	Game theory	x					x				x		x					x		
Zhang HP	2015	International Journal of Simulation Model	Not mentioned	x				x					x				x			x		
Ren SJ, Hu C, Ngai E, Zhou M	2015	Production Planning & Control	Service-dominant logic	x					x		x				x					x		
Herrmann S, Rogers H, Gebhard M, Hartmann E	2015	Production Planning & Control	Not mentioned	x				x			x				x					x		
Carrillo J, Druehl C, Hsuan J	2015	Decision Sciences	Not applicable	x				x					x					x		x	x	

Authors	Year	Journal	Theory	Factors		Approach					Context				Method					Type of Innovation		
				Facilit	Bar	PSP	PCCC	INPDP	SA	OI	Ind	Serv	Gen	SME	EQt	CS	EQl	LR	Conc	Prod	Proc	MP
Sjoerdsma M, van Weele AJ	2015	Journal of Purchasing & Supply Management	Resource-based view	x				x			x					x				x		
Nasr ES, Kilgour MD, Noori H	2015	European Journal of Operational Research	Game theory	x			x				x						x			x		
Mazzola E, Bruccoleri M, Perrone G	2015	Journal of Purchasing & Supply Management	Social capital theory	x					x		x				x					x		
Elvers D, Song CH	2016	Journal of Business & Industrial Marketing	Resource-based view	x				x			x						x			x		
Wu SB; Gu X, Wu GD, Zhou, Q	2016	International Journal of Simulation Model	Not mentioned	x				x			x						x			x		
Yoon SN, Lee DH, Schniederjans M	2016	Technological Forecasting & Social Change	Not mentioned	x					x			x			x					x	x	
Bouncken RB, Pluschke BD, Pesch R, Kraus S	2016	Review of Management Science	Dynamic capabilities theory	x					x		x				x					x		
Fornasiero R, Zangiacomi A, Franchini V, Bastos J, Azevedo A, Vinelli A	2016	Production Planning & Control	Not mentioned	x					x		x					x				x		
Zhang M, Zhao X, Voss C, Zhu G	2016	International Journal of Production Economics	Knowledge-based view	x					x		x					x				x	x	
Isaksson OHD, Simeth M, Seifert RW	2016	Research Policy	Not mentioned	x					x		x				x					x		
Zubielqui GC, Jones J, Statsenko L	2016	Entrepreneurship research journal	Complexity theory	x					x					x	x					x		
Chiang IR, Wu SJ	2016	IEEE TRANSACTIONS ON ENGINEERING MANAGEMENT	Game theory	x				x			x							x		x		
Ojha D, Shockley J, Acharya C	2016	International Journal of Production Economics	Resource-based view	x				x			x				x					x		
Bravo MIR, Moreno AR, Llorens-Montes	2016	Supply Chain Management: An	Complementarity Theory	x				x			x				x					x		

Authors	Year	Journal	Theory	Factors		Approach					Context				Method					Type of Innovation		
				Facilit	Bar	PSP	PCCC	INPDP	SA	OI	Ind	Serv	Gen	SME	EQt	CS	EQl	LR	Conc	Prod	Proc	MP
FJ		International Journal																				
Lo Nigro G	2016	Journal of Business Research	Not applicable	x				x					x					x		x	x	
Ku ECS, Wu WC, Chen YJ	2016	Information Systems and e-Business Management	Resource-based view	x				x			x				x					x		
Yan T, Azadegan A	2017	International Journal of Production Economics	Knowledge-based view	x	x				x		x				x					x		

Facilit: Facilitators; Bar: Barriers.
PSP: Partnerships for specific purposes (or ad-hoc); PCCC: Project coordination by the client company; INPDP: Integration of the new product development process; SA: Strategic alignment; OI: Open innovation strategy.
EQt: empirical quantitative study; CS: Case study; EQl: empirical qualitative study; LR: Literature review; Conc: conceptual study.
Ind: Industry; Serv: Services; Gen: Generic; SME: Small and Medium-sized Enterprises.
Prod: Product; Proc: Process; MP: Management practice or marketing method

APPENDIX 2

Table 30 - Appendix 2 - Studies about the relationship between supply chain and innovation

Paper	Year	Journal
Bruce, M; Moger ST	1999	Technology Analysis & Strategic Management
Kim, B	2000	European Journal of Operational Research
Sobrero, M; Roberts EB	2002	Research Policy
Roy S; Sivakumar K; Wilkinson IF	2004	Journal of the Academy of Marketing Science
McIvor R, Humphreys P	2004	Omega
Kim B, Oh H	2005	Supply Chain Management: An International Journal
Petersen KJ, Handfield RB, Ragatz GL	2005	Journal of Operations Management
Ettlie JE, Pavlou PA	2006	Decision Sciences
Choi TY, Krause DR	2006	Journal of Operations Management
Lau AKW, Yam RCM, Tang EPY	2007	Industrial Management & Data Systems
Koufteros XA, Cheng TCE, Lai KH	2007	Journal of Operations Management
Soosay CA, Hyland PW, Ferrer M	2008	Supply Chain Management: An International Journal
Tether BS, Tajar A	2008	Research Policy
Lee J, Veloso FM	2008	Journal of Product Innovation Management
Craighead CW, Hult GTM, Ketchen Jr DJ	2009	Journal of Operations Management
Bhaskaran RS, Krishnan V	2009	Management Science
Bakhshi H, McVittie E	2009	Innovation: management, policy & practice
Panayides PM, Lun YHV	2009	International Journal of Production Economics
Modi SB, Mabert VA	2010	Journal of Supply Chain Management
Pero M, Abdelkafi N, Sianesi A, Blecker T	2010	Supply Chain Management: An International Journal
Wynstra F, von Corswant F, Wetzels M	2010	Journal of Product Innovation Management
Lin YC, Wang YC, Yu CH	2010	International Journal of Production Economics
Roy S, Sivakumar K	2010	Journal of Business Research
Cao M, Zhang Q	2010	International Journal of Production Economics
Hilletofth P, Eriksson D	2011	Industrial Management & Data Systems
Chong AYL, Chan FTS, Ooi KB, Sim JJ	2011	Industrial Management & Data Systems
Lau AKW	2011	Industrial Management & Data Systems
Johnsen TE	2011	International Journal of Operations & Production Management
Zolghadri M, Amrani A, Zouggar S, Girard P	2011	International Journal of Computer Integrated Manufacturing
Wang LW, Yeung JHY, Zhang M	2011	International Journal of Production Economics
Bouncken RB	2011	Engineering Management Journal
Hernández-Espallardo M, Sánchez-Pérez M, Segovia-López C	2011	Technovation
Lee KH, Kim JW	2011	Business Strategy and the Environment
Koufteros X, Vickery SK, Droge C	2012	Journal of Supply Chain Management
Berghman L, Matthyssens P, Vandenbempt K	2012	Industrial Marketing Management
Fawcett SE, Jones SL, Fawcett AM	2012	Business Horizons

Paper	Year	Journal
Caridi M, Pero M, Sianesi A	2012	International Journal of Production Economics
Hsieh KN, Tidd J	2012	Technovation
Jean RJ, Kim D, Sinkovics RR	2012	Decision Sciences
Langenberg KU, Seifert RW, Tranchez JS	2012	International Journal of Production Economics
Hazen BT, Overstreet RE, Cegielski CG	2012	The International Journal of Logistics Management
Machikita T, Ueki Y	2012	Asian Journal of Technology Innovation
Bendoly E, Bharadwaj A	2012	Production and Operations Management
Salvador F, Villena VH	2013	Journal of Supply Chain Management
Kuhne B, Gellynck X, Weaver RD	2013	Supply Chain Management: An International Journal
Golgeci I, Ponomarov SY	2013	Supply Chain Management: An International Journal
Tomlinson PR, Fai FM	2013	International Journal of Production Economics
Peitz M, Shin D	2013	Journal of Economic Behavior & Organization
Fitjar RD, Rodriguez-Pose A	2013	Research Policy
Cabigiosu A, Zirpoli F, Camuffo A	2013	Research Policy
Jayaram J, Pathak S	2013	International Journal of Production Research
Tracey M, Neuhaus R	2013	Journal of Purchasing & Supply Management
Peng DX, Verghese A, Shah R, Schroeder RG	2013	Journal of Supply Chain Management
Narasimhan R, Narayanan S	2013	Journal of Supply Chain Management
Oke A, Prajogo DI, Jayaram J	2013	Journal of Supply Chain Management
Blome C, Schoenherr T, Kaesser M	2013	Journal of Supply Chain Management
Vickery SK, Koufteros X, Droge C	2013	IEEE Transactions on Engineering Management
Wong CWY, Wong CY, Boon-itt S	2013	International Journal of Production Economics
Billington C, Davidson R	2013	Production and Operations Management
Fox GL, Smith J, Cronin Jr JJ, Brusco M	2013	International Journal of Operations & Production Management
Ganotakis P, Hsieh WL, Love JH	2013	Production Planning & Control
Germani M, Mandolini M, Mengoni M, Peruzzini M	2013	International Journal of Computer Integrated Manufacturing
Cheng JH, Chen MC, Huang CM	2014	Supply Chain Management: An International Journal
He YQ, Lai KK, Sun HY, Chen Y	2014	International Journal of Production Economics
Jean RJ, Sinkovics RR, Hiebaum TP	2014	Journal of Product Innovation Management
Wagner SM, Bode C	2014	Journal of Operations Management
Yeniyurt S, Henke Jr. JW, Yalcinkaya G	2014	Journal of the Academy of Marketing Science
Ge ZH, Hu QY, Xia YS	2014	Production and Operations Management
Schoenherr T, Griffith DA, Chandra A	2014	International Journal of Production Research
Tan YC, Ndubisi NO	2014	Journal of Business & Industrial Marketing
Seo YJ, Dinwoodie J, Kwak DW	2014	Supply Chain Management: An International Journal
Storer M, Hyland P, Ferrer M, Santa R, Griffiths A	2014	The International Journal of Logistics Management
Wu GD	2014	International Journal of Simulation Model
Jafarian M, Bashiri M	2014	Applied Mathematical Modelling
Saenz MJ, Revilla M, Knoppen D	2014	Journal of Supply Chain Management
von Massow M, Canbolat M	2014	International Journal of Production Research
Gualandris J, Kalchschmidt M	2014	Journal of Purchasing & Supply Management

Paper	Year	Journal
Ma XF, Kaldenbach M, Katzy B	2014	Technology Analysis & Strategic Management
Pulles NJ, Veldmann J, Schielle H, Sierksma H	2014	Journal of Supply Chain Management
Hernández JE, Lyons AC, Mula J, Poler R, Ismail H	2014	Production Planning & Control: The Management of Operations
Chong AYL, Zhou L	2014	International Journal of Production Economics
Bellamy MA, Ghosh S, Hora M	2014	Journal of Operations Management
Liao SH, Kuo FI	2014	International Journal of Production Economics
Singh PJ, Power D	2014	International Journal of Production Research
Lee VH, Ooi KB, Chong AYL, Seow C	2014	Expert Systems with Applications
Lefebvre VM, Raggi M, Viaggi D, Sia-Ljungström C, Minarelli F, Kühne B, Gellynck X	2014	Creativity and Innovation Management
Manasakis C, Pretrakis E, Zikos V	2014	Southern Economic Journal
Piening EP, Salge TO	2015	Journal of Product Innovation Management
Ren S, Eisingerich AB, Tsai H	2015	Journal of Business Research
Wang J, Shin H	2015	Production and Operations Management
Golgeci I, Ponomarov SY	2015	Technology Analysis & Strategic Management
Arsenyan J, Büyüközkan G, Feyzioglu O	2015	Expert Systems with Applications
Zhang, H. P.	2015	International Journal of Simulation Model
Steven Jifan Ren, Caihong Hu, E.W.T. Ngai & Mingjian Zhou	2015	Production Planning and Control
Stefanie Herrmann, Helen Rogers, Marina Gebhard & Evi Hartmann	2015	Production Planning and Control
Janice E. Carrillo, Cheryl Druehl	2015	Decision Sciences
Maarten Sjoerdsma, Arjan J.van Weele	2015	Journal of Purchasing & Supply Management
Eman S. Nasr, Marc D. Kilgour, Hamid Noori	2015	European Journal of Operational Research
Erica Mazzola, Manfredi Bruccoleri, Giovanni Perrone	2015	Journal of Purchasing & Supply Management
David Elvers and Chie Hoon Song	2016	Journal of Business & Industrial Marketing
Wu, S. B; Gu, X; Wu, G. D. & Zhou, Q	2016	International Journal of Simulation Model
Seong No Yoon, DonHee Lee, Marc Schniederjans	2016	Technological Forecasting & Social Change
Ricarda B. Bouncken, Boris D. Pluschke, Robin Pesch, Sascha Kraus	2016	Review of Management Science
Rosanna Fornasiero, Andrea Zangiacomi, Valentina Franchini, João Bastos, Americo Azevedo & Andrea Vinelli	2016	Production Planning & Control
Min Zhang, Xiande Zhao, Chris Voss, Guilong Zhu	2016	International Journal of Production Economics
Olov H.D. Isakssona, Markus Simeth, Ralf W. Seifert	2016	Research Policy
Graciela Corral de Zubielqui, Janice Jones and Larissa Statsenko	2016	Entrepreneurship Research Journal
I. Robert Chiang and S. Jinhui Wu	2016	IEEE Transactions on Engineering Management
Divesh Ojha, Jeff Shockley, Chandan Achary	2016	International Journal of Production Economics

Paper	Year	Journal
María Isabel Roldán Bravo, Antonia Ruiz Moreno and Francisco Javier Llorens-Montes	2016	Supply Chain Management: An International Journal
Giovanna Lo Nigro	2016	Journal of Business Research
Edward C. S. Ku, Wu-Chung Wu, Yan Ju Chen	2016	Information Systems and e-Business Management
Ricardo Zimmermann, Luís M.D. Ferreira, António C. Moreira	2016	Supply Chain Management: Na International Journal
Tingting Yana, Arash Azadegan	2017	International Journal of Production Economics

* The papers that are part of the intellectual base of the topic are presented in bold.

APPENDIX 3 - Questionnaire in Portuguese

Questionário composto por quatro partes:
PARTE A – Gestão da Cadeia de Abastecimento / Suprimentos
PARTE B – Gestão da Inovação
PARTE C – Ambiente de negócios
PARTE D – Resultados da empresa

PARTE A – ESTRATÉGIAS DE GESTÃO DA CADEIA DE ABASTECIMENTO – SUPPLY CHAIN MANAGEMENT STRATEGIES

Em que medida é que concorda com a afirmação de que a cadeia de abastecimento da sua empresa relativamente ao do seu principal produto (ou linha de produtos) apresenta as seguintes características?

AL1. A nossa cadeia fornece produtos previsíveis
(1) Discordo totalmente (2) Discordo (3) Discordo um pouco (4) Nem concordo nem discordo (5) Concordo um pouco (6) Concordo (7) Concordo totalmente

AL2. A nossa cadeia reduz ao máximo todos os tipos de desperdício
(1) Discordo totalmente (2) Discordo (3) Discordo um pouco (4) Nem concordo nem discordo (5) Concordo um pouco (6) Concordo (7) Concordo totalmente

AL3. A nossa cadeia reduz os custos por via de produção em massa
(1) Discordo totalmente (2) Discordo (3) Discordo um pouco (4) Nem concordo nem discordo (5) Concordo um pouco (6) Concordo (7) Concordo totalmente

AL4. A nossa cadeia fornece aos clientes produtos padronizados
(1) Discordo totalmente (2) Discordo (3) Discordo um pouco (4) Nem concordo nem discordo (5) Concordo um pouco (6) Concordo (7) Concordo totalmente

AL5. A nossa cadeia precisa manter uma relação longa e rígida com um número pequeno de fornecedores
(1) Discordo totalmente (2) Discordo (3) Discordo um pouco (4) Nem concordo nem discordo (5) Concordo um pouco (6) Concordo (7) Concordo totalmente

AL6. A nossa cadeia seleciona os fornecedores com base no desempenho em termos de custo e qualidade
(1) Discordo totalmente (2) Discordo (3) Discordo um pouco (4) Nem concordo nem discordo (5) Concordo um pouco (6) Concordo (7) Concordo totalmente

AL7. A estrutura da nossa cadeia raramente muda
(1) Discordo totalmente (2) Discordo (3) Discordo um pouco (4) Nem concordo nem discordo (5) Concordo um pouco (6) Concordo (7) Concordo totalmente

AA1. A nossa cadeia enfrenta habitualmente uma procura instável por parte dos clientes
(1) Discordo totalmente (2) Discordo (3) Discordo um pouco (4) Nem concordo nem discordo (5) Concordo um pouco (6) Concordo (7) Concordo totalmente

AA2. A nossa cadeia responde rapidamente às mudanças no ambiente de mercado
(1) Discordo totalmente (2) Discordo (3) Discordo um pouco (4) Nem concordo nem discordo (5) Concordo um pouco (6) Concordo (7) Concordo totalmente

AA3. A nossa cadeia necessita manter um excesso de capacidade instalada para responder à volatilidade do mercado
(1) Discordo totalmente (2) Discordo (3) Discordo um pouco (4) Nem concordo nem discordo (5) Concordo um pouco (6) Concordo (7) Concordo totalmente

AA4. A nossa cadeia fornece aos clientes produtos customizados
(1) Discordo totalmente (2) Discordo (3) Discordo um pouco (4) Nem concordo nem discordo (5) Concordo um pouco (6) Concordo (7) Concordo totalmente

AA5. A nossa cadeia seleciona naturalmente os fornecedores com base na flexibilidade e capacidade de resposta
(1) Discordo totalmente (2) Discordo (3) Discordo um pouco (4) Nem concordo nem discordo (5) Concordo um pouco (6) Concordo (7) Concordo totalmente

AA6. A nossa cadeia necessita manter um relacionamento próximo e flexível com um grande número de fornecedores

(1) Discordo totalmente (2) Discordo (3) Discordo um pouco (4) Nem concordo nem discordo (5) Concordo um pouco (6) Concordo (7) Concordo totalmente

AA7. A estrutura da nossa cadeia muda frequentemente para conseguir lidar com a volatilidade do mercado

(1) Discordo totalmente (2) Discordo (3) Discordo um pouco (4) Nem concordo nem discordo (5) Concordo um pouco (6) Concordo (7) Concordo totalmente

Avalie as seguintes características para o principal produto (ou linha de produtos) da empresa:

ASDU1. Qual o tempo médio do ciclo de vida dos produtos?

(1) >5 anos (2) 2–5 anos (3) 1–2 anos (4) 6–12 meses (5) <6 meses

ASDU2. Quantas variantes estão disponíveis para a principal linha de produtos?

(1) <20 (2) 20–49 (3) 50–99 (4) 100-999 (5) 1,000 ou mais

ASDU3. Qual é a margem de erro média para os modelos de previsão utilizados?

(1) 0% - 9% (2) 10% – 19% (3) 20% - 39% (4) 40% - 59% (5) 60% - 100%

ASDU4. Qual o número estimado de locais de venda para a principal linha de produtos?

(1) <100 (2) 100-499 (3) 500-999 (4) 1000-1499 (5) 1,500 mais

ASDU5. Qual é a frequência de mudanças no conteúdo da ordem de encomenda da principal linha de produtos?

(1) Extremamente baixa (2) Baixa (3) Média (4) Alta (5) Extremamente alta

Classifique a importância/relevância das seguintes ações para a principal linha de produtos:

ASCR1. Aumentar a confiabilidade das entregas

(1) Irrelevante (2) Pouco importante (3) Nem importante nem "não importante" (4) Importante (5) Extremamente importante

ASCR2. Manter stocks de segurança adequados para os componentes ou para os produtos finais

(1) Irrelevante (2) Pouco importante (3) Nem importante nem "não importante" (4) Importante (5) Extremamente importante

ASCR3. Dispor de um excesso de capacidade instalada de produção

(1) Irrelevante (2) Pouco importante (3) Nem importante nem "não importante" (4) Importante (5) Extremamente importante

ASCR4. Responder rapidamente a procura com características imprevisíveis

(1) Irrelevante (2) Pouco importante (3) Nem importante nem "não importante" (4) Importante (5) Extremamente importante

ASCR5. Aumentar a frequência da introdução de novos produtos

(1) Irrelevante (2) Pouco importante (3) Nem importante nem "não importante" (4) Importante (5) Extremamente importante

PARTE B – CAPACIDADES DE INOVAÇÃO – INNOVATION CAPABILITIES

Responda a cada uma as seguintes afirmações abaixo com "Discordo totalmente", "Discordo", "Discordo um pouco", "Nem concordo nem discordo", "Concordo um pouco", "Concordo" ou "Concordo totalmente".

BR1. A nossa empresa desenvolve tecnologia por meio de investimento em Investigação e Desenvolvimento (I&)

(1) Discordo totalmente (2) Discordo (3) Discordo um pouco (4) Nem concordo nem discordo (5) Concordo um pouco (6) Concordo (7) Concordo totalmente

BR2. A nossa empresa adquire novas tecnologias

(1) Discordo totalmente (2) Discordo (3) Discordo um pouco (4) Nem concordo nem discordo (5) Concordo um pouco (6) Concordo (7) Concordo totalmente

BR3. A nossa empresa é reconhecida por disponibilizar produtos tecnologicamente superiores

(1) Discordo totalmente (2) Discordo (3) Discordo um pouco (4) Nem concordo nem discordo (5) Concordo um pouco (6) Concordo (7) Concordo totalmente

BR4. A nossa empresa, na área do desenvolvimento de novos produtos, emprega alguns dos profissionais mais qualificados da indústria no país

(1) Discordo totalmente (2) Discordo (3) Discordo um pouco (4) Nem concordo nem discordo (5) Concordo um pouco (6) Concordo (7) Concordo totalmente

BMK1. A nossa empresa é capaz de segmentar e atingir mercados específicos

(1) Discordo totalmente (2) Discordo (3) Discordo um pouco (4) Nem concordo nem discordo (5) Concordo um pouco (6) Concordo (7) Concordo totalmente

BMK2. A nossa empresa utiliza ferramentas de marketing (design de produto, preços, publicidade) para diferenciar seus produtos

(1) Discordo totalmente (2) Discordo (3) Discordo um pouco (4) Nem concordo nem discordo (5) Concordo um pouco (6) Concordo (7) Concordo totalmente

BMK3. A nossa empresa adota novos métodos para a definição dos preços para a exportação de produtos ou serviços

(1) Discordo totalmente (2) Discordo (3) Discordo um pouco (4) Nem concordo nem discordo (5) Concordo um pouco (6) Concordo (7) Concordo totalmente

BMK4. A nossa empresa utiliza novos canais de venda no exterior

(1) Discordo totalmente (2) Discordo (3) Discordo um pouco (4) Nem concordo nem discordo (5) Concordo um pouco (6) Concordo (7) Concordo totalmente

BMK5. A nossa empresa emprega técnicas inovadoras para promover produtos no exterior

(1) Discordo totalmente (2) Discordo (3) Discordo um pouco (4) Nem concordo nem discordo (5) Concordo um pouco (6) Concordo (7) Concordo totalmente

BM1. A nossa empresa é consistente em termos da qualidade na produção

(1) Discordo totalmente (2) Discordo (3) Discordo um pouco (4) Nem concordo nem discordo (5) Concordo um pouco (6) Concordo (7) Concordo totalmente

BM2. A nossa empresa fabrica produtos desenvolvidos por meio de I&D (Investigação e desenvolvimento) de modo a atender às necessidades dos clientes

(1) Discordo totalmente (2) Discordo (3) Discordo um pouco (4) Nem concordo nem discordo (5) Concordo um pouco (6) Concordo (7) Concordo totalmente

BM3. A nossa empresa cumpre os prazos estipulados/acordados para a entrega dos nossos produtos

(1) Discordo totalmente (2) Discordo (3) Discordo um pouco (4) Nem concordo nem discordo (5) Concordo um pouco (6) Concordo (7) Concordo totalmente

BM4. A nossa empresa emprega tecnologias de produção avançadas em comparação com os principais concorrentes internacionais

(1) Discordo totalmente (2) Discordo (3) Discordo um pouco (4) Nem concordo nem discordo (5) Concordo um pouco (6) Concordo (7) Concordo totalmente

BL1. A nossa empresa monitoriza e acompanha as principais tendências tecnológicas

(1) Discordo totalmente (2) Discordo (3) Discordo um pouco (4) Nem concordo nem discordo (5) Concordo um pouco (6) Concordo (7) Concordo totalmente

BL2. A nossa empresa promove uma cultura de aprendizagem que permite a identificação, assimilação e exploração de novos conhecimentos essenciais para o seu sucesso competitivo

(1) Discordo totalmente (2) Discordo (3) Discordo um pouco (4) Nem concordo nem discordo (5) Concordo um pouco (6) Concordo (7) Concordo totalmente

BL3. Sempre que precisamos de desenvolver novas competências ou tecnologias para oferecer novos produtos, conseguimos fazê-lo de forma eficiente

(1) Discordo totalmente (2) Discordo (3) Discordo um pouco (4) Nem concordo nem discordo (5) Concordo um pouco (6) Concordo (7) Concordo totalmente

BL4. Conseguimos facilmente aprender novas competências e adquirir novas capacidades que permitem a introdução de novos produtos

(1) Discordo totalmente (2) Discordo (3) Discordo um pouco (4) Nem concordo nem discordo (5) Concordo um pouco (6) Concordo (7) Concordo totalmente

BL5. Preenchemos eficazmente a lacuna entre o que sabemos ou temos e o que precisamos saber ou ter para o desenvolvimento dos produtos desejados e para sua introdução no mercado

(1) Discordo totalmente (2) Discordo (3) Discordo um pouco (4) Nem concordo nem discordo (5) Concordo um pouco (6) Concordo (7) Concordo totalmente

BO1. Quando é necessário, a nossa empresa adota uma estrutura organizacional flexível de forma a que se ajuste aos novos projetos focados em inovação de produtos ou processos

(1) Discordo totalmente (2) Discordo (3) Discordo um pouco (4) Nem concordo nem discordo (5) Concordo um pouco (6) Concordo (7) Concordo totalmente

BO2. A nossa empresa oferece aos gestores um nível considerável de autonomia nos processos de inovação

(1) Discordo totalmente (2) Discordo (3) Discordo um pouco (4) Nem concordo nem discordo (5) Concordo um pouco (6) Concordo (7) Concordo totalmente

BO3. Na nossa empresa existe uma forte coordenação entre os departamentos técnicos (como engenharia ou de projetos/desenvolvimento), vendas e de produção

(1) Discordo totalmente (2) Discordo (3) Discordo um pouco (4) Nem concordo nem discordo (5) Concordo um pouco (6) Concordo (7) Concordo totalmente

BO4. A nossa empresa adota novas técnicas de gestão para melhorar as rotinas e práticas de trabalho e para facilitar o uso e a troca de informações, conhecimento e competências

(1) Discordo totalmente (2) Discordo (3) Discordo um pouco (4) Nem concordo nem discordo (5) Concordo um pouco (6) Concordo (7) Concordo totalmente

BO5. A nossa empresa adota novos métodos de organização do trabalho de modo a melhor distribuir responsabilidades e tarefas que exijam a tomada de decisão (como a formação de equipas de trabalho, decentralização ou integração de departamentos)

(1) Discordo totalmente (2) Discordo (3) Discordo um pouco (4) Nem concordo nem discordo (5) Concordo um pouco (6) Concordo (7) Concordo totalmente

BRE1. A nossa empresa combina interna e externamente tecnologias já desenvolvidas (como tecnologias desenvolvidas por parceiros de negócio)

(1) Discordo totalmente (2) Discordo (3) Discordo um pouco (4) Nem concordo nem discordo (5) Concordo um pouco (6) Concordo (7) Concordo totalmente

BRE2. A nossa empresa dispõe dos recursos financeiros necessários para manter a introdução de novos produtos no mercado

(1) Discordo totalmente (2) Discordo (3) Discordo um pouco (4) Nem concordo nem discordo (5) Concordo um pouco (6) Concordo (7) Concordo totalmente

BRE3. A nossa empresa aloca de forma eficaz os colaboradores às tarefas

(1) Discordo totalmente (2) Discordo (3) Discordo um pouco (4) Nem concordo nem discordo (5) Concordo um pouco (6) Concordo (7) Concordo totalmente

BRE4. Os nossos colaboradores esforçam-se continuamente para melhorar os nossos produtos e processos

(1) Discordo totalmente (2) Discordo (3) Discordo um pouco (4) Nem concordo nem discordo (5) Concordo um pouco (6) Concordo (7) Concordo totalmente

BRE5. Os nossos colaboradores acreditam ser responsáveis pela melhoria dos nossos produtos e processos

(1) Discordo totalmente (2) Discordo (3) Discordo um pouco (4) Nem concordo nem discordo (5) Concordo um pouco (6) Concordo (7) Concordo totalmente

BS1. A formulação da nossa estratégia é conduzida por uma forte visão empreendedora

(1) Discordo totalmente (2) Discordo (3) Discordo um pouco (4) Nem concordo nem discordo (5) Concordo um pouco (6) Concordo (7) Concordo totalmente

BS2. A gestão de topo da nossa empresa é totalmente capaz de compreender os fatores externos que afetam as operações de negócios

(1) Discordo totalmente (2) Discordo (3) Discordo um pouco (4) Nem concordo nem discordo (5) Concordo um pouco (6) Concordo (7) Concordo totalmente

BS3. A gestão de topo da nossa empresa antecipa rapidamente os movimentos dos concorrentes vindos de outros mercados e ajusta as estratégias de acordo com estes movimentos

(1) Discordo totalmente (2) Discordo (3) Discordo um pouco (4) Nem concordo nem discordo (5) Concordo um pouco (6) Concordo (7) Concordo totalmente

BS4. Na nossa empresa existe uma forte ligação entre inovação e reconhecimento do valor criado para os clientes

(1) Discordo totalmente (2) Discordo (3) Discordo um pouco (4) Nem concordo nem discordo (5) Concordo um pouco (6) Concordo (7) Concordo totalmente

PARTE C – AMBIENTE DE NEGÓCIOS

Indique a sua opinião sobre as seguintes afirmações relativas ao ambiente de negócios em que a empresa desenvolve a sua atividade.

CM1. O ambiente em que a empresa compete pode suportar um crescimento sustentado da empresa

(1) Discordo totalmente (2) Discordo (3) Discordo um pouco (4) Nem concordo nem discordo (5) Concordo um pouco (6) Concordo (7) Concordo totalmente

CD2. O ambiente em que a empresa compete caracteriza-se por mudanças difíceis de prever e que aumentam as incertezas para os elementos chave da empresa

(1) Discordo totalmente (2) Discordo (3) Discordo um pouco (4) Nem concordo nem discordo (5) Concordo um pouco (6) Concordo (7) Concordo totalmente

CC3. O ambiente em que a empresa compete é caracterizado por grande incerteza e grande necessidade de processamento de informação

(1) Discordo totalmente (2) Discordo (3) Discordo um pouco (4) Nem concordo nem discordo (5) Concordo um pouco (6) Concordo (7) Concordo totalmente

Em que medida as seguintes afirmações adequam-se aos produtos finais e ao processo produtivo da empresa?

CS1. A procura de cada tipo de produto final varia rapidamente

(1) Muito inadequada (2) Inadequada (3) Pouco inadequada (4) Nem adequada nem inadequada (5) Pouco adequada (6) Adequada (7) Muito adequada

CS2. O time-to-market dos novos produtos é muito curto

(1) Muito inadequada (2) Inadequada (3) Pouco inadequada (4) Nem adequada nem inadequada (5) Pouco adequada (6) Adequada (7) Muito adequada

CS3. O volume de cada tipo de produto final é muito grande

(1) Muito inadequada (2) Inadequada (3) Pouco inadequada (4) Nem adequada nem inadequada (5) Pouco adequada (6) Adequada (7) Muito adequada

CS4. Indique o tempo médio estimado para o intervalo de introdução de novos produtos

(1) <3 meses (2) 3–6 meses (3) 7–11 meses (4) 1–2 anos (5) 2–3 anos (6) 3–5 anos (7) >5 anos

PARTE D – BUSINESS PERFORMANCE

Avalie o desempenho da empresa em comparação com seus principais concorrentes para cada um dos seguintes aspetos:

DC1. Crescimento das vendas

(1) muito menor que os concorrentes (2) --- (3) --- (4) igual aos concorrentes (5) -- (6) -- (7) muito maior que os concorrentes

DC2. Reputação e imagem

(1) muito menor que os concorrentes (2) --- (3) --- (4) igual aos concorrentes (5) -- (6) -- (7) muito maior que os concorrentes

DC3. Satisfação dos clientes

(1) muito menor que os concorrentes (2) --- (3) --- (4) igual aos concorrentes (5) -- (6) -- (7) muito maior que os concorrentes

DC4. Market share / Quota no mercado (do principal produto)

(1) muito menor que os concorrentes (2) --- (3) --- (4) igual aos concorrentes (5) -- (6) -- (7) muito maior que os concorrentes

DC5. Sucesso do lançamento de novos produtos

(1) muito menor que os concorrentes (2) --- (3) --- (4) igual aos concorrentes (5) -- (6) -- (7) muito maior que os concorrentes

DF1. Retorno sobre o Investimento– ROI

(1) muito menor que os concorrentes (2) --- (3) --- (4) igual aos concorrentes (5) -- (6) -- (7) muito maior que os concorrentes

DF2. Lucro como percentagem das vendas (Lucro / vendas totais)

(1) muito menor que os concorrentes (2) --- (3) --- (4) igual aos concorrentes (5) -- (6) -- (7) muito maior que os concorrentes

DF3. Produtividade da força de trabalho

(1) muito menor que os concorrentes (2) --- (3) --- (4) igual aos concorrentes (5) -- (6) -- (7) muito maior que os concorrentes

DIPT1. Substituição dos produtos que estão a ser eliminados

(1) muito menor que os concorrentes (2) --- (3) --- (4) igual aos concorrentes (5) -- (6) -- (7) muito maior que os concorrentes

DIPT2. Quantidade de novos produtos introduzidos (nos últimos três anos) dentro da principal linha de produtos

(1) muito menor que os concorrentes (2) --- (3) --- (4) igual aos concorrentes (5) -- (6) -- (7) muito maior que os concorrentes

DIPT3. Quantidade de produtos fora da principal linha de produtos

(1) muito menor que os concorrentes (2) --- (3) --- (4) igual aos concorrentes (5) -- (6) -- (7) muito maior que os concorrentes

DIPT4. Desenvolvimento de produtos "amigos do meio ambiente" (environment-friendly)

(1) muito menor que os concorrentes (2) --- (3) --- (4) igual aos concorrentes (5) -- (6) -- (7) muito maior que os concorrentes

DIPT5. Abertura de novos mercados internacionais

(1) muito menor que os concorrentes (2) --- (3) --- (4) igual aos concorrentes (5) -- (6) -- (7) muito maior que os concorrentes

DIPT6. Abertura de novos públicos alvo no mercado doméstico

(1) muito menor que os concorrentes (2) --- (3) --- (4) igual aos concorrentes (5) -- (6) -- (7) muito maior que os concorrentes

DIPS1. Aumento da flexibilidade da produção

(1) muito menor que os concorrentes (2) --- (3) --- (4) igual aos concorrentes (5) -- (6) -- (7) muito maior que os concorrentes

DIPS2. Redução dos custos de produção por meio de redução dos custos de mão-de-obra por unidade

(1) muito menor que os concorrentes (2) --- (3) --- (4) igual aos concorrentes (5) -- (6) -- (7) muito maior que os concorrentes

DIPS3. Redução dos custos de produção por meio da redução do consumo de materiais

(1) muito menor que os concorrentes (2) --- (3) --- (4) igual aos concorrentes (5) -- (6) -- (7) muito maior que os concorrentes

DIPS4. Redução dos custos de produção por meio da redução do consumo de energia

(1) muito menor que os concorrentes (2) --- (3) --- (4) igual aos concorrentes (5) -- (6) -- (7) muito maior que os concorrentes

DIPS5. Redução dos custos de produção por meio da redução das taxas de rejeição na produção

(1) muito menor que os concorrentes (2) --- (3) --- (4) igual aos concorrentes (5) -- (6) -- (7) muito maior que os concorrentes

DIPS6. Redução dos custos de produção por meio da redução dos custos de projeto (desenvolvimento/design)

(1) muito menor que os concorrentes (2) --- (3) --- (4) igual aos concorrentes (5) -- (6) -- (7) muito maior que os concorrentes

DIPS7. Redução dos custos de produção por meio da redução dos tempos dos ciclos de produção

(1) muito pior (2) pior (3) pouco pior (4) no mesmo nível (5) pouco melhor (6) melhor (7) muito melhor

DIPS8. Melhoria da qualidade dos produtos

(1) muito menor que os concorrentes (2) --- (3) --- (4) igual aos concorrentes (5) -- (6) -- (7) muito maior que os concorrentes

DIPS9. Melhoria das condições de trabalho

(1) muito menor que os concorrentes (2) --- (3) --- (4) igual aos concorrentes (5) -- (6) -- (7) muito maior que os concorrentes

DIPS10. Redução de danos ao meio ambiente

(1) muito menor que os concorrentes (2) --- (3) --- (4) igual aos concorrentes (5) -- (6) -- (7) muito maior que os concorrentes

DIR1. Indique a fração do volume de negócios da empresa (em 2016) relativa a produtos novos ou significativamente melhorados introduzidos no mercado entre 2014 e 2016:

(1) 0% – 19% (2) 20% – 39% (3) 40% – 59%

IO. Identificação da organização:

IO1. Nome da Unidade de negócio: _____

IO2. Setor de atuação da empresa? _____

IO4. Em que ano a empresa foi fundada? _____

IO5. Em que ano esta planta foi criada? _____

IO6. Tamanho da unidade de negócio (nº de funcionários em 2017) _____

APPENDIX 4 - Questionnaire in English

Questionnaire consisting of four parts:
PART A – Supply Chain Management
PART B – Innovation Management
PART C – Business conditions
PART D – Firm performance

PARTE A – SUPPLY CHAIN STRATEGIES

To what extent do you agree that the supply chain of your company's major product/product mix has the following characteristics?

AL1. Our supply chain supplies predictable products
(1) Strongly disagree (2) Disagree (3) Disagree somewhat (4) Neither agree nor disagree (5) Agree somewhat (6) Agree (7) Strongly agree

AL2. Our supply chain reduces any kind of waste as much as possible
(1) Strongly disagree (2) Disagree (3) Disagree somewhat (4) Neither agree nor disagree (5) Agree somewhat (6) Agree (7) Strongly agree

AL3. Our supply chain reduces costs through mass production
(1) Strongly disagree (2) Disagree (3) Disagree somewhat (4) Neither agree nor disagree (5) Agree somewhat (6) Agree (7) Strongly agree

AL4. Our supply chain provides customer with standardized products
(1) Strongly disagree (2) Disagree (3) Disagree somewhat (4) Neither agree nor disagree (5) Agree somewhat (6) Agree (7) Strongly agree

AL5. Our supply chain needs to maintain a long and rigid relationship with a small number of Suppliers
(1) Strongly disagree (2) Disagree (3) Disagree somewhat (4) Neither agree nor disagree (5) Agree somewhat (6) Agree (7) Strongly agree

AL6. Our supply chain selects the suppliers based on their performance on cost and quality
(1) Strongly disagree (2) Disagree (3) Disagree somewhat (4) Neither agree nor disagree (5) Agree somewhat (6) Agree (7) Strongly agree

AL7. Our supply chain structure seldom changes
(1) Strongly disagree (2) Disagree (3) Disagree somewhat (4) Neither agree nor disagree (5) Agree somewhat (6) Agree (7) Strongly agree

AA1. Our supply chain always faces the volatile customer demand
(1) Strongly disagree (2) Disagree (3) Disagree somewhat (4) Neither agree nor disagree (5) Agree somewhat (6) Agree (7) Strongly agree

AA2. Our supply chain responds to the changing market environment quickly
(1) Strongly disagree (2) Disagree (3) Disagree somewhat (4) Neither agree nor disagree (5) Agree somewhat (6) Agree (7) Strongly agree

AA3. It is necessary for our supply chain to maintain a higher capacity buffer to respond to volatile market
(1) Strongly disagree (2) Disagree (3) Disagree somewhat (4) Neither agree nor disagree (5) Agree somewhat (6) Agree (7) Strongly agree

AA4. Our supply chain provides customer with personalized products
(1) Strongly disagree (2) Disagree (3) Disagree somewhat (4) Neither agree nor disagree (5) Agree somewhat (6) Agree (7) Strongly agree

AA5. Our supply chain selects the suppliers based on their performance on flexibility and responsiveness
(1) Strongly disagree (2) Disagree (3) Disagree somewhat (4) Neither agree nor disagree (5) Agree somewhat (6) Agree (7) Strongly agree

AA6. Our supply chain needs to maintain a short and flexible relationship with a large number of Suppliers
(1) Strongly disagree (2) Disagree (3) Disagree somewhat (4) Neither agree nor disagree (5) Agree somewhat (6) Agree (7) Strongly agree

AA7. Our supply chain structure often changes in order to cope with volatile market

(1) Strongly disagree (2) Disagree (3) Disagree somewhat (4) Neither agree nor disagree (5) Agree somewhat (6) Agree (7) Strongly agree

Please evaluate the following characteristics for the main product line:

ASDU1. How long is the average life-cycle of the products in the main product line?

(1) >5 years (2) 2–5 years (3) 1–2 years (4) 6–12 months (5) <6 months

ASDU2. How many different variants are available for the main product line?

(1) <20 (2) 20–49 (3) 50–99 (4) 100-999 (5) 1,000 or more

ASDU3. What is the average margin of error in the forecast based on units at the time production is committed?

(1) 0% - 9% (2) 10% – 19% (3) 20% - 39% (4) 40% - 59% (5) 60% - 100%

ASDU4. What is the number of sales locations for the main product line?

(1) <100 (2) 100-499 (3) 500-999 (4) 1000-1499 (5) 1,500 or more

ASDU5. What is the frequency of change in order content for the main product line?

(1) Extremely low (2) Low (3) Medium (4) High (5) Extremely high

Please indicate the strategic supply chain priorities for the main product line:

ASCR1. Improve delivery reliability

(1) Not important at all (2) Not important (3) Neither important nor not important (4) Important (5) Extremely important

ASCR2. Maintain buffer inventory of parts or finished goods

(1) Not important at all (2) Not important (3) Neither important nor not important (4) Important (5) Extremely important

ASCR3. Retain buffer capacity in manufacturing

(1) Not important at all (2) Not important (3) Neither important nor not important (4) Important (5) Extremely important

ASCR4. Respond quickly to unpredictable demand

(1) Not important at all (2) Not important (3) Neither important nor not important (4) Important (5) Extremely important

ASCR5. Increase frequency of new product introductions

(1) Not important at all (2) Not important (3) Neither important nor not important (4) Important (5) Extremely important

PARTE B – INNOVATION CAPABILITIES

In this section, answer each of the statements with "Strongly disagree", "Disagree", "Disagree somewhat", "Neither agree nor disagree", "Agree somewhat", "Agree" or "Strongly agree".

BR1. Our company develops technologies by investing in R&D (Research and Development)

(1) Strongly disagree (2) Disagree (3) Disagree somewhat (4) Neither agree nor disagree (5) Agree somewhat (6) Agree (7) Strongly agree

BR2. Our company acquires new technologies

(1) Strongly disagree (2) Disagree (3) Disagree somewhat (4) Neither agree nor disagree (5) Agree somewhat (6) Agree (7) Strongly agree

BR3. Our company is recognised for products that are technologically superior

(1) Strongly disagree (2) Disagree (3) Disagree somewhat (4) Neither agree nor disagree (5) Agree somewhat (6) Agree (7) Strongly agree

BR4. Our company, in product development, employs some of the most qualified industry experts in the country

(1) Strongly disagree (2) Disagree (3) Disagree somewhat (4) Neither agree nor disagree (5) Agree somewhat (6) Agree (7) Strongly agree

BMK1. Our company can segment and target specific markets

(1) Strongly disagree (2) Disagree (3) Disagree somewhat (4) Neither agree nor disagree (5) Agree somewhat (6) Agree (7) Strongly agree

BMK2. Our company can utilise marketing tools (product design, pricing, advertising) to differentiate our products

(1) Strongly disagree (2) Disagree (3) Disagree somewhat (4) Neither agree nor disagree (5) Agree somewhat (6) Agree (7) Strongly agree

BMK3. Our company implements new pricing methods for the export of goods and services
(1) Strongly disagree (2) Disagree (3) Disagree somewhat (4) Neither agree nor disagree (5) Agree somewhat (6) Agree (7) Strongly agree

BMK4. Our company utilises new sales channels abroad
(1) Strongly disagree (2) Disagree (3) Disagree somewhat (4) Neither agree nor disagree (5) Agree somewhat (6) Agree (7) Strongly agree

BMK5. Our company applies new techniques to promote products abroad
(1) Strongly disagree (2) Disagree (3) Disagree somewhat (4) Neither agree nor disagree (5) Agree somewhat (6) Agree (7) Strongly agree

BM1. Our company is consistent in the quality of product manufacturing/production
(1) Strongly disagree (2) Disagree (3) Disagree somewhat (4) Neither agree nor disagree (5) Agree somewhat (6) Agree (7) Strongly agree

BM2. Our company manufactures products designed through R&D (Research and Development) efforts that meet customer needs
(1) Strongly disagree (2) Disagree (3) Disagree somewhat (4) Neither agree nor disagree (5) Agree somewhat (6) Agree (7) Strongly agree

BM3. Our company complies with delivery times in the manufacturing/production of our products
(1) Strongly disagree (2) Disagree (3) Disagree somewhat (4) Neither agree nor disagree (5) Agree somewhat (6) Agree (7) Strongly agree

BM4. Our company employs advanced technologies in manufacturing/production compared to our international competitors
(1) Strongly disagree (2) Disagree (3) Disagree somewhat (4) Neither agree nor disagree (5) Agree somewhat (6) Agree (7) Strongly agree

BL1. Our company identifies and applies technological trends in our industry
(1) Strongly disagree (2) Disagree (3) Disagree somewhat (4) Neither agree nor disagree (5) Agree somewhat (6) Agree (7) Strongly agree

BL2. Our company promotes a learning culture that allows for the identification, assimilation and exploitation of new knowledge essential to the competitive success of the company
(1) Strongly disagree (2) Disagree (3) Disagree somewhat (4) Neither agree nor disagree (5) Agree somewhat (6) Agree (7) Strongly agree

BL3. Whenever we have needed to develop new skills or technologies to offer new products, we have been able to do so efficiently
(1) Strongly disagree (2) Disagree (3) Disagree somewhat (4) Neither agree nor disagree (5) Agree somewhat (6) Agree (7) Strongly agree

BL4. Learning new skills and acquiring new capabilities that enable the introduction of new products is easily achieved
(1) Strongly disagree (2) Disagree (3) Disagree somewhat (4) Neither agree nor disagree (5) Agree somewhat (6) Agree (7) Strongly agree

BL5. We effectively bridge the gap between what we know or have and what we need to know or have to develop new desired products and to introduce them on the market
(1) Strongly disagree (2) Disagree (3) Disagree somewhat (4) Neither agree nor disagree (5) Agree somewhat (6) Agree (7) Strongly agree

BO1. When necessary, our company adopts a flexible organisational structure to adjust to new projects focused on product or process innovation
(1) Strongly disagree (2) Disagree (3) Disagree somewhat (4) Neither agree nor disagree (5) Agree somewhat (6) Agree (7) Strongly agree

BO2. Our company offers managers considerable autonomy in the innovation process
(1) Strongly disagree (2) Disagree (3) Disagree somewhat (4) Neither agree nor disagree (5) Agree somewhat (6) Agree (7) Strongly agree

BO3. In our company, there is strong coordination between the technical (e.g., engineering, projects), sales and manufacturing departments
(1) Strongly disagree (2) Disagree (3) Disagree somewhat (4) Neither agree nor disagree (5) Agree somewhat (6) Agree (7) Strongly agree

BO4. Our company implements new management techniques to improve routines and work practices and to facilitate the use and exchange of information, knowledge and skills within the company

(1) Strongly disagree (2) Disagree (3) Disagree somewhat (4) Neither agree nor disagree (5) Agree somewhat (6) Agree (7) Strongly agree

BO5. Our company implements new work organisation methods to better distribute responsibilities and decision-making tasks, e.g., the establishment of teamwork, the decentralisation or integration of departments, etc.

(1) Strongly disagree (2) Disagree (3) Disagree somewhat (4) Neither agree nor disagree (5) Agree somewhat (6) Agree (7) Strongly agree

BRE1. Our company combines internally and externally developed technologies (e.g., technologies developed by business partners)

(1) Strongly disagree (2) Disagree (3) Disagree somewhat (4) Neither agree nor disagree (5) Agree somewhat (6) Agree (7) Strongly agree

BRE2. Our company maintains a continuous flow of financial resources for the introduction of new products on the market

(1) Strongly disagree (2) Disagree (3) Disagree somewhat (4) Neither agree nor disagree (5) Agree somewhat (6) Agree (7) Strongly agree

BRE3. Our company is skilled in the allocation of personnel

(1) Strongly disagree (2) Disagree (3) Disagree somewhat (4) Neither agree nor disagree (5) Agree somewhat (6) Agree (7) Strongly agree

BRE4. Our personnel continually strive to improve our products and processes

(1) Strongly disagree (2) Disagree (3) Disagree somewhat (4) Neither agree nor disagree (5) Agree somewhat (6) Agree (7) Strongly agree

BRE5. Our employees believe that they are responsible for improving our products and processes

(1) Strongly disagree (2) Disagree (3) Disagree somewhat (4) Neither agree nor disagree (5) Agree somewhat (6) Agree (7) Strongly agree

BS1. In our company, strategy formulation is guided by a strong entrepreneurial vision

(1) Strongly disagree (2) Disagree (3) Disagree somewhat (4) Neither agree nor disagree (5) Agree somewhat (6) Agree (7) Strongly agree

BS2. In our company, senior management is highly capable of understanding external factors that may affect business operations

(1) Strongly disagree (2) Disagree (3) Disagree somewhat (4) Neither agree nor disagree (5) Agree somewhat (6) Agree (7) Strongly agree

BS3. In our company, senior management quickly anticipates the movement of foreign competitors and adjusts strategies to this movement

(1) Strongly disagree (2) Disagree (3) Disagree somewhat (4) Neither agree nor disagree (5) Agree somewhat (6) Agree (7) Strongly agree

BS4. In our company, there is a strong connection between innovation and value recognition by customers

(1) Strongly disagree (2) Disagree (3) Disagree somewhat (4) Neither agree nor disagree (5) Agree somewhat (6) Agree (7) Strongly agree

PARTE C – BUSINESS CONDITIONS

Please indicate your opinion on the following statements concerning the business condition of your company:

CM1. The environment in which the firm competes can support sustained growth and sustainability (environmental munificence)

(1) Strongly disagree (2) Disagree (3) Disagree somewhat (4) Neither agree nor disagree (5) Agree somewhat (6) Agree (7) Strongly agree

CD2. The environment in which the firm competes is characterised by changes that are hard to predict and that heighten uncertainty for key organizational members (environmental dynamism)

(1) Strongly disagree (2) Disagree (3) Disagree somewhat (4) Neither agree nor disagree (5) Agree somewhat (6) Agree (7) Strongly agree

CC3. The environment in which the firm competes is characterised by great uncertainty and great information-processing requirement (environmental complexity)

(1) Strongly disagree (2) Disagree (3) Disagree somewhat (4) Neither agree nor disagree (5) Agree somewhat (6) Agree (7) Strongly agree

To what extent are the following statements suitable descriptions of your company's end products or production process?

CS1. The demand of each type of end product vary quickly

(1) Most unsuitable (2) Unsuitable (3) Unsuitable somewhat (4) Neither suitable nor unsuitable (5) Suitable somewhat (6) Suitable (7) Most suitable

CS2. The new product's time-to-market is very short

(1) Most unsuitable (2) Unsuitable (3) Unsuitable somewhat (4) Neither suitable nor unsuitable (5) Suitable somewhat (6) Suitable (7) Most suitable

CS3. The volume of each type of end product is very high

(1) Most unsuitable (2) Unsuitable (3) Unsuitable somewhat (4) Neither suitable nor unsuitable (5) Suitable somewhat (6) Suitable (7) Most suitable

CS4: Indicate the best estimate time for the introduction interval of new products

(1) <3 months (2) 3–6 months (3) 7–11 months (4) 1–2 years (5) 2–3 years (6) 3–5 years (7) >5 years

PARTE D – BUSINESS PERFORMANCE

In this section, value your company performance in comparison with your competitors for each of the aspects:

DC1. Sales growth

(1) much lower than competitors (2) -- (3) -- (4) equal to competitors (5) -- (6) -- (7) much higher than competitors

DC2. Reputation and image

(1) much lower than competitors (2) -- (3) -- (4) equal to competitors (5) -- (6) -- (7) much higher than competitors

DC3. Customer satisfaction

(1) much lower than competitors (2) -- (3) -- (4) equal to competitors (5) -- (6) -- (7) much higher than competitors

DC4. Market share (of the main product)

(1) much lower than competitors (2) -- (3) -- (4) equal to competitors (5) -- (6) -- (7) much higher than competitors

DC5. Success of new product launches

(1) much lower than competitors (2) -- (3) -- (4) equal to competitors (5) -- (6) -- (7) much higher than competitors

DF1. Return on investment – ROI

(1) much lower than competitors (2) -- (3) -- (4) equal to competitors (5) -- (6) -- (7) much higher than competitors

DF2. Profits as percent of sales

(1) much lower than competitors (2) -- (3) -- (4) equal to competitors (5) -- (6) -- (7) much higher than competitors

DF3. Labor productivity

(1) much lower than competitors (2) -- (3) -- (4) equal to competitors (5) -- (6) -- (7) much higher than competitors

DIPT1. Replacement of products being phased out.

(1) much lower than competitors (2) -- (3) -- (4) equal to competitors (5) -- (6) -- (7) much higher than competitors

DIPT2. Extension of product range within main product field through new products.

(1) much lower than competitors (2) -- (3) -- (4) equal to competitors (5) -- (6) -- (7) much higher than competitors

DIPT3. Extension of product range outside main product field.

(1) much lower than competitors (2) -- (3) -- (4) equal to competitors (5) -- (6) -- (7) much higher than competitors

DIPT4. Development of environment-friendly products.

(1) much lower than competitors (2) -- (3) -- (4) equal to competitors (5) -- (6) -- (7) much higher than competitors

DIPT5. Opening of new markets abroad.

(1) much lower than competitors (2) -- (3) -- (4) equal to competitors (5) -- (6) -- (7) much higher than competitors

DIPT6. Opening of new domestic target groups.

(1) much lower than competitors (2) -- (3) -- (4) equal to competitors (5) -- (6) -- (7) much higher than competitors

DIPS1. Improvement of production flexibility.

(1) much lower than competitors (2) -- (3) -- (4) equal to competitors (5) -- (6) -- (7) much higher than competitors

DIPS2. Reduction of production costs by cutting labor cost per unit.

(1) much lower than competitors (2) -- (3) -- (4) equal to competitors (5) -- (6) -- (7) much higher than competitors

DIPS3. Reduction of production costs by cutting material consumption.

(1) much lower than competitors (2) -- (3) -- (4) equal to competitors (5) -- (6) -- (7) much higher than competitors

DIPS4. Reduction of production costs by cutting energy consumption.

(1) much lower than competitors (2) -- (3) -- (4) equal to competitors (5) -- (6) -- (7) much higher than competitors

DIPS5. Reduction of production costs by cutting rejected production rate.

(1) much lower than competitors (2) -- (3) -- (4) equal to competitors (5) -- (6) -- (7) much higher than competitors

DIPS6. Reduction of production costs by cutting design costs.

(1) much lower than competitors (2) -- (3) -- (4) equal to competitors (5) -- (6) -- (7) much higher than competitors

DIPS7. Reduction of production costs by cutting production cycle.

(1) much lower than competitors (2) -- (3) -- (4) equal to competitors (5) -- (6) -- (7) much higher than competitors

DIPS8. Improvement of product quality.

(1) much lower than competitors (2) -- (3) -- (4) equal to competitors (5) -- (6) -- (7) much higher than competitors

DIPS9. Improvement of labor conditions.

(1) much lower than competitors (2) -- (3) -- (4) equal to competitors (5) -- (6) -- (7) much higher than competitors

DIPS10. Reduction of environmental damage.

(1) much lower than competitors (2) -- (3) -- (4) equal to competitors (5) -- (6) -- (7) much higher than competitors

DIR1. Indicate the fraction of the firm's turnover (in 2016) relating to new or substantially improved products introduced over the period 2014-2016

(1) 0% – 19% (2) 20% – 39% (3) 40% – 59% (4) 60% – 79% (5) 80% – 100%

IO. Identification of the organisation:

IO1. Business unit name: _____
IO2. Which of the following sectors best describes the company's activities? _____
IO3. Country: _____
IO4. When was the company founded (year)? _____
IO5. When was the business unit founded (year)? _____
IO6. Number of employees of the business unit (2017) _____

APPENDIX 5 – FACTOR ANALYSIS

Table 31 – Appendix 5 - Factor analysis for SC strategies

	Agile Eigenvalue = 3.78 Cronbach's Alpha = 0.849	**Lean Eigenvalue = 3.61 Cronbach's Alpha = 0.837**
AL1	-0.177	**0.742**
AL2	0.018	**0.756**
AL3	-0.098	**0.797**
AL4	-0.153	**0.766**
AL5	-0.277	**0.541**
AL6	-0.050	**0.715**
AL7	-0.297	**0.525**
AA1	**0.615**	-0.241
AA2	**0.778**	-0.037
AA3	**0.608**	-0.177
AA4	**0.698**	-0.230
AA5	**0.777**	-0.014
AA6	**0.769**	-0.049
AA7	**0.719**	-0.205

Numbers greater than 0.50 are presented in bold.

Table 32 – Appendix 5 - Factor analysis for business performance

	Commercial Eigenvalue = 2.43 Cronbach's Alpha = 0.803	**Economic and productivy Eigenvalue = 2.24 Cronbach's Alpha = 0.806**
DC1	**0.617**	0.354
DC2	**0.859**	0.220
DC3	**0.762**	0.216
DC4	**0.701**	0.215
DC5	NA	NA
DF1	0.273	**0.853**
DF2	0.232	**0.869**
DF3	0.273	**0.673**

Numbers greater than 0.50 are presented in bold.

* Item excluded from the final construct due to high cross-loadings (above 0.40).

Table 33 – Appendix 5 - Factor analysis for innovation performance

	Process Eigenvalue = 3.40 Cronbach's Alpha = 0.833	**Product Eigenvalue = 4.17 Cronbach's Alpha = 0.904**
DIPT1	0.324	**0.644**
DIPT2	0.212	**0.767**
DIPT3	0.041	**0.708**
DIPT4	0.176	**0.744**
DIPT5	0.154	**0.656**
DIPT6	0.265	**0.658**
DIPS1	**0.562**	0.360
DIPS2	**0.798**	0.116
DIPS3	**0.802**	0.099
DIPS4	**0.738**	0.225
DIPS5	**0.827**	0.135
DIPS6	**0.687**	0.227
DIPS7	**0.698**	0.278
DIPS8	NA	NA
DIPS9	NA	NA
DIPS10	NA	NA

Numbers greater than 0.50 are presented in bold.

* Items excluded from the final construct due to high cross-loadings (above 0.40).

Table 34 – Appendix 5 - Factor analysis for product characteristics

	Innovative Eigenvalue = 1.52	**Functional Eigenvalue = 1.08**
CS1	**0.731**	-0.058
CS2	**0.859**	0.143
CS3	0.210	**0.869**
CS4	-0.453	**0.544**

Numbers greater than 0.50 are presented in bold.