

Contributions to Management Science

António Carrizo Moreira
Luís Miguel D. F. Ferreira
Ricardo A. Zimmermann *Editors*

Innovation and Supply Chain Management

Relationship, Collaboration and
Strategies



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Contributions to Management Science

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Editors

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Preface

Innovation plays an important role in a firm's competitiveness. Its role has been extensively studied at product, process, organizational, and marketing level. It has also been analyzed using a multifaceted perspective, with implications for a firm's performance. However, although innovation processes are important from the firm's perspective, the role of interorganizational networks must not be overlooked. How a firm shares innovation processes throughout the supply chain (SC) underpins a firm's competitiveness as much as the innovation processes inside the firm.

Systematic and discontinuous innovation has a pervasive role in spreading change. When firms embrace innovation in their interorganizational processes, in developing new products jointly with their partners, they involve multiple innovation processes in upstream and downstream activities in the supply chain. In the context of new technologies that threaten to alter the configuration of supply chains, this book discusses the key issues, challenges, opportunities, and trends in the relationship between innovation and supply chain management (SCM).

In our recent experience as professors, researchers, and consultants, we have witnessed the challenges that both innovation and supply chains have faced and the opportunities they have offered separately and altogether. The idea of this book has evolved from these perceptions. We endorse and complement Zinn and Goldsby's statement in a recent editorial from the *Journal of Business Logistics*: What a great time in history to be contributors to the fields of innovation management and supply chain management!

This work builds upon the conclusions of Zimmermann, Ferreira, and Moreira in a recent article published in the *Supply Chain Management: An International Journal* as it seeks to identify and explore the intellectual structure of the intersection of innovation and supply chains (especially in Part I) and explore the different ways that the topic is addressed in the literature. Many of the authors who contribute to this book are engaged in this intellectual pursuit and have devoted their wisdom to this area for several years.

The book is composed of state-of-the-art contributions from innovation and supply chain management scholars from all over the world (UK, Portugal, Brazil,

Italy, the Netherlands, USA, Denmark, Sweden, Canada, France, and China), whose contributions are of added value to academic researchers and practitioners, providing some of the most advanced research, concepts, experiences, and case studies in order to improve firms' competitiveness.

The book also presents some of the most recent developments and best practices in the fields of innovation and supply chain management. This book is intended and designed for a broad audience that includes practitioners and managers, as well as academics and postgraduate students who seek readers regarding relationships, collaboration, and technology involving innovation throughout the supply chain. In this respect, this book is unique as it encompasses applied research, concepts, and practical experience organized in 15 chapters that have been grouped into four different parts.

We hope you enjoy reading the book as much as we enjoyed being the editors and working with our colleagues!

Aveiro, Portugal
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Ricardo A. Zimmermann

Introduction

The book encompasses applied research, concepts, and practical experience organized in 15 chapters that have been grouped into four different parts. Part I describes the intellectual structure of the relationship between innovation and supply chain management. Part II deals with strategies and implications for innovation in the supply chain when involving suppliers. This part covers the importance of coordination, cooperation, and collaboration in new product development (NPD) throughout the supply chain, as well as how small and medium-sized firms (SMEs) differ from large firms. This part also contributes to the debate about supplier-enabled innovation in complex projects and how the Product Innovation Charter (PIC) needs to be addressed by introducing suppliers to the PIC. Finally, this part also addresses the intricacies and practicalities of supplier involvement in NPD.

Part III, titled “Strategies and Implications for Innovation,” embraces and explores different topics, such as purchasing involvement in discontinuous innovation, the importance of culture in information sharing among manufacturing firms, risk allocation and supplier development, and the importance of supply chain innovation. This contributes to our understanding of the importance of the purchasing department in stimulating innovation in the supply chain. The importance of culture in information sharing among industrial firms features strongly in this part, although it has previously been under-researched. While Part II focuses on qualitative studies, as well as personal points of view, Part III offers several quantitative studies, which is a clear indication of the diversity of approaches used.

Finally, Part IV addresses some very exciting topics for the future innovative outlook of supply chains: new technologies and their importance for firms’ future competitiveness. Among the most important topics we can refer Industry 4.0, technological innovation, advanced supply chains, and the role of big data and predictive analytics. They are certainly game changers for most firms.

Part I: The Intellectual Structure

Part I is composed of a single chapter that describes the intellectual structure of the relationship between innovation and supply chain management.

In chapter “*The Intellectual Structure of the Relationship Between Innovation and Supply Chain Management*”, Zimmermann, Ferreira, and Moreira analyze the intellectual structure of the relationship between innovation and supply chain management. Starting from the importance and complexity of this relationship, and using the principles of systematic literature review to identify the papers to be analyzed, the authors develop a bibliometric analysis of the topic. The results show the relevance, the topicality, and the all-embracing character of the theme. Citation analysis was used to identify the most influential studies in the area, and co-citation analysis made it possible to identify the knowledge base of the topic and its intellectual structure. The 35 articles identified as the intellectual base of the topic are divided into four clusters: papers that focus on the structural characteristics of the supply chain network, papers that are predominately characterized by the study of supply chain trust and collaborative advantage, papers that highlight the importance of the long-term integration of suppliers and customers, and papers that deal with some miscellaneous trends in the topic. The chapter contributes to theory by identifying the different approaches that address the relationship between innovation and supply chains in the literature.

Part II: Strategies and Implications for Innovation

Part II is composed of seven chapters dealing with supplier–client relationships, new product development, complex projects, early supplier involvement, and the product innovation charter. Hilletoft, Reitsma, and Erikson authored chapter “*Coordination of New Product Development and Supply Chain Management*”, which deals with a specific but important topic: the coordination of supply chain management and new product development. In a case study, they analyze why and how NPD and SCM should be coordinated. To that end, they explore the critical success factors (CSFs) for NPD involving the market, product, strategic, and product characteristics. Hilletoft, Reitsma, and Erikson conclude that a strong focus on the demand side to develop premium products will necessarily drive high demands on the supply side of the company (SCM), which leads to the development outcome of coordinating NPD and SCM. In this way, the company can ensure that it is able to develop new products and that its supply chain can deliver innovative solutions. Time to market is guaranteed, not only during the NPD phase, but also the product is moved rapidly to the market. Consumer preferences are respected in relation to new products, as well as in lead times, service levels, and supply chain solutions. NPD processes need to identify customer-oriented solutions, well beyond mere technological

improvements, which requires that the company understands its consumers, as well as having supply chain solutions that provide proper consumer services. Holistic solutions in the NPD processes need to involve marketing, product development, R&D, and manufacturing representatives as traditionally occurs, but also involve representatives from sourcing and distribution, in order to coordinate NPD and SCM from the very beginning.

Chapter “*An Investigation of Contextual Influences on Innovation in Complex Projects*” deals with supplier-enabled innovation in the context of complex products, where Kavin and Narasimhan propose a framework for the analysis of innovation-fostering practices to address innovation performance. Based on the unique characteristics of complex products, they argue that an open approach to innovation with external partners needs to be undertaken in order to internalize external knowledge. Flexible management practices that employ network-based solutions are necessary. Risk-taking behavior needs to be ingrained in the organizational practices together with a well-developed absorptive capacity, so that innovation thrives in the firm. For innovation-fostering practices to succeed, Kavin and Narasimhan state that organizational incentives and infrastructural governance practices are needed that foster collaboration and knowledge sharing practices among internal and external stakeholders. This implies that communication must be based on trust and commitment in order to build confidentiality among external partners. They conclude that if firms are to succeed in complex product contexts, they need to follow a relational, network-based approach in which transparency and effective communication encourage commitment and knowledge sharing.

Chapter “*Necessary Governing Practices for Success and Failure of Client-supplier Innovation Cooperation*”, by Servajean-Hilst, is about governance practices for the success of supplier–client innovation cooperation. Based on the necessary condition analysis (NCA) of 160 supplier–client relationships, he concludes that, to succeed, firms need to manage their supplier–client relationships and portfolios strategically. The involvement of the supplier’s top management is a necessary condition for success, and lack of involvement of the client’s top management is a necessary condition for failure. Moreover, involving purchasing and R&D functions is essential for the supplier–client relationship to work positively. Encouraging attitudes and the absence of threats are necessary conditions for success. Defining governance roles and responsibilities are also crucial if relationships are meant to last. The chapter ends with a list of critical government practices that are necessary, and those that should be avoided, to promote the flourishing of suppliers and clients in innovation cooperation.

Chapter “*Collaborative New Product Development in SMEs and Large Industrial Firms. Relationships Upstream and Downstream in the Supply Chain*”, by Silva and Moreira, addresses collaborative new product development (CNPD) involving upstream and downstream relationships with suppliers and clients, taking into account both SMEs and large firms. Based on a set of eight case studies—where they analyze the type of collaboration, CNPD focus, CNPD objectives, and types of suppliers and clients—they seek to answer two research questions: How does CNPD

differ in upstream and downstream relationships? How do firms intervene in CNPD according to their size and the innovation created?

This chapter concludes that CNPD is asymmetric, more often actively engaging suppliers than clients, because interaction involving industrial suppliers is more frequent and intense than interaction with industrial clients. Moreover, firms generally involve their suppliers to diversify their product portfolio. Silva and Moreira also conclude that CNPD is not restricted to large firms but also occurs when SMEs involve large firms as suppliers. Silva and Moreira demonstrate that CNPD is influenced by the technological intensity of the industry in which firms operate. In general, collaboration between firms operating in the same industry results in product differentiation, whereas CNPD carried out between firms operating in different industries creates diversified products or promotes increased efficiency in the firms' activities.

Silva and Moreira conclude that although CNPD is normally carried out between large firms operating in high-tech industries with large-scale production, SMEs operating in high-tech industries involve large firms in CNPD. Moreover, upstream and downstream CNPD is influenced by the technological intensity of firms' operating industries, and firm size affects their intervention in CNPD only when a high scale of production is required.

Product Innovation Charters are the focus of chapter "*It's Time to Include Suppliers in the Product Innovation Charter (PIC)*", where Roy explores the importance of the mission statement of innovation to managers in influencing how and when to involve suppliers. Roy explains the importance of the Product Innovation Charter and argues that suppliers need to be explicitly included in the charter. For that, firms need to be aware of the roles and capabilities, not only of existing suppliers but also of new potential suppliers, as they can be a new source of ideas and technology. In order to balance the innovative potential, whether incremental or radical, the Product Innovation Charter needs to include the management/incorporation of new technologies as well as intellectual property concerns throughout the whole product development process in order to avoid intellectual property leaks and to encourage active/participative supplier involvement. At the end of the chapter, Roy sets out a set of guidelines for framing supplier relationships in a Product Innovation Charter.

In chapter "*Mission Impossible: How to Make Early Supplier Involvement Work in New Product Development?*", Van Weele reports insights from his personal reflection on PhD research projects he has supervised, dealing with the obstacles and difficulties with early supplier involvement in new product development. This chapter builds on the premise that problems of effective supplier involvement are related to the manufacturer organization, the supplier organization, and the supplier–manufacturer relationship. Van Weele supports the idea of using timely supplier involvement rather than early supplier involvement, where timeliness is matched to key processes—prioritizing, mobilizing, coordinating, timing, and informing—

when dealing with supplier interface management involving development management activities, project management activities, and product management activities with suppliers. Effective supplier collaboration must involve strategic, operational, and collaborative management processes, which need the exchange of information between all parties involved and human capital to generate time-tuned group dynamics among firms. Van Weele concludes that, although early supplier involvement may result in disappointments, in order to embark on joint collaborative product development activities, it is important to address the human perspective with sufficient resources and adequate governance rules. Joint project teams need to be aware of the project mission, project objectives, and the project work plan and be aware how investments will be recorded, how both parties deal with intellectual property, and how progress is assessed regularly so that teams are committed to the relationship.

Part III: Strategies and Implications for Innovation

Part III is composed of four chapters that deal with four different topics: purchasing involvement in discontinuous innovation, the importance of culture in information sharing among manufacturing firms, risk allocation and supplier development, and the importance of supply chain innovation.

Calvi, Johnsen, and Picaud address purchasing involvement in discontinuous innovation in chapter “*Purchasing Involvement in Discontinuous Innovation: An Emerging Research Agenda*”. This is an important and under-researched topic dealing with the role of the purchasing department in the organizational structure and its influence on product innovation involving discontinuous change. After a systematic literature review of an initial sample of 287 papers that resulted in the analysis of 22 articles, they conclude that a common theme across the research is that radical/discontinuous/breakthrough innovation leads to the need to change supplier relationships, which is at odds with the typical steady-state behavior of most purchasing departments that seek stable relationships that maintain cost and integrate responsibility of their suppliers over the entire product life cycle. Calvi, Johnsen, and Picaud put forward three propositions to help purchasing departments deal with discontinuous innovation. First, the purchasing function needs to go well beyond the existing supply chain, so that it can complement the delicate balance of long-term collaborative relationships with the flexibility of being constantly aware of breakthrough technology from potential new suppliers. Second, the purchasing function needs to handle the challenge of discontinuous innovation through an ambidextrous approach; it is important to organize the purchasing department with skills and competences to develop strategic sourcing activities and at the same time to explore the possibility of embedding new technologies from new sources. Third, the purchasing department, as an innovation-oriented organization, needs to develop absorptive capabilities in order to acquire, assimilate, transform, and exploit external knowledge from the supply chain to help the firm to develop and produce brand new

products and generate discontinuous innovation. As recommended in chapter “*It’s Time to Include Suppliers in the Product Innovation Charter (PIC)*” by Van Weele, the purchasing department needs to play an important facilitator role with R&D and engineering departments in technology scouting if the firm is to generate new discontinuous products.

Golini, Mazzoleni, and Kalchschmidt study the national culture as an antecedent for information sharing in supply chains in chapter “*National Culture as an Antecedent for Information Sharing in Supply Chains: A Study of Manufacturing Companies in OECD Countries*”. Using an interesting approach, Golini et al. investigate the relationship between national culture and the willingness of a company to invest in information sharing with both their suppliers and customers. The main focus of the chapter is the specific role of the country’s cultural peculiarities of power distance and individualism–collectivism in influencing the extent of external supply chain information sharing. The authors used data from the fifth edition of the International Manufacturing Strategy Survey, a project that studies manufacturing and supply chain strategies through a detailed questionnaire administered simultaneously in different countries. A set of 392 companies from 16 countries belonging to OECD were used in the analysis. For Golini et al., the results indicate a significant and complex relationship between individualism–collectivism and power distance and the amount of investment that a focal company is willing to make in information sharing with its supply chain partners. The chapter provides an interesting contribution both to theory—extending the debate on supply chain integration at global level—and practice—helping managers to recognize the cultural implications of cross-cultural collaboration.

In chapter “*Risk Allocation and Supplier Development in Automotive Supply Chains: A Study of Nissan Europe*”, Camuffo investigates the case of Nissan Europe—in the context of the merger with Renault—to discuss risk allocation in Original Equipment Manufacturer (OEM)–supplier relationship, a topic that is critical to ensure innovation and competitiveness. Camuffo analyzes vertical interfirm relationships and explores the extent to which Nissan shares risk with its suppliers and how the level of risk sharing relates to suppliers’ financial, structural, location, and technological characteristics. The data used were collected from a variety of sources, including data provided by Nissan and structured interviews, as well as information on the supplier relations of the Nissan Europe Barcelona plant with 113 companies. These companies supply about 80% of the total purchasing volume for the car models produced at the plant, and for these suppliers, Nissan represents a significant share of their business, up to 60% of their revenues. The results show that the OEM absorbs more risk (a) the greater the supplier’s environmental uncertainty, (b) the more risk averse the supplier, and (c) the less severe the supplier’s moral hazard. The analysis also shows that Nissan absorbs risk from their suppliers to a non-negligible degree, but that global pressure to reduce costs, technological changes, and organizational changes related to the alliance with Renault moved the company toward a more competitive configuration.

Chapter “*Does Supply Chain Innovation Pay Off?*” investigates the relationship between supply chain innovation and firm performance among 187 Danish

manufacturers. Stentoft and Rajkumar separate supply chain innovation into three main components—business process, network structure, and technology. Firm performance is measured in terms of market performance and operational performance. They conclude that, when analyzed as a single construct, supply chain management exerts more influence on operational performance than on market performance. This indicates that although firms understand the development of a market-oriented supply chain, firms must be forced to manage their supply chain if they are to improve their competitive behavior. When the supply chain management construct is decomposed into its three main components, the results are somewhat different. Business process, network structure, and technology all influence operational performance, but only network structure influences market performance. The results clearly indicate that firms associate supply chain management more with operations than with market issues. However, firms need to be aware that if they want to be competitive and succeed in the market place, they must intertwine business processes, network structures, and technology at both market and operational levels.

Part IV: Information and Technology

Part II is composed of four chapters that address technology-based issues that are important for the future competitiveness of firms: Industry 4.0, technological innovation, advanced supply chains, and the role of big data and predictive analytics.

In chapter “*Technological Innovations in Supply Chains*”, Druehl, Carrillo, and Hsuan offer an overview of a set of emerging technologies—3D printing, virtual reality, autonomous vehicles, drones, and the Internet of Things (IoT)—that can be applied in many stages of the supply chain (SC) and that offer tremendous potential to improve SC transparency, reduce costs, and increase convenience for consumers. Druehl et al. focus on those five technologies to achieve a more profound view of each, their impact on the SC, and interesting future research questions. They highlight not only the stages in which these technologies are but also their potential impact. They discuss each technology, identifying where and how each can be used in the SC. They identify managerial, IS/IT, and policy implications including benefits, risks, existing research, and potential future research areas. Druehl et al. argue that there is still a great deal of uncertainty about these technologies as they are still under development, the regulatory landscape is evolving, and dominant designs and platforms are not yet established. All the technologies will require changes to public or corporate infrastructure such as factories, SC networks, highways, and communication networks. Most require integration with existing SC information systems, as well as with suppliers’ and customers’ systems, to gain the full benefits. Moreover, the technologies and their uses raise some fundamental questions about data safety and privacy. As standards and dominant designs emerge, there will probably be a period of consolidation in each industry and its supporting industries. More interesting is the question of how these technologies will combine. Combinations seem likely at some future date as these technologies address different needs in

the SC, and where they can potentially interact, they seem to reinforce one another, each making the other more useful.

In chapter “*The Role of Informational and Human Resource Capabilities for Enabling Diffusion of Big Data and Predictive Analytics and Ensuing Performance*”, Mishra, Luo, and Hazen discuss the role of information and human resource capabilities for enabling diffusion of big data and predictive analytics (BDPA) and ensuing performance. Mishra et al. claim that meaningful information cannot be extracted by just applying analytical tools to data. It requires intense collaboration between analysts and managers exploiting data and analytic tools to discover new knowledge. Innovations like BDPA have the potential to improve customer response times, lower inventories, shorten time to market for new products, improve decision-making processes, and enable a supply chain visibility. However, to realize these benefits of innovation, it is not sufficient to simply adopt the innovation. Instead, it must be accepted, routinized, and assimilated to some extent within the organization. The authors argue that the current knowledge on BDPA regarding how it might link organizational capabilities and organizational performance remains unclear, and knowledge of the support human resources (HR) might give this linkage is even more limited. Drawing from the resource-based view, Mishra et al. propose a model to examine how information technology deployment (strategic information technology flexibility, business–BDPA partnership, and business–BDPA alignment) and HR capabilities affect organizational performance through BDPA. A survey mainly targeted at Indian firms was conducted and 159 usable responses were obtained. Mishra et al. conclude that strategic information technology flexibility, business–BDPA partnership, business–BDPA alignment, and HR capabilities have a direct impact on BDPA diffusion, whereas these constructs have an indirect impact on organizational performance. Those findings provide guidance and assurance that BDPA usage can benefit organizations.

In chapter “*Adoption of Industry 4.0 Technologies in Supply Chains*”, Dalmarco and Barros discuss how supply chains may benefit from the adoption of I4.0 technologies by their partners and highlight some of its implementation challenges. I4.0 is a concept used to characterize the new strategic positioning of German industry, based on a flexible Internet-based production system that uses communication improvements that allow a more decentralized production process, integrating sensors and actuators through Internet connection. Dalmarco and Barros analyze eight technologies that cover most I4.0 applications and claim that, at an individual level, technologies such as additive manufacturing, collaborative robots, visual computing, and cyber-physical systems establish the connectivity of a certain company. However, the integration of the whole supply chain, based on the principles of I4.0, demands that information provided by each company (big data) is shared through a collaborative system based on cloud computing and IoT technologies. To share useful information safely, cyber security techniques must be implemented in individual systems and cloud solutions. Summing up, even though the adoption of I4.0 demands an individual initiative, it will only raise the supply chain’s competitive advantage if all companies adapt their manufacturing and supply chain

processes. The main advantage foreseen here is based on an improved communication system for the whole supply chain, bringing consumers closer to the production process. To assist companies and researchers interested in I4.0 for supply chains, this chapter summarizes the main technologies applied to I4.0 and examples of their adoption by different industries.

Dalmarco and Barros argue that, besides improving the productivity of the supply chain, the adoption of I4.0 technologies adds the possibility of new business models. The integration and expansion of the supply chain and the combination of products and services available to other companies and to the final customer are some of the possibilities available. The development of innovative projects among supply chain companies is also easier when partners are already digitally integrated. In the end, the use of the Internet to share and absorb data is the new trend of the Internet-based society, and the adoption of technologies related to I4.0 is the first step supply chains should take to stay competitive.

To conclude, in chapter “*Advanced Supply Chains: Visibility, Blockchain and Human Behaviour*”, Kharlamov and Parry discuss one of the most recent and potentially most significant technologies: Blockchain technology. Blockchain technology is secure by design and can enable decentralization and visibility, with applications in cryptocurrency transactions, historical records, identity management, traceability, authentication, and many other areas. Blockchain technology is a great invention of the digital age with a multitude of possible applications in supply chains. However, successful adoption of such technology requires that the people, process, and technology are ready. Kharlamov and Parry propose a conceptual framework where the concept and technology can balance between positive and negative manifestations depending on human behavior, therefore determining the success of Blockchain technology application in supply chains. Kharlamov and Parry claim that, while both the concept and technology are relatively ready, human behavior is a challenge, as it is known that people suffer from habits and perform poorly when exposed to large volumes of data. The list of biases is extensive with the respective debiasing methods that can potentially help to correct for error. Therefore, any implementation of the Blockchain technology in the future should consider the behavioral aspect in order to ease its implantation, acceptance, and use. The authors claim that much of the possible future of supply chains depends on the readiness of human psychology to accept automated and decentralized systems.

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First, a word of gratitude to all coauthors who embarked with us in this exploratory journey of intertwining not only topics of innovation with supply chain but also their knowledge and experience creating an insightful book that otherwise would not be possible.

Last but not the least, to all our beloved ones.

Thanks to Alice for “steering the boat” in my absence. Without her patience and support, it would have been harder. To my son and daughter, Luís and Isabel, a word of gratitude. They just don’t know that I miss them twice as much as they miss me.

Thanks to Isabel, companion of a life, thank you for your immense patience, support, and love. For my dear children, Joao and Joana, who often wonder why I spend so much time in the office, I dedicate this book to them too.

Thanks to Patrícia for being the “coauthor” of my life now and ever. Thanks to Miguel for being a great son and a little big friend. And thanks to my daughter Lara, who was born during this journey and has been a new reason to carry on and go further.

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Ricardo A. Zimmermann

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Part I
Innovation and Supply Chain Management

The Intellectual Structure of the Relationship Between Innovation and Supply Chain Management



Ricardo A. Zimmermann, Luís Miguel D. F. Ferreira,
and António Carrizo Moreira

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 analyzes 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.

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 et al. 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 and Sivakumar 2010; Golgeci and Ponomarov 2013; Narasimhan and Narayanan 2013; Arlbjorn and Paulraj 2013; Zimmermann et al. 2016).

Innovation enables the development of unique products and services leveraging firms in their quest for competitive advantage (Hilletoft and Eriksson 2011; Blome et al. 2013; Bellamy et al. 2014). As firms' ability to innovate is the result of internal

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and external factors (Roy et al. 2004; Berghman et al. 2012; Fawcett et al. 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 et al. 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 and 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 et al. 2005; Fawcett et al. 2012; Blome et al. 2013).

Taking these facts into account, this chapter analyzes 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 analyzing 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 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 analyzed 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 analyzed 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 analyzed, 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:

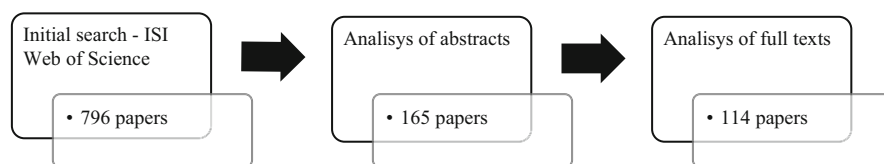


Fig. 1 Location and selection of the articles

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). The search was conducted in March 2017 (Fig. 1).

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.

3 Bibliometric Analysis

Gerdri et al. (2013, p. 404) define bibliometric analysis as “a method that uses statistical and mathematical methods to analyze 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 et al. 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 Charvet 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

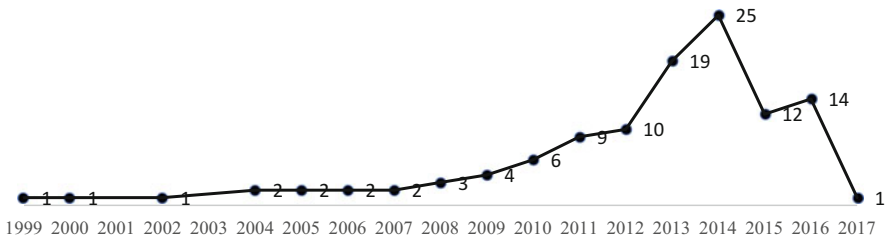


Fig. 2 Number of articles per year

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. 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).

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 2 shows the evolution of the topic in the literature since 1999, when the first article was published. About 70% of the articles were published in the last 5 years (since 2012), which shows that the theme is relatively new in the literature.

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 1 presents the main publishing journals.

Table 1 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

(continued)

Table 1 (continued)

Journal	1999	2000	2002	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Total
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

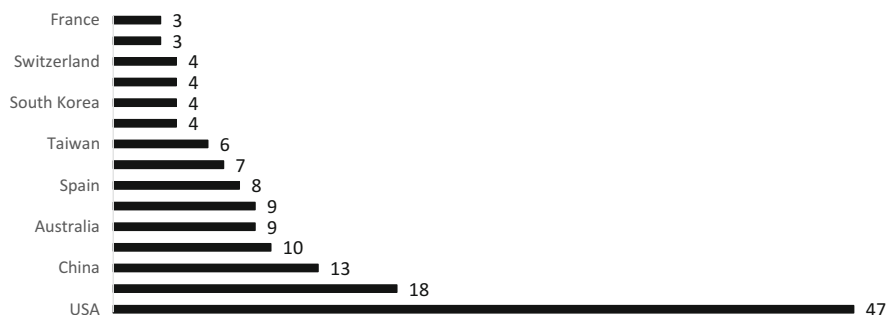


Fig. 3 Countries with the largest number of publications

Finally, the articles are also widely dispersed geographically (authors from 32 countries were identified), demonstrating that the subject is of global interest, as Fig. 3 shows.

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.

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 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.

Table 2 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 modeling	3

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 3.

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 and 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 and 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 (Fig. 4).

Table 3 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

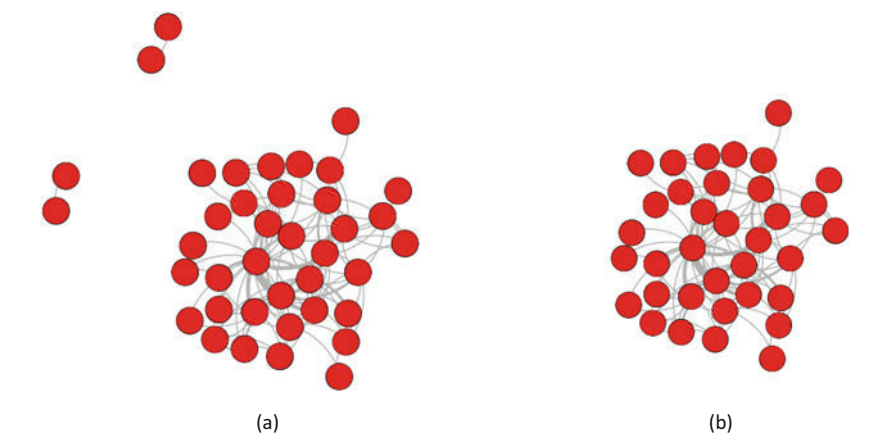


Fig. 4 Co-citation network with and without remote nodes removed. (a) The initial 39-node co-citation network. (b) The 35-node co-citation network after removing the with remote nodes remote nodes

The 35 papers remaining articles can be understood to be intellectual base of the topic (Table 4).

Table 4 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	
Wang LW	2011	V134	INT J PROD ECON
Panayides PM	2009	V122	INT J PROD ECON
Pero M	2010	V15	SUPPLY CHAIN MANAG
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

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 and Cater 2015). The nodes of a network



Fig. 5 The position of the four literature clusters

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 5 shows the position of the four clusters.

Figure 6 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.

Table 5 shows the number of articles published each year in each cluster and Table 6 shows the articles that belong to each cluster.

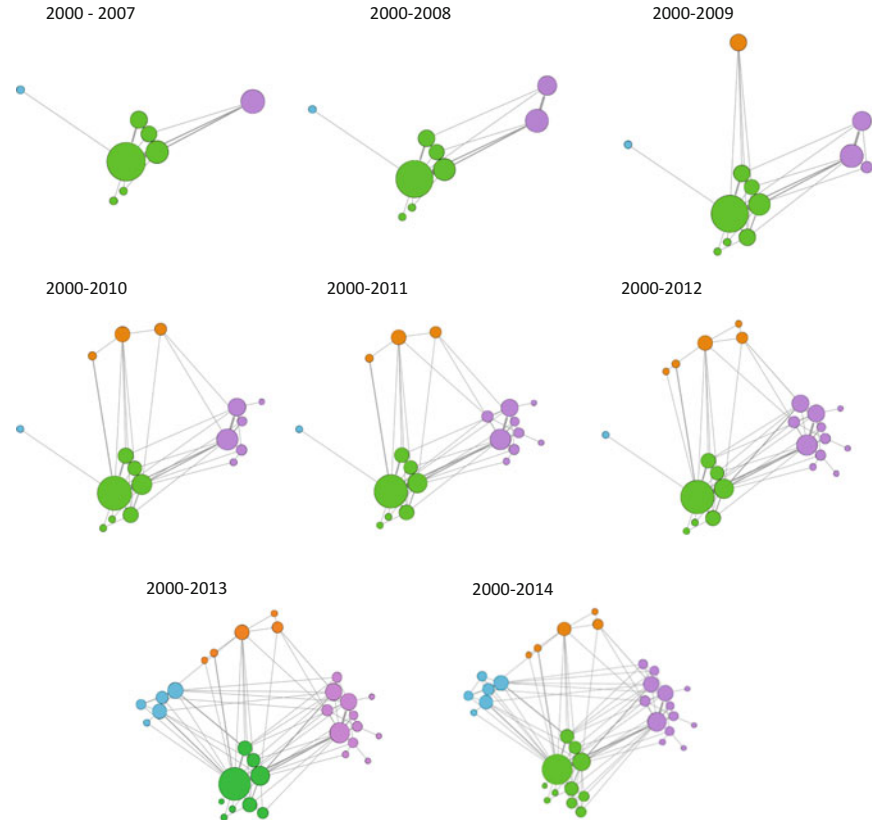


Fig. 6 Evolution of the research areas/clusters over time

Table 5 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 6 Papers belonging to each cluster: co-citation PageRank measure

Cluster 1	Cluster 2	Cluster 3	Cluster 4
Petersen K, 2005, V23, P371, J OPER MANAG	Roy S, 2004, V32, P61, J ACAD MARKETING 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, MANAGEMENT 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		