D 2018

U. PORTO
FEUP FACULDADE DE ENGENHARIA
UNIVERSIDADE DO PORTO

UNDERSTANDING CUSTOMER-FOCUSED SUPPLY CHAIN MANAGEMENT: A SET-BASED CONCEPT FRAMEWORK

JOÃO AUGUSTO DE SOUSA BASTOS

TESE DE DOUTORAMENTO APRESENTADA
À FACULDADE DE ENGENHARIA DA UNIVERSIDADE DO PORTO EM 18-12-2018

ÁREA CIENTÍFICA DE ENGENHARIA E GESTÃO INDUSTRIAL

João Augusto de Sousa Bastos

U. PORTO
FEUP FACULDADE DE ENGENHARIA
UNIVERSIDADE DO PORTO
DEPARTAMENTO DE ENGENHARIA E GESTÃO INDUSTRIAL

Understanding Customer-Focused Supply Chain Management: A Set-Based Concept Framework

Submitted to Faculdade de Engenharia da Universidade do Porto in partial fulfilment of the requirements for the degree of Doctor of Philosophy in Industrial Engineering and Management, supervised by Américo Lopes de Azevedo, Associate Professor of Faculdade de Engenharia da Universidade do Porto and co-supervised by Paulo António Silva Ávila, Coordinator Professor of Instituto Superior de Engenharia do Porto do Instituto Politécnico do Porto

Department of Industrial Engineering and Management
Faculdade de Engenharia da Universidade do Porto
2018

This research was partially supported by INESC TEC.

“What's beyond the door?
Sometimes answers lead to more questions”

Olivia in Fringe TV Series

ACKNOWLEDGMENTS

After this lengthy project, the author wishes to extend its gratitude and appreciation for several people. Firstly, I would like to thank my wife and long-term companion, Rosa Maria, for her love, kindness, and support she has shown during the past years it has taken me to finalize this thesis. Furthermore, I would also like to thank my daughter, Joana, for their endless love and patience, especially in the summer periods. I also want to send a particular word to my brother Alberto, for his support and encouragement in the difficult times I encountered during this endeavor. At the same time, I cannot forget my family and friends in general, who always supported me with their love, friendship, and appreciation.

Equally, I would like to thank INESC TEC for all support provided during these years. Primarily, I would like to thank my supervisor Doctor Américo Azevedo not only for his friendship but also due to his continuous motivation, assistance, and guidance during the entire doctoral program. Also, I would like to underline the support provided by my colleagues António Almeida, Roberto da Piedade Francisco, and Álvaro Caldas, as well as by the director of INESC TEC, Eng. Luís Carneiro, who always provided me with the resources and infrastructures necessaries to the fulfillment of this doctoral program. Not forgetting Professor Jorge Pinho de Sousa is valuable support and friendship.

Finally, and yet necessary, I would like to be grateful to the Department of Mechanical Engineering of ISEP, more concretely the Doctor Paulo Ávila, co-supervisor and colleague, for believing in my project and for is continuous support and friendship.

ABSTRACT

The current business reality, grounded in a customer-focused orientation, demands for an ever-growing number of new and innovative products framed within an increasingly shorter time response, smaller delivery quantities and shorter life cycles. In reaction, the modern supply chains are required to respond quickly, effectively, proactively and efficiently to changes in the marketplace to sustain, and furthermore, foster competitive advantage.

This research proposes to study how customer-focused supply chain management can address the future challenges that their networked organizations are facing shortly, namely through the adoption of cooperative and collaborative strategies addressing the value-chain.

The present study started with the objective of investigating and understanding the different instances of supply chains materializations through an analysis model. An extensive literature review and a comprehensive study of the fashion footwear industrial sector inspired the analysis model proposal. The developed model proved to be a valid instrument for the supply chain classification and further understanding. The present proposal, aiming to assist both practitioners and academicians, established a correspondence between each one of the classification dimensions (product; demand & sourcing; infrastructure) and the adequate operational strategy for the supply chain. The proposed analysis model and the correspondent operational strategy mapping undergo a test and validation phase in four supply chain instances.

Bearing with the analysis model and supported with the multiple case analysis located in the fashion footwear industry sector, it was possible to identify, and detailed relevant business processes, methods, and tools required to address the specificities and challenges of customer-focused supply chains. The research project, departing from the results of this study, progressed with the design and development of an innovative supply chain framework. The framework fosters a knowledge-intensive approach and is based in a lean-inspired Set-Based Concurrent Engineering (SBCE) design support tool.

The framework addresses nine critical collaborative business processes and includes the development of three business support tools. The first, KMT (Knowledge Management Tool) aimed to collect market knowledge regarding consumers' trends and expectations for innovative and fashionable products. The second tool, Set-BasePD (Set-Based Product Design Tool) targeted to support the collaborative design of complex and innovative products in a network environment. The third tool, CPlan (Collaborative Planning Tool), it is intended to assist and support negotiated collaborative planning in customer-focused supply chains of independent and non-hierarchical networks of companies.

The entire framework was tested and validated within two different industrial sectors, both of them presenting complex manufacturing processes in customer-focused environments. The present framework proposal aims to bring further insights to the body of knowledge of customer-focused supply chain management by addressing the critical processes that companies need to endorse and dynamically tackle the unpredictable demand of innovative and fashionable products.

RESUMO

A atual realidade empresarial, assente numa orientação focada no cliente enfrenta a necessidade de produzir um número cada vez maior de produtos novos e inovadores enquadrados em tempos de resposta cada vez mais curtas, menores quantidades nos lotes de produção e ciclos de vida do produto mais curtos. Em reação, as cadeias de abastecimento modernas são compelidas a responder às solicitações do mercado de uma forma cada vez mais rápida, efetiva, proactiva e eficiente, a fim de sustentar e, além disso, promover a vantagem competitiva. O atual mercado de negócios aspira a um número cada vez maior de produtos novos e inovadores enquadrados em respostas cada vez mais curtas com menores períodos de entrega e ciclos de vida mais reduzidos.

O presente projeto de pesquisa propôs-se estudar como os vários gestores das cadeias de fornecimento podem encarar os desafios que suas organizações em rede enfrentam num futuro próximo, nomeadamente através da adoção de estratégias colaborativas e cooperativas nas suas cadeias de valor.

A presente pesquisa, começou por investigar, procurar compreender e caracterizar as diferentes instâncias das cadeias de fornecimento através do desenvolvimento de um modelo de análise. O modelo de análise foi inspirado numa extensa revisão da literatura e numa pesquisa com recurso ao estudo de múltiplas instâncias no setor industrial do calçado. Este modelo foi desenvolvido como um instrumento para a classificação e compreensão das cadeias de fornecimento atuais. Com o objetivo de auxiliar tanto os profissionais como os acadêmicos. A presente proposta estabeleceu uma correspondência entre cada uma das dimensões da classificação (produto, procura & aprovisionamento, rede) e a estratégia operacional adequada para a cadeia de abastecimento. O modelo de análise resultante da investigação foi testado em quatro casos de estudo.

Munido do modelo de análise e suportado com a pesquisa dos casos de estudo múltiplos orientada para o setor da indústria do calçado foi possível identificar processos, métodos e ferramentas de negócio relevantes para atender às especificidades e desafios das cadeias de abastecimento focadas no cliente. Como resultado deste estudo, um quadro de referência inovador para a cadeia de fornecimento foi projetado e desenvolvido. O quadro de referência promove uma abordagem intensiva de conhecimento e é baseado na ferramenta de suporte à conceção de produtos *Set-Based Concurrent Engineering* (SBCE) inspirada no *lean*.

O quadro de referência aborda nove processos críticos de negócio colaborativos e inclui o desenvolvimento de três ferramentas de suporte empresarial. A primeira, o KMT (Knowledge Management Tool), que tem como objetivo recolher o conhecimento do mercado sobre as tendências e expectativas dos consumidores dos produtos inovadores e de moda. A segunda ferramenta, Set-BasePD (Set-Based Product Design), orientada para apoiar a conceção colaborativo de produtos complexos e inovadores num ambiente de rede. E a terceira ferramenta, o CPlan (Collaborative Planning), uma ferramenta projetada para auxiliar e apoiar o planeamento colaborativo numa base negociada em cadeias de abastecimento focadas no cliente para redes de empresas independentes e não hierárquicas.

Todo o quadro de referência foi testado e validado em dois setores industriais distintos, ambos relacionados com a produção de produtos complexos em ambientes colaborativos. A presente proposta do quadro de referência visa acrescentar maior compreensão à área de conhecimento da gestão de cadeias de abastecimento focadas no cliente, abordando os processos críticos que as empresas precisam promover para lidar dinamicamente com a procura imprevisível de produtos inovadores e sazonais.

PREFACE

This thesis represents a culmination of a long path of work and dedication that has taken place throughout seven years (2010 - 2017). During this period, I participated in two R&D European Commission funded projects comprising two large consortiums of European research institutions, Engineering schools, and industrial partners. During these projects, I have met amazing people, with whom I have acquired valuable knowledge, explored and developed not only technical competences but also soft and relational skills. From this group of people, I would like to highlight my colleagues at INESC TEC with whom it was possible to have long and fruitful discussions that had a profound impact on the success of my research.

At the beginning of this long research journey, there was a pure academic desire to understand better and grasp the concept of a supply chain in the current business landscape. During the early stages of the research, it was possible to perceive that several of the contemporary supply chain practices may no longer fit the volatile context that most businesses operate. The study showed that current methods were previously developed under assumptions of stability and predictability that no longer hold valid. Facing this new reality, the focus of this research was redirected to identify and understand what business processes, practices, and tools supply chain managers need to endorse and achieve customer satisfaction.

At this stage, I would like to emphasize the guidance of my supervisor Doctor Américo Azevedo, during these recent years of my research endeavor. Our involvement in two research projects has enabled a better understanding of customer-focused supply networks. Primarily, I would like to highlight the importance of our participation in the European project called "CoReNet - Customer-oriented and eco-friendly networks for healthy fashionable goods." This project developed and co-financed under the umbrella of the 7th Framework Program from the European Commission involved more than 13 European institutions from industrial and scientific areas.

The project CoReNet aimed to study the consumer needs and expectations of a wide range of European citizens as well as specific target groups. Using this knowledge, the European Textile, Clothing and Footwear Industry would be able to supply small series of clothes and footwear products with high quality, affordable price and eco-compatibility assurance. Due to my involvement in this project, I had the opportunity to travel to different European countries and meet people from some of the best research institutions in the field such as CNR-ITIA from the Polytechnic of Milano, DITF and IPA Fraunhofer from Germany. At the same time, I had the chance to share experiences and acquire valuable knowledge regarding European Textile, Clothing and Footwear Industry. This industrial sector is facing first-hand the demand of small series of functional and fashionable clothes and footwear goods with high customization, short response times at competitive prices. During the project, it was possible to perform an in-depth study of the supply chain management practices and approaches of textile companies such: ColorTextil in Germany or Bivolino in Belgium; and footwear companies such as Manas in Italy, Ecco, and Kyaia in Portugal.

It was possible, advancing from the CoRenet project results, to identify specific business processes, methods, and tools that enable customer-focused supply chains to address the increasing turbulence in the market demand. These research findings guided the implementation of a new conceptual framework designed to support the creation, management, and decision-making of customer-focused supply chains.

As a 'proof of concept' of the proposed framework, we have successfully developed a set of management tools, strictly focused on assisting supply chain decision-makers in managing the entire life cycle of a customer-focused supply chain. These management tools were installed in several textile and footwear industrial companies, namely at Bivolino, Fratelli Piacenza, Manas, and others, and are supporting decision makers to enhance the competitiveness of their companies.

Moreover, with the INESC TEC support, I had the opportunity to participate in a series of international conferences where I disseminated my research work related with the proposed set-based customer-focused framework with some of the experts in the area. For instance, I would like to highlight my participation in the PRO-VE 2013, PRO-VE 2015, PRO-VE 2016 conferences where I had rich and rewarding discussions and suggestions from a panel of experts.

In sum, I firmly believe that the entire path that followed during this doctoral program gave me not only the valuable knowledge and experiences to develop the work reported in this document, but also to prepare myself for successfully dealing with the challenges that will arise during my life after finishing my Ph.D.

Contents

List of Figures

List of Tables

List of Abbreviations and Acronyms

BPM: Business Process Management

BPMN: Business Process Modelling Notation

BSC: Balance Scorecard

CN: Collaborative Network

CO: Customer Order

CRM: Customer Relationship Management

DfE: Design for Environment

DSR: Design Science Research

DM: Data Mining

DW: Data Warehouse

ECD: Environmentally Conscious Design

ECR: Efficient Consumer Response

EDI: Electronic Data Interchange

EMS: Environmental Management System

EPD: Environmental Product Declaration

ERP: Enterprise Resource Planning

ETL: Extract, Transform and Load Data

GrSCM: Green Supply Chain Management

ICT: Information and Communication Technologies

IT: Information Technology

JIT: Just in Time

KPI: Key Performance Indicator

LCA: Life-Cycle Assessment/Analysis

LM: Lean Management

NPD: New Product Development

OLAP: On-Line Analytical Processing

PIM: Product Information Management

PO: Production Order

QbD: Quality by Design

QFD: Quality Function Deployment

R&D: Research and Development

SBCE: Set-Based Concurrent Engineering

SC: Supply Chain

SCM: Supply Chain Management

SCOR: Supply Chain Operations Reference Model

SQL: Script Query Language

S&OP: Sales and Operations Planning

TCFI: Textile, Clothing and Footwear Industry

TQM: Total Quality Management

WIP: Work in Progress

Chapter One

INTRODUCTION

The increasing globalization over the past decades has forced the industrial enterprises to update its supply chain strategy in line with the new and challenging circumstances of a globalized and competitive market. Thus, company managers have put a growing interest in developing strategies designed to provide companies with the resources and capabilities to compete successfully in the market. Companies' managers, facing a competitive market, are constantly challenged to reduce the lead-time between technical or market opportunity arising and satisfying the customer need with full-rate production of a quality product.

The time to market on the case of innovative goods is a critical factor since all competitors get access to new technical ideas and further market information at about the same time. This context forces companies to rethink their strategies. To design, develop, produce and distribute such products, new approaches and related supporting services for collaborative networking are increasingly mandatory to companies succeed in addressing the market demand through the next generation of supply chains.

In line with this context, chapter one of this document presents succinctly the scope of this research project as well as the results that are expected to introduce in the supply chain management domain. In addition to the topics previously described from the research perspective, this chapter also includes the outlined research questions and the methodology used to conduct this research project successfully.

1.1. Context and Relevance

The acceleration of globalization and rapid technological evolution are leading to increased unpredictability and instability across all regional and national markets. The emergence of global markets are forcing the companies, SMEs in particular, to adapt to a new competitive environment to proactively respond to challenging market requirements with increased responsiveness and flexibility (Zangiacomi et al. 2013). The emphasis is now on adaptability to change in business environments and in meeting the market, and customers demand in a proactive manner (Cigolini, Cozzi, and Perona 2004) (Wadhwa, Mishra, and Saxena 2007) (Fantazy, Kumar, and Kumar 2009).

The unstable reality observed in the marketplace is amplified by the fact that consumer goods, in particular, innovative and fashionable products, have in the last decades been facing an increased number of product variants with a dramatic reduction of time-to-market responses (Jovane, Westkämper, and Williams 2009). In many cases, product life-cycles have been cut to one third or even one fourth over the past decades (Trinkfass 2013). Briefly, the modern business landscape faces small series production batches, shorter product life-cycles, rapid new product introductions, increasingly knowledgeable, well informed, and sophisticated customers (Hines 2004, Lyons et al. 2012, Simchi-Levi 2010).

The paradigm shift from a traditional mass production approach to a demand dictated, customer-driven and knowledge-based production, reshaping traditional manufacturing policies. Furthermore, paradigms such as mass customization and personalization are forcing companies to increased flexibility and responsiveness to produce small series, till one-of-a-kind products to satisfy customer demand (Bastos, Azevedo, and Ávila 2015). These issues pose a challenge for companies' managers: how can companies adequately address consumers demand for personalization and value adding of harmonized products not only concerning quality but also regarding innovative functionalities and responsiveness?

Company managers comprehend the fact that market competition is shifting from company-centered scenarios to supply chains with complex inter-organizational structures and intricate networked manufacturing processes. As a consequence, it is surfacing at the industrial level the adoption of collaborative and cooperative strategies addressing the manufacturing complexity of highly customized products with increased emphasis in the service levels and the reduction of the response times. Indeed, to solve this new type of customer demand, it is necessary to develop new methods and tools for customer-focused value chains supported in the collaborative network organizational paradigm (Camarinha-Matos and Afsarmanesh 2006).

This networking trend led to an increasing need for integration and interconnection of market players in all sectors of the economic activity. Hence, the emergence of the concepts such as Virtual Enterprise, Extended Enterprise, Collaborative Networks, Dynamic Supply Chains, Customer-Driven Supply Chains and other new forms of organizations in which the participating entities are involved in complex processes of cooperation (Gunasekaran, Lai, and Edwin Cheng 2008); (Camarinha-Matos and Afsarmanesh 2008c); (Azevedo 1999); (Gattorna 2010); (McKone-Sweet and Lee 2009); (Lyons et al. 2012).

The new forms of networked organizations present a promising approach to deal with the need to customer-driven focus, reduced time to market of new products and cost-effective manufacturing in a cooperative and collaborative environment.

Nevertheless, there are limits to how organizations could integrate effective networks due to the company's "natural" resistance to share technological process knowledge, market and product data, limitations in communication mechanisms, and the hardship to interconnect the many independent nodes that constituted the business channels. Furthermore, companies are often reluctant to form closer dependences for fear of losing leverage when it came to working and negotiating with channel players (Ross 2010).

The companies competitive advantage becomes increasingly dependent on new management methods strongly supported by ICT (information communication technologies) tools that enable the companies to take advantage of practical skills of each one of the business partners in order to achieve efficiency, effectiveness and ultimately increased competitiveness (Lou et al. 2004) (Setia 2008) (Riezebos and Klingenberg 2009). Furthermore, organizations need a support infrastructure that gives them control over the business processes they establish with other companies, but at the same time, agility, adaptability and flexibility to react proactively to the market demands (Tallon 2008) (Gallagher and Worrell 2008) (Setia, Sambamurthy, and Closs 2008) (Buchanan 2008).

Nowadays, the main assets within effective networks are the dissemination of information and knowledge sharing among the chain (Gunasekaran, Lai, and Edwin Cheng 2008) (Fidel, Schlesinger, and Cervera 2015). As Dalkir and Beaulieu (2017) argued, the strategical benefits of knowledge sharing include: connecting professionals across platforms and distances; standardization of professional practices; avoidance of mistakes; leverage of best practices; reduction of time to innovation; and support on stewardship for strategic capabilities.

Although the constant need for innovative and knowledge-based information infrastructures and technologies for supply chain management, the most recent empirical studies have shown limited results in this area. The requirements for these new forms of organization, whether at the functional level, or the technological infrastructure are still not fully satisfied by current solutions available in the market, namely in the case of information systems such as ERP, MES, SCM, and CRM (Eschinger, Klappich, and Payne 2009) (Kache and Seuring 2017) (Qrunfleh and Tarafdar 2014) (Singh and Teng 2016) (Durugbo 2015).

On the other hand, from the supply chain operational perspective, several manufacturing approaches have surfaced in the last twenty years. Operational strategies such as "agile manufacturing," "lean production" and more recently "leagile supply chain" have been disseminated across the global supply chain landscape (Mason-Jones, Naylor, and Towill 2000b) (Katayama 1999) (Fan, Xu, and Gong 2007) (Krishnamurthy and Yauch 2007).

With the emergence of these different strategies for networked manufacturing administration and sustainable management of flows, supply chain managers and stakeholders are now facing new challenges and in consequence demanding for new methods, tools and decision support systems (Prajogo and Olhager 2012) (Ross 2010) (Christopher 2016) (Sodhi and Tang 2017) (Melnyk, Narasimhan, and DeCampos 2014).

There is now a significant amount of research work done in the field of supply chain management and supporting technologies. However, it is recognized that there are still open issues and identified problems that require better solutions or new methodological approaches (Fornasiero et al. 2010) (Sukati, Hamid, Baharun, and Yusoff 2012) (Teller, Kotzab, and Grant 2012) (Melnyk, Narasimhan, and DeCampos 2014) (Garcia and You 2015) (Christopher 2016) (Kache and Seuring 2017).

In fact, the current supply chain management approaches, especially for small series, require not only the combination of several collaboration advances (opportunity-based co-ordination, operation and governance of virtualized cross-sectoral networks), adaptations on the organizational level, but also concepts, methods and tools from an ICT point of view (Christopher 2016) (Kache and Seuring 2017).

Thus, given these new business environment trends and challenges, the advances in ICT technologies, there is a recognizable need for better understanding of the supply chain landscape. Namely, which organizational forms supply chains need embrace to respond to the challenges that they are facing; the critical business processes that they need to endorse; and the supporting technologies and ICT tools that they need to adopt.

1.2. Challenges and Research Questions

The growing importance of the supply chain role in today's companies is a result of a transformation in several critical business processes that have arisen over the past decades. This transformation is raising new challenges in the way companies do business, and in the manner, decision-makers design the supply chains to reach the marketplace with their products and services.

A first challenge derives from the globalization. Globalization has been transforming the 'status quo' in many local, regional and national markets unleashing new forms of competition among traditional players. The globalization wave is changing the way businesses are conducted and, therefore, the way supply chains strategically, tactically, and operationally are managed. As companies expand worldwide in the search for new markets, they must develop new channel infrastructures that provide them with the ability to sell and source beyond their own regional or national markets. This expansion creates an urgent need for supply chain integration and alignment. The enhancements of today's ICT technologies, the universal presence of the Internet, and the advances in logistics systems are enabling the integration of these next-generation supply channels.

A second challenge arises from the transformation of the strategy behind the construction of the supply chains. During the twenty-first century, the vast majority of companies have abandoned policies based on the vertical integration of resources. The main reason derived from the fact that when companies adopt policies around vertical integration, they start dispersing themselves in functions that are either not profitable or for which they have weak competencies. On the other hand, companies have discovered that by closely collaborating with their supply chain partners, they find out new competitive advantages. Namely they can outsource noncore operations to other more specialized and more adequate partners, or can leverage complimentary partner capabilities with their own to facilitate the creation of new products and services, or they can shorten the total length of the design, plan, execute and delivery stages in order to respond promptly to the market needs. Achieving these advantages can only occur when the entire supply chain work aligned and interconnected to maximize complementary competencies.

A third challenge arises from today's marketplace demand for companies to be responsive, innovative, as well as efficient. This need results in the appearance of novel forms of virtual organizations and interoperable processes, which demand supply chain collaboration and cooperation. This new "vertical integration" paradigm is compelling companies to collaboratively integrated processes that require the generation of organizational structures capable of combining different capabilities. Namely, by supporting the joint development of new products and new technologies, by implementing networked manufacturing processes, and by developing next generation information and communication technologies.

A fourth challenge resulted from the need to cross the value chain, optimize processes, reduce non-added value activities, to be responsive and flexible, to implement knowledge-intensive product development activities, to execute agile and scalable manufacturing operations, to effectively execute the distribution functions across a network of supply and delivery partners. The goal is to remove persistently all forms of inefficiencies where supply chain entities interconnect, while simultaneously enabling customer-focused, agile, responsive, knowledge-intensive, excellent quality and service level excellence in supply chain channels of products and services.

A fifth challenge emerged from the difficulty in applying a single and universal strategic solution to all the supply chain problems. As the world becomes increasingly interconnected, the traditional "lean" philosophy aimed to reduce costs and optimize channel connections, starts to become under scrutiny. Supply chain managers have become increasingly aware that they need to establish responsive and agile relationships with their supply chain partners to bear market uncertainty. Today's market demand for supply chains able to: be responsive by adapting to changes in customer needs; flexible by adjusting the volume and the variety of products; and innovative through the offer of creative, fashionable and novel products.

A sixth challenge arises due to the turbulence and uncertainty supply chain managers face in today's marketplace. Market events such as the introduction of disruptive products, regulatory and fiscal uncertainties, changes in regulatory and environmental policies, financial uncertainty, and market restructuring, threaten the classical view of the supply chain strategic management model. Nowadays the different stakeholders are seeking dynamic supply chains that enable the whole channel ecosystems to reconfigure themselves proactively in response to the disruptive events without compromising the operational efficiency and customer service level.

A seventh challenge is an after-effect of matching the requirements between business needs and IT supporting platforms. The introduction of computerized systems and management methods such as Enterprise Resource Planning (ERP), Supply Chain Management (SCM), Business Process Management (BPM), Customer Relationship Management (CRM), Lean Management (LM) and others are forcing the change across the supply chain. These systems are transposing the need for efficiency and responsiveness from the local companies' management to the entire supply chain governance.

In short, all the previous challenges converge in the following defiance:

How can the supply chain managers address consumers' unpredictable demand for customized, value-added and sustainable products not only regarding quality but also regarding innovative functionalities and responsiveness?

In practical terms, the supply chain managers are facing the need to transform each one of their network organizations into full operational customer-focused supply chains.

The present work, aligned with this supply chain manager' requirement, has identified the following three main areas of research that entail the need for a deeper understanding of the supply chain management landscape and continue to be a trial for the researchers and practitioners in the field:

1. *A comprehensive description of the current supply chain instances regarding characteristics and configurations.*
2. *A lack of appropriate organizational reference models, conceptual frameworks and methods for customer-focused supply chains, namely for small series production of innovative and fashionable goods.*
3. *An inadequacy of the current supporting technologies and tools that enable the creation and configuration of competitive customer-focused supply chains namely for innovative consumer environments for products or services design.*

Thus, this research work proposes to embrace these fundamental research areas in the context of customer-focused supply chains.

To overcome the challenges previously identified, we formulated two research questions. The proposed questions worked as a guideline to define the strategy and path to follow during the entire research program.

Following sections present and detail the proposed research questions:

RQ1. How to describe and characterize the current supply chain instances?

With this research question, the objective is to identify a relevant set of dimensions that support a classification schema for supply chains. Furthermore, starting from the proposed classification schema for supply chains, the final goal is to establish a correspondence between each one of the classification dimensions and establish an adequate operational strategy for the entire supply chain.

Especially in this classification schema, there is the intention to study and characterize new forms of networked organizations, namely customer-focused supply chains that present a promising approach to deal with the need to customer-driven focus, reduced time to market of new products and cost-effective manufacturing operations in cooperative and collaborative environments.

RQ2. Which business processes, methods, practices, and tools customer-focused supply chains require to address the current and future marketplace challenges?

Departing from the identified challenges and obstacles that customer-focused supply chains are facing in the marketplace, the goal is to detail the critical business processes, methods, practices, and tools that are required for customer-focused supply chains compete in a globalized marketplace offering value delivery systems that are not only responsive to fast-changing markets but also much more consistent and reliable.

Complementarily, to answer this second research question, there is the intention to integrate the tailored business processes, methods, practices, and tools into a single structure or conceptual framework. The proposed framework will support the different supply chain stakeholders to understand better the complexity of the responsive and flexible supply chains, always envisioning the achievement of higher levels of competitiveness for the entire organization.

Finally, the research approach aims to develop collaborative tools supported in innovative information technologies embedded in the framework. These tools, seek to enable companies to look at their supply chains as a revolutionary source of competitive advantage through cyber-collaboration, allowing joint product innovation, networked planning, and operations management, and customer-focused fulfillment.

1.3. Outcomes

The literature on inter-organizational networks lacks a truly comprehensive classification framework for the current forms of supply chains (Lamming et al. 2000) (Harland et al. 2001) (Singhal, Agarwal, and Mittal 2011). Along with this need, the present research project focused on better understanding the different types of existing supply chains, by presenting a classification proposal for supply chains. This classification proposal takes into account the present literature achievements on this subject but also include relevant field data from specific industrial cases in different business sectors and scenarios.

The present research project, facing the new marketplace needs, focused in the development of knowledge and insights on the supply chain management areas, mainly in the scope of business processes modeling, network formation, collaborative design of new products, collaborative planning, and knowledge gathering and reutilization. Aiming to materialize this new knowledge, this research project, designed and implemented an innovative customer-focused supply chain framework based on a set-based approach strategy.

Following the above, the present project established as primary objective to accomplish the following two main outcomes by the end of this research:

I. **Classification Schema for Supply Chains**: envisioning a more proactive comprehension of the supply chain management body of knowledge, the first objective of this research project is to build a classification model to assist managers and decision-makers in the comprehension of the supply chain they integrate, and their positioning concerning other networks in the market. The classification model developed in the form of a classification schema for supply chains helps to clarify the different network structures, value proposition offers and market approaches observed in the contemporary supply chains. The classification effort is not intended to assess or benchmark current instantiated forms of supply chains, but to help network managers, stakeholders and relevant actors, in locating the current position of their network in the defined classification dimensions, and frame theoretical or practical evolutionary exercises for different supply chain strategic positioning.

II. **Set-based Customer-Focused Supply Chain Framework**: As the most relevant result, this research intends to propose a new framework aimed to support companies in defining and forming customer-focused supply chains designed to attend the demand of innovative, fashionable and sustainable products with short life cycles, small batch production, and high configurability and parameterization. The framework is based on matching theoretical approaches from literature, namely the collaborative networks organizational paradigm and the lean approach of set-based design, but also, by matching practical requirements and constraints observed in R&D industrial case projects namely on the TCFI (textile, clothing and footwear industry) sector and sectorial multiple study analysis in the Footwear sector. The objective of the framework is to offer the combination of a well-structured methodology supported in a characterization of the relevant business processes and best practices and complemented with a set of supporting technological tools.

1.4. Research Development

Current research literature identifies two main research approaches that apply to scientific studies: inductive and deductive. The inductive study aims to “understand the phenomenon in its terms” building a theory through data collection (Hirschman 1986). On the other hand, the deductive approach aims to “add the body of knowledge by building a formal theory that explains, predicts and controls the phenomenon of interest”(Golicic, Davis, and McCarthy 2005).

Nowadays, the business environment in which logistics and supply chain phenomena resides is becoming increasingly complex and less adequate to full characterization by quantitative approaches. To describe accurately, genuinely understand and begin to explain the complex phenomena of supply chain management, research projects are including more studies using qualitative methods. These qualitative approaches can capture more complex knowledge constructs present in this research area. Therefore, thought the inductive approach, it is possible to collect data, gather knowledge and requirements, and propose a theory to explain the complex studied reality.

Golicic, Davis, and McCarthy (2005) sustained that there is a need for a more balanced approach to research using inductive research methods (typically qualitative) in addition to deductive methods (typically quantitative) in supply chain management.

Because the qualitative approach aims to comprehend the phenomenon, the first step on the qualitative path is data collection. The collected data is analyzed by working inductively from detailed elements to more general perspectives. The collecting process is especially necessary if the focus includes the elicitation of requirements for the modeling and design of new information system tools (Zowghi and Coulin 2005).

In the present research study, the objective is to yield a substantive theory of the phenomenon, describing relationships among actors, capturing the dynamic nature of the phenomenon and proposing a conceptual framework to model and guide the processes. Therefore, in our perspective, the identified problems stated previously for this research makes an inductive approach pertinent and applicable.

Recently, there has also been an increasing interest within the information systems research community in organizational and social issues. These issues present itself critical to success in the development and implementation of computer-based information systems and supply chain management support. The increasing interest has resulted in consciousness need to use qualitative research methods, such as Design Science Research (DSR), in which a designer answers questions relevant to human problems via the creation of innovative artifacts, thereby contributing new knowledge to the body of scientific evidence (Hevner and Chatterjee 2010a).

As the primary objective of the present research project is not only to collect data and measure the behavior of a specific variable but also to analyze the different structures and knowledge that people place upon their business activities, it requires a qualitative approach. Furthermore, since the analyst intends to use his understand to address the needs and aspirations of the relevant actors in the context studied, and since it is a complex human phenomenon with high subjectivity, his full comprehension of the suited domain recommends the use of a qualitative approach and specifically a Design Science Research method.

The Design Science paradigm seeks to develop and justify theories that explain or predict organizational and human phenomena surrounding the analysis, design, implementation, and use of ICT systems. Those theories ultimately enlighten researchers and practitioners of the interactions among people, technology, and organizations and must be managed if an information system is to achieve its stated purpose, namely improving the effectiveness and efficiency of an organization (Hevner and Chatterjee 2010b)

Based on Vaishnavi and Kuechler (2015), Figure 1 resumes the steps to apply a design science research approach to the present work. This methodology outlines the research objectives and questions as the basis to define a set of propositions (suggestions) that will be validated by a theoretical finding study and a tentative design (to evaluate their appliance on real scenarios). After these steps, we perform a final evaluation to drive for the last conclusions. An important aspect is the iterative nature of the approach. Through a feedback loop, it is possible to revise and refine the set of propositions from the knowledge contributions helping to achieve a consistent outcome (artifact).

Dul and Hak (2008) described a generic approach called: “Research strategy of practice-oriented descriptive research.” The authors presented this approach to address scenarios that lack relevant variables at the beginning of the investigation. If the relevant variable is unknown at the start of the study, it is not possible to specify indicators that can be observed or measured. Therefore, it is not possible to make use of quantitative research strategies and use the adequate methods of data analysis such as experiments or surveys that assume to know at least one relevant variable. In this case, the researcher needs first to explore a range of situations at which a variable is expected to be identified and described.

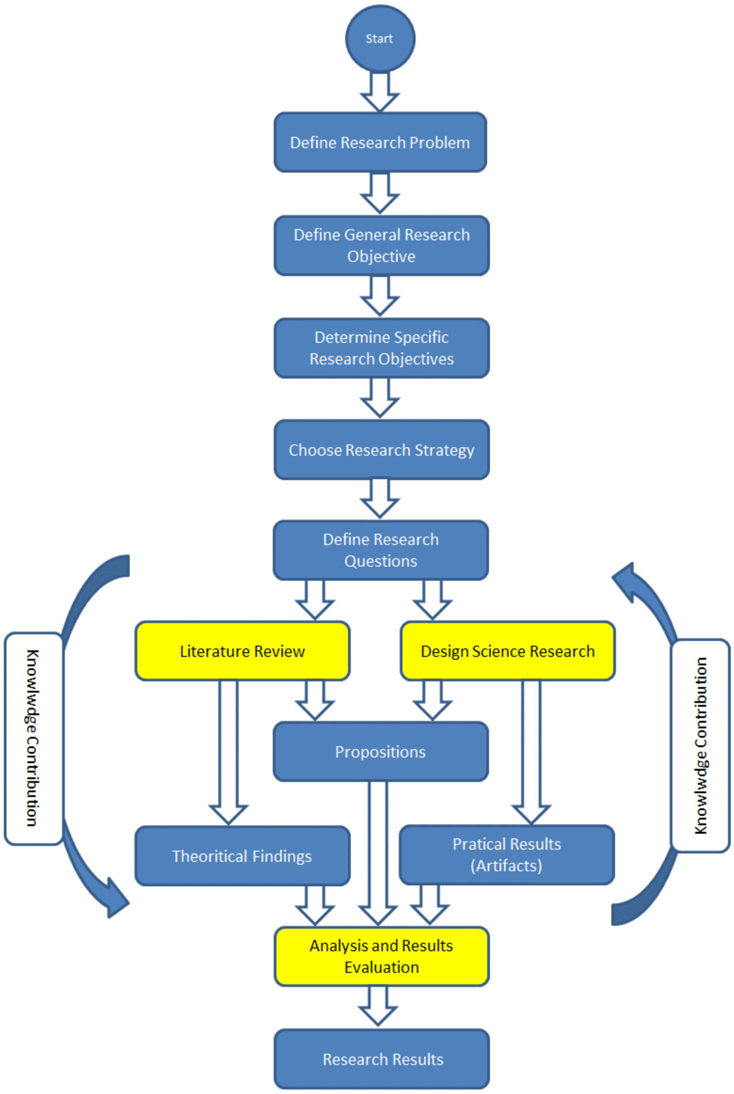


Figure 1 - Research Methodology (based on Dul and Hak (2008))

With this approach, in order to find knowledge regarding the possible implementation strategies available for this type of design, the researcher needs (according to Dul and Hak):

i. to identify different situations in which similar designs have been implemented;
ii. to identify and to describe the different types of the implementation strategy;
iii. to compare the findings from the different situations in order to develop a typology of implementation strategies.

As a result, the selected situations are tentative designs, because they are instances from the domain of relevant situations and because they came from the domain of similar practices in which a similar design has been implemented and selected for the study. As a consequence, the analysis is comparative since it addresses several objects. According to Vaishnavi and Kuechler (2015), the potential outcomes of the design research can be:

- Constructs – a conceptual vocabulary of a domain;
- Models - sets of propositions or statements expressing relationships between constructs;

- Frameworks - real or conceptual guides to serve as support or guide;
- Architectures - high-level structures of systems;
- Methods - sets of steps used to perform tasks (how-to knowledge).

All of the identified outcomes can contribute to the researcher's knowledge about the studied object. Figure 2 presents the flowchart of the descriptive practice-oriented approach followed in the present research.

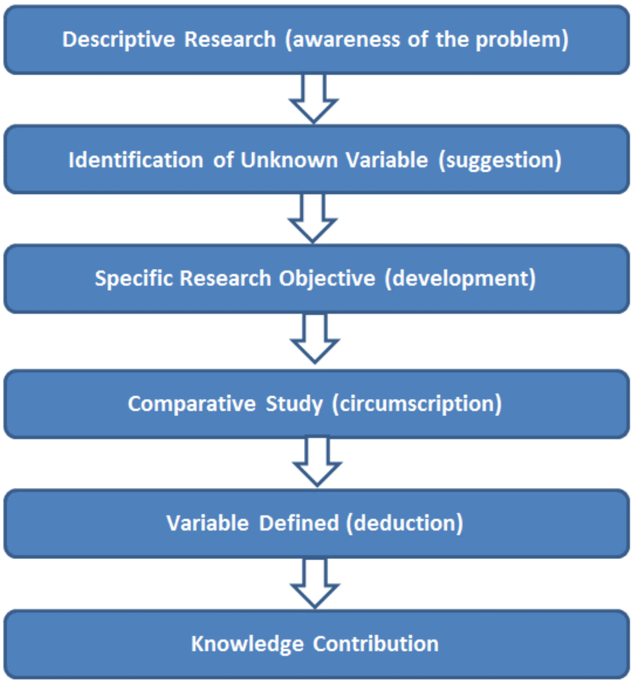


Figure 2 - Descriptive practice-oriented approach (adapted from Dul and Hak (2008))

Starting from this approach, the first step to achieve the awareness of the problem, include the data serialization and integration, contextualizing of the case, evaluation of domain actors' capacities and difficulties, and ultimately the definition of first requirements. The findings are then obtained from inferences between key subjects; the company and the underlying context, and the identification of the significant relationships between all process stakeholders.

Aiming at responding to the challenges and, more concretely, the research questions previously proposed, we conducted this research project using a design science research approach as a reference.

It is important to note that a supply chain study, namely the analysis of its business processes, practices, strategy approaches, and tools goes beyond the traditional single instance analysis due to the networked nature of the supply chain. Therefore, in order to achieve the research objectives, it is required according to Dul and Hak (2008) to perform a comparative case study, involving data from several (two or more) instances.

This comparative or multiple case study analysis offers the means to study in real life conditions several supply chains instances providing the data to uncover areas for research and theory development, and subsequently, test the theories developed in previous stages and predict future outcomes.

Since in today's marketplace there is a multitude of different supply chains operating in a large variety of industrial sectors, special care was demanded in the choice, first of the industrial sector, and secondly the selection of specific cases to be studied.

The industrial sector selected for this supply chain management analysis was the Footwear sector. We supported our choice in the following information[1]:

- The footwear sector includes around 21.000 enterprises, generates EUR 24 billion in turnover, and produced EUR 6.2 billion in added-value (around 0.5% of total EU manufacturing).
- The industry directly employs 280,000 people.
- Two-thirds of total EU footwear production is concentrated in three countries: Italy, Spain, and Portugal.
- Many European companies have moved to high quality and high-added value segments and niche markets. These include high-end footwear, children's shoes, footwear for specific applications (protective, golf, skiing boots), and bespoke footwear.
- European footwear products are highly sought after, both within the EU and global markets, due to their quality, design, and style.
- All footwear manufacturers are tightly integrated into European-wide networks covering the whole production chain.

As a manufacturing sector in general, the European Footwear industry is highly globalized with the competition coming from countries with low labor cost and less-regulated working conditions. These market conditions have forced EU production into serious restructuring strategies and policies based on high added-value production to target middle-class population.

The unbalanced supply of the global market has deeply affected footwear industry overall performance in the EU, but there is an increasing share of the market willing to buy products not only for low price but also for their performance regarding design, innovation, comfort, health care, and environmental attention.

Today, the footwear industry sector in European is strongly pulled by a highly unstable and rapidly changing demand, due to fashion-related and seasonal fluctuations, as well as emerging consumers' needs regarding well-being, health, and sustainability.

A profound restructuring of the distribution system is also taking place, giving more bargaining power of the distributors and putting more pressure on prices. More and more, firms need to pursue innovation strategies based on creativity, quality, and differentiation of products.

In particular, customization of product design (for example shoes and clothes) based on consumer interaction is applied mainly by big producers like Nike and Adidas. These manufacturers are selling co-ordinated total look collections developed with a top-down approach and proposed to the market using a fashion driving action and promotion.

---

[1] Source: European Commission - http://ec.europa.eu/growth/sectors/fashion/footwear/eu-industry_en

Manufacturers in the Footwear industry focus on initiatives to improve supply chain management effectiveness, in order to increase their profitability and improve production efficiency. In addition to cost savings, a better performing supply chain helps reducing cycle times and better meeting customers' demands.

Technological investments are mainly focused on streamlining operations, partially automate formerly manual processes, improve customers' service and knowledge, enable new ways of innovating products and speed up distribution.

Sustainability is becoming more and more important in this sector because, while reduction of scraps is part of the everyday operative strategy, the introduction of assurance systems to monitor product/process quality can add value to the final product. Also, eco-labeling and EPD (Environmental Product Declaration) implementation are under special study in this sector.

After the choice of the Footwear sector, in order to perform the multiple case study analysis, we select four companies. This selection included one large company with more than 17.000 employees and 3 SMEs companies ranging from 100 to 400 employees. The companies selected were from Portugal and Italy.

Before the multiple case study analysis, we conduct comprehensive research of supply chains management literature with the goal of isolating the industry's best practices, the market leader's approach to the supply chain management processes, and the main strategic options identified by practitioners and decision-makers.

This information was useful in the development of the research protocol used in the subsequent interviews, and in particular to focus the questions about the most critical issues of each company's processes and practices.

One important aspect to emphasize is that throughout the entire research process the findings were continually feedback to practitioners for assessment and validation. This feedback loop aimed to make the research process and the outcomes more meaningful to practitioners and aligned with the reality of the day-to-day supply chain practices.

Furthermore, since in each instance, the studied object was quite complex and presented singular characteristics, the successful development of the research project relied on a set of different data sources and distinct data gathering approaches.

The first iteration and one of the most critical phases of the data collection process consisted of an extensive literature review. This supply chain management state-of-the-art review provided the starting background for the following phases. The subsequent data gathering phases performed in the field included several techniques such as formal and informal interviews, focus groups discussions, participant observation, and a review of the industrial partner's documentation. The objective behind the use of all of these techniques was to approximate as much as possible the researcher's mindset to the strategic, tactical and operational reality present in each of the studied supply chain cases.

Aiming to synthesize the research work roadmap applied during the entire doctoral program Figure 3 presents the main stages of the research project life cycle.

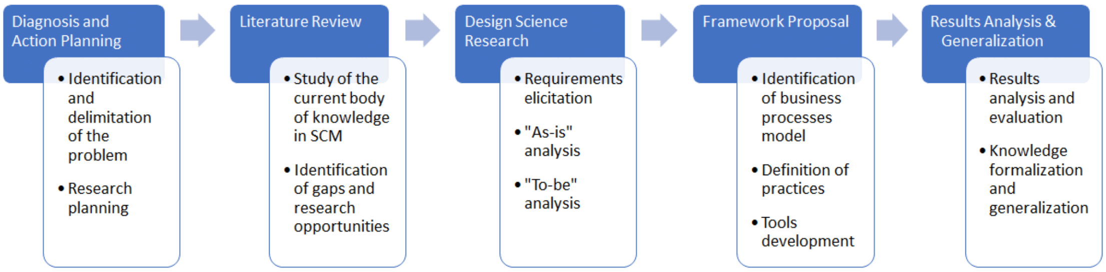


Figure 3 - Research Plan Diagram

Diagnose and Action Planning – Initially, it was necessary to define the problem scope and context. Since the subject to explore is very broad and requires a multi-disciplinary approach, during this initial stage it was critical for our deep involvement with concrete supply chain instances. This involvement was possible through the participation in two R&D projects funded by the European Commission as INESC TEC[2] representatives. The first project called VFF - "Holistic, extensible, scalable and standard Virtual Factory Framework" was a European collaborative project that included about thirty partners from several European industrial companies, universities, and research centers. It aimed to accomplish the definition of the next generation of a Virtual Factory Framework. The second project was called CoReNet – "Customer-oriented and eco-friendly networks for healthy fashionable goods" and it was a European collaborative project that included thirteen partners from several European companies, universities and research centers, and it aimed to address consumer needs and expectations for supplying small series of functional and fashionable clothes and footwear.

During the execution of the R&D projects, it was possible to engage industrial partners holding complex manufacturing systems that not only recognized the importance of the issues explored in this research project but also were receptive to enhance their internal supply chain processes by implementing and testing the methods and tools to be developed. As previously explained, obtaining high levels of participation and collaboration of all actors involved in the research is fundamental for the successful implementation of a multiple case study research strategy. This requirement is fundamental since multiple case study approaches require participants to play an important role in the entire research process, from its design until its implementation and validation. After the diagnosis and definition of the action plan regarding the cases to be explored, a detailed literature review regarding supply chain management body of knowledge was performed.

Literature Review – The state-of-the-art literature review focused on the conceptual area of supply chain management. We collected the current concepts, trends and strategic approaches for the discipline of supply chain management. This literature review involved deep and extensive research on bibliographic sources, scientific papers and published doctoral thesis. Also made it possible to identify the gaps in the present supply chain body of knowledge and point to alternative research opportunities. As a result, the author of this document included a consistent state-of-art chapter and used the gathered knowledge to

[2] The INESC TEC - Institute for Systems and Computer Engineering, Technology and Science is an Associate Laboratory with more than 30 years of experience in R&D and technology transfer. Present in 6 sites of the Portuguese cities of Porto, Braga and Vila Real, incorporates 13 R&D Centres and one Associate Unit with complementary competences.

develop a consistent conceptual view for the remaining of the research project. This literature review partially supported the construction of a classification schema for supply chains helping to clarify the different network structures, value proposition offers and market approaches observed in the contemporary supply chains. The literature findings were also important in the development of the research protocol used in case interviews, in particular by identifying the most critical issues to assess companies' processes and practices.

Design Science Research – The research study addressed the supply chain sector of the footwear industry in four different organizations. A research protocol was designed to capture domain knowledge through a two-phase elicitation. The first phase with the objective of addressing the current situation (as-is-analysis), and a second phase with the objective of addressing the future business scenarios (to-be-analysis). The first section of the research protocol aimed to characterize the current state of the company, their strengths and weaknesses, technical and operational limitations and challenges, and strategic guidelines. The second section focused on identifying future scenarios requirements, business processes and trends that supply chain managers and the different stakeholders are facing or expect to encounter shortly. During the drafting of the protocol, we placed particular attention in the simultaneous analysis of four supply chain dimensions of interest (Knowledge, ICT, Organizational and Sustainability).

Framework Proposal - With the conceptual model carefully developed during the diagnosis, literature review and the multiple case study phases, it was possible to define and detail the subsequent research execution phase with the enunciation of the propositions and the achievement of practical results. This execution phase culminated with a framework proposal aiming to overcome the gaps identified in the previous phases. The framework aims to assist decision-makers better understand how the supply chains can be created and structured to develop business processes characteristics such as responsiveness, adaptability, flexibility, and agility in meeting the market demand of innovative and fashionable products. The customer-focused framework proposal includes an overall architecture description and a detailed definition of necessary components to support the entire life cycle of a supply chain. Complementing the framework, which is a conceptual exercise, it was developed a set of supporting tools necessary to assist the collaborative management of a supply chain using web-based technology solutions. As "prove-of-concept" each one of these supporting tools was developed and installed in several nodes of the case supply chains. By following this prototyping approach, it was possible to fulfill the guidelines retrieved from the industrial partners, and as well to provide the supply chain practitioners community with a concept testing and validation toolset.

Results Analysis and Generalization – Finally, the research results, namely the framework proposal, particularly the set of prototype tools were tested and assessed in different industrial partners. The prototype evaluation tests were carried out in several companies belonging to different sectors beyond the Footwear industry sector, offering the opportunity to generalize the research results beyond the initial case study focus sector. Also, the writing of this report enabled an important effort of knowledge structuring and formalization. The present document materializes the aspiration to compile all the knowledge produced throughout the research project and especially explain the validity and usefulness of a customer-focused supply chain framework proposal. From the author's perspective, this innovative framework proposal is worthy of discussion and dissemination within the scientific community and a reference for future research in the study area of supply chain management.

Fulfilling the knowledge dissemination purpose of the present research project, the author not only participated in other smaller projects (i.e. satellite projects), aiming to apply the theory developed within other contexts and scopes, but also submitted several scientific papers for publication within national and international conferences and journals, aiming to continuously validate the research work done within the scientific community.

1.5. Document Structure

With this document, organized in six chapters, the author aims to provide readers with a broader understanding of the discipline of supply chain management, specifically by addressing the issue of responsiveness, the ability to respond to customers' requirements in ever-shorter time frames. Thus, this introductory first chapter presents the scope and relevance of the research project, as well as the research strategy applied.

Chapter 2 presents the initial theoretical literature research that served as a foundation for the remaining of the research work. Indeed, this chapter can be seen as the driver of the entire research project, since it presents the state-of-the-art findings, namely gaps, challenges and study researches performed until now, as well as respective scientific and technological achievements and contributions. Thus, we divided chapter 2 into nine main sections. Section one presents an overall introduction to the supply chain management theme and its relevancy. Section two details the supply chain management body of knowledge by addressing the role of strategy in supply chain and how it aligns with the competitive and the manufacturing strategy. Following, section three details and compares the main operational approaches present in the literature and identifies the main driving factors for the definition of the supply chain management strategy. Section four addresses the topic of products effect in supply chain strategy namely identifying several factors that must be taken into account when supply chain managers intend to select the most suitable approach to follow. Section five examines several comparative studies on supply chain strategies. The following section explains the current researchers view about ICT technologies impact in the definition of the supply chain strategy. The seventh section describes the growing role of sustainability policies and issues in the universe of supply chain management. Section eighth presentes an overview of the main concepts that lay the ground for the customer-focused supply chain concept. Finally, the last section summarizes the highlights of the literature review and details the unresolved issues present in the supply chain management body of knowledge.

After understanding the state of the art that supports this research project, Chapter 3 presents a classification model proposal for supply networks. This model lays on a three-dimensional axis: demand & sourcing; product & process; and infrastructure. This classification model is intended to assist supply chain managers in defining the adequate manufacturing strategy for the overall supply network management.

Chapter 4 presents a cross-sectorial qualitative requirements analysis to investigate "how" and "why" networked companies interact with their supply network. The study first focuses on an "as-is" description of the current business processes, supply chain strategies, and operational practices. Then, subsequently, shifts the focus to future scenarios analysis. Namely, to the characterization of the business processes required for the qualification and selection of potential partners, the network formation, operation, and the necessary ICT tools and functionalities to support customer-focused supply chains. Mainly this study explores how the companies' managers can adapt their supply chains to address challenging scenarios of reducing the lead time between technical or market opportunities arising and subsequently satisfying the customer need of innovative, fashionable and sustainable products.

Chapter 5, presents a lean-based supply chain framework intended to cope with the challenges posed to the manufacturers by the consumers demand of products of low volume, high variability and increasingly reduced time-to-market expectations. This framework maps its decisional levels (strategic, tactical and operational) with its structural dimensions, namely organizational, knowledge, ICT, and sustainability. All these levels are instantiated along with the dimensions and embedded with the contributions from the collaborative networks paradigm and the lean set-based development system approach. The framework proposal also includes a set of tools designed to support the retrieval of market knowledge information, collaborative design of complex products and collaborative production planning.

Finally, chapter 6 presents the main conclusions regarding the developed set-based customer-focused supply chain framework, as well as the main contribution of this research work for industrial companies and supply chain practitioners. Moreover, it will be enumerated some further work and future lines of investigation that should be performed after the finishing of this doctoral program, in order to not only enhance the research work done until now, but also guarantee the successful transfer of the knowledge, expertise and technology developed to the with manufacturing with manufacturing industry.

Chapter Two

THEORETICAL FOUNDATIONS

Although the subject of the supply chain management strategy is in vogue for the most recent decades, there has been limited research into how the different types of supply networks can be created, operated and evolve, and how they address rapidly evolving and volatile markets. This chapter deepens the topic of design and operations management strategies with a particular focus on rapidly evolving and continuously adapting the dynamic behavior of customer-driven supply chains. It provides a comprehensive literature review of the most relevant operations and practices in networked organizations. It addresses the state-of-the-art supply chain sustainability issues and practices, including the new conceptual paradigm of customer-focused supply chains. It concludes by presenting unresolved issues that are still pending in the research field of supply chain management.

2.1. Introduction

Is it possible to imagine a world where customer preferences can shift overnight, product lifecycles are measured in weeks, and the value of a product shrinks to nothing if it misses the latest trend?

This reality is the world of fast fashion and is becoming the world of an increasing number of mass products ranging from clothing and footwear products to innovative and technological goods. It is in this turbulent new world that Industria de Diseio Textil (Inditex) with its flagship brand Zara has been competing and growing in recent decades.

Since its beginning in 1975 with a single store in La Coruna, *Inditex* embraced the concept of fast fashion and organized its supply chain with a focus in his final customer. They have transformed their design, production, and distribution systems to respond to current and emerging market trends by adapting their merchandise collections as quickly and effectively as possible. The idea behind fast fashion retailers approach is to beat the high-fashion houses and ready-to-wear designers to the market with budget interpretations of catwalk model designs encompassing the traditional values of exclusivity, glamour, originality, luxury, and lifestyle by the values of a trend, massclusivity, and planned spontaneity (Tokatli 2008).

The success of this fast fashion retailer has been undeniable with net sales rising on average more than 14% each year for the last ten years[3] until it became the world largest clothing retailer recently.

What distinguishes Zara from her competitors? Zara has developed a super-responsive supply chain. In 2013 *Inditex* invested 1200 million Euros, the most notably on logistics. The company can design, produce, and deliver a new garment and put it on display in its stores worldwide in a mere 15 days. This response time is unprecedented in the fashion business, where designers typically spend months planning for the next season. Because Zara can offer a large variety of the latest designs quickly and in limited quantities, it collects 85% of the full ticket price on its retail clothing, while the industry average is 60% to 70% (Ferdows, Lewis, and Machuca 2004).

Specialized by garment type, Zara's factories use sophisticated just-in-time systems, developed in cooperation with Toyota, that allow the company to customize its processes and exploit innovations. For example, Zara uses "postponement" to gain more speed and flexibility, purchasing more than 50% of its fabrics undyed so that it can react faster to midseason color changes (Galavan, Murray, and Markides 2008).

Far from pushing its factories to maximize their output, the company intentionally leaves extra capacity. Rather than chase economies of scale, Zara manufactures and distributes products in small batches.

Due to her tailored supply chain strategy, *Inditex* operates 6.340 stores in 85 countries and leads the highly competitive fast fashion industry, which includes retail giants like H&M.

---

[3] Source: Financial Reports from Inditex - http://www.inditex.com/media/financial_results

Inditex competitivity is based in the speed with which new products are developed and introduced into stores. It is along this key dimension that Zara excels and constantly seeks to improve.

Alongside the *Inditex* success story, there are numerous less successful cases in the establishment of coherent supply chain strategies. One of those examples was the automaker General Motors (GM) in the early 1990s.

United States automobile customers are among the most demanding customers of the world regarding service levels. Customers are not willing to wait the time it takes for a customized car to be built to order. Instead, they are prone to accept a similar model if it is available at the moment in the stand. GM estimated that 95% of their sales come directly from vehicles in stock at the dealer's parking lot (Diaz 2001).

Facing this type of demand, GM devised the following two-stage strategy: segment markets much more finely introducing new vehicles to target these niche markets; offer extensive customization options in all the vehicles as a way to differentiate their commercial offerings (Braese 2005b).

What were the consequences of following both of these strategies? In the middle of an intense competition in cost with the Japanese and European manufacturers, and with a supply chain that was not suitable to support any of these strategies, the GM supply chain's was under stress. It suffer from excessive model proliferation, over customization and reduced margins due to competition in cost which led to some of its worst losses and a radical restructuring with significant cost-cuts.

Both of the previous cases demonstrate the importance of supply chain design and the correct definition of strategies that should provide the means to managers get their products and services to the various customer groups they have opted to serve. Moreover, most importantly, what method should they use to devise those strategies.

In reality, the conception and design of a supply chain strategy is a complex task. Part of this complexity derives from the lack of a methodological approach. Indeed as Bakir and Bakir (2006) stated: "*In the past two decades, the very concept of purposeful strategy has been seriously undermined by the recognition that unintended organizational strategies often emerge out of social interactions and adaptation within and outside their boundaries.*" These authors also add that several studies demonstrate that strategy processes, particularly in complex environments, are persistently non-rational, resembling what has come to be known as "muddling through" and "organized anarchy."

In the same wavelength, Hicks (1999) states that "it is often the case that high-level discussions of supply chain strategy are completely void of facts." High-levels decision about how to organize company operations and logistics can end up being a forum for political gaming and salesmanship, with outcomes decided by personal charisma and volume rather than rationality and science, according to the author.

This elusiveness of strategy itself is also evident by a survey on the role of coherent supply chain strategy and performance management in achieving competitive advantage conducted by Harrison and New (2002). This international survey showed that more than half of the supply chain strategies in over 250 firms across diverse sectors "were either non-existent, patchily defined with poor definition, or had only some elements defined and lacked detail" and that there was much inconsistency in the way that many businesses relate their supply chain strategy, corporate strategy and investment strategy together. More recent studies have shown similar weaknesses (Garcia and You 2015) (Hugos 2018) (Fawcett et al. 2015).

Several analysts suggest that supply chain strategy is hardly ever made explicit and more importantly, only minimal or moderate investment in supply chain strategy instantiation to implement valid supply chain strategies is applied (Perez-Franco 2010) (Harrison and New 2002) (Payne and Peters 2004).

This reality usefully alerts managers to the complexity of strategy formulation and hence the problems inherent in rational supply chain strategy formation. It also points out to the need of rationalistic strategy tools that will work in a highly complex and interconnected world with increased volatility and reduced product lifecycles.

The remaining of this chapter presents the literature review and the theoretical foundations from the research field of Supply Chain Management (SCM) that are strictly related with the formulation and delivering of the appropriated supply chain strategies for manufacturing networks, especially in highly dynamic and volatile markets of customer-focused supply chains.

2.2. Supply Chain Management

The concept of supply chain management goes back to pioneering work from Forrester (1958), who identified the dynamics of response to demand changes in supply chains. Forrester has discovered a distortion in demand patterns created by the dynamic complexity present in transferring demand from end users along a chain of supply to manufacturers and material suppliers.

One of the key results of this work was the identification of the interdependence between stakeholders in supply chains regarding information data flows, but also the time-related effects present in the dynamics of the phenomena.

For a long time, the supply chain managers have considered the importance of information and time as a competitive advantage and a strategic weapon. The ability to reach the markets faster than the competition with the right products, the capacity to meet the demands of customers with increasingly faster delivery times, and to ensure that the supply chains can be synchronized to meet the fluctuations of demand, is clearly of critical importance in this era of time-based competition (Stalk Jr 1998).

Today's new-generation companies compete with flexible manufacturing and rapid-response systems, expanding the variety and increasing innovation in an unprecedented level, by shortening the planning loop in the product development cycle and trimming process time in the entire supply chain.

In order to face the new challenges derived from the market conjuncture, supply chain managers have sought and endorsed for new strategies.

The strategy is a word of military origin and refers to a plan of action designed to achieve a specific goal. Specifically, Chrisman, Hofer, and Boulton (1988) present strategy as the "fundamental characteristics of the match that an organization achieves among its skills and resources and the opportunities and threats in its external environment that enables it to achieve its goals and objectives."

Supply Chain Management integrates supply and demand management within and across companies. Supply Chain Management is an integrating function with primary responsibility for linking major business functions and business processes within and across companies into a cohesive and high performing business model. It includes all of the logistics management activities,'- as well as manufacturing operations, and it drives coordination of processes and activities with and across marketing, sales, product design, finance and information technology ((CSCMP) 2013).

Enterprises and networked organizations can plan and implement changes in their profile and structure. According to Hofer and Schendel (1978), these changes can be of two types: changes that affect the relationships between the organization and its environment; and changes that affect the internal structure of the organization and the operating activities. Usually, the environmental changes relate to the organization's effectiveness; on the other hand, the internally oriented changes have a greater influence on its efficiency.

According to literature, effectiveness defines the degree to which the actual outputs of the system match to its desired outputs, while efficiency evaluates the ratio of the actual value of the outputs to the value of the actual inputs (Jeong and Phillips 2001) (Fugate, Mentzer, and Stank 2010) (Griffis et al. 2004).

As any management activity, the Supply Chain Management in order to be effective relies on the establishment of goals and the definition of consequent strategies to achieve these goals. In understanding strategy as navigational translation, managers can see that strategy is a set of complex processes impacted by a fluid and interlocking set of intervening conditions that are beyond managerial control, and that may change the dimensional location of the properties of the strategy categories so generating unintended outcomes (Bakir and Bakir 2006).

Hicks (1999) arguments that supply chain strategic problems have been nearly impossible to model and analyze rationally. These problems involve huge data sets with complex data interrelationships and a great deal of uncertainty making it unfeasible to solve a strategic planning problem computationally. This difficulty is especially true due to the non-quantitative or "soft" arguments that greatly condition the supply chain strategy definition.

Therefore, the need to go back to the basics describing and characterizing the building of supply chain management strategy.

2.2.1. Strategy in Supply Chain Management

In order to understand the complex world of supply chain management strategies, the field researchers have made an effort to build a systematic classification of the various types of strategies through the proposal of different typologies.

The literature review identifies two schools of thought. The first and oldest is based in a hierarchical classification of the supply chain and studies its environment and critical variables from top to bottom. The second approach, with its origins in the logistics school, starts from a functional view of the supply chain, seeking to compartmentalize the different functional areas and their strategic management issues.

The following sections present these two fundamental approaches.

2.2.1.1. Hierarchical Strategy Taxonomy

Initially Hofer and Schendel (1978), and subsequently Kotha and Orne (1989) in their work have classified overall supply chain strategy in four levels according to Figure 4.

Figure 4 – Supply Chain Strategy Hierarchy Levels (based in Kotha and Orne (1989))

The authors detailed in their hierarchy of strategy the following levels:

- Industry Strategy – it is concerned with macro industry and government policies that affect the firm's competitiveness and revolves around issues such as an incentive for investments, inflation, and cost of capital, transportation infrastructures, import and export trade barriers, and others.

- Corporate Strategy– relates to decisions on the definition of businesses in which the corporation wishes to participate and the acquisition and allocation of resources to these business units. Decisions at the corporate level involve financial structure and basic design of organizational structure and processes. At the network level, the strategy affects how the firm's different business complements and reinforce each other.

- Business Strategy – is associated with issues such as the scope the business and the operational links with corporate strategy and the core competencies on which the business unit will achieve and maintain a competitive advantage within its industry. In most cases, the major functional area policy decisions include product line, market development distribution, R&D policies, plus major manufacturing system design choices. At the network level, it focuses on the integration of different functional area activities within a single business.

- Functional Strategy - At this level, functional strategy specifies the tasks and the objectives of the different functions in each business unit that will support the desired competitive business level strategy. The focus is on the maximization of resource productivity. At this level, the synergy involves coordination and integration of activities in the production flow.

This hierarchy of strategic levels (from Kotha and Orne) has direct implications in the establishment of the production approach since manufacturing strategy is one fundamental element of the functional strategy level.

Each of the four levels described has an important and distinct role to play in achieving competitive advantage. In most of the cases, systems-oriented decision flow models have been used to link the manufacturing decisions with the business unit goals, corporate goals and the contingencies of the external world, therefore, conditioning the overall supply chain management strategy.

2.2.1.2. Functional Strategy Taxonomy

The second school of thought with its origins in the logistic operations management proposes a topology based on functional areas. Cohen and Roussel (2005) follow this school and argue that the strategic supply chain management building is composed of the following five critical configuration components:

- Operations strategy - determines how to manage factories, warehouses, and sales points, as well as how to design processes and information systems;

- Outsourcing strategy – establishes the outsourcing policies based on an analysis of existing supply chain skills and expertise;

- Channel strategy - defines how to get products and services to buyers or end users.

- Customer service strategy – defines the overall volume and profitability of the customer's accounts and seeks to prioritize and focus companies' capabilities according to the customer's needs;

- Asset network - includes the decisions regarding the company's asset network (factories, warehouses, production equipment, sales points, and service centers) by defining the location, size, and mission of these assets.

Figure 5 presents the diagram with the five critical configuration components of the strategic supply chain management topology.

Specifically, concerning the first strategy configuration component, Anderson, Cleveland, and Schroeder (1989) conducted a literature review on operations strategy based on manufacturing strategy, and yet they also included a preliminary analysis on service operations.

Figure 5 – Functional Strategic Supply Chain Configuration Components (based on Cohen and Roussel (2005))

A few years later, Hayes and Upton (2005) proposed an operations based strategy which included both the manufacturing and service operations. Hayes and Upton identified three operating capabilities which are crucial to understanding operations strategy:

- Process-based operating capacity – is the capacity to achieve an operating advantage, including low cost and high quality, during the process of transferring material or information to a product or service;
- Coordination-based operating capacity - capacity to achieve operating advantages, such as short lead times, product and service ranges, and customization, through coordination excellence throughout the entire operating system;
- Organization-based operating capacity: capacity to introduce new technology, design new products, and build new facilities faster than competitors.

At the same time Cohen and Roussel (2005) identified the following types of operations strategies and their applicability:

- Make to stock - is the best strategy for standardized products that sell in high volume. Larger production batches keep manufacturing costs down, and having these products in inventory means that customer demand can be met quickly;
- Make to order - is the preferred strategy for customized products or products with infrequent demand. Companies following this strategy produce a shippable product only with a customer order in hand. This strategy keeps inventory levels low while allowing for a wide range of product options.
- Configure to order - is a hybrid strategy in which a product is partially completed to a generic level and then finished when an order is received. This strategy is the

preferred strategy when there are many variations of the end product, and the managers want to achieve low finished-goods inventory and shorter customer lead times than make to order can deliver.

- Engineer to order - which shares many of the characteristics of make to order, is used in industries where complex products and services created to unique customer specifications.

Based on these premises the authors build Table 1 identifying when to apply a specific operations strategy and the benefits obtained.

Table 1 – Types of Operations Strategies (based on Cohen and Roussel (2005))

Strategy	When to Apply	Benefits
Make to Stock	For standardized products selling in high volume	Low manufacturing costs; Meeting customer demands quickly;
Configure to Order	For products requiring many configurations	Customization; Reduced inventory; Improved service levels;
Make to Order	For customized products or products with infrequent demand	Low inventory levels; A wide range of product options; Simplified planning;
Engineer to Order	For complex products that meet unique customer needs	Enables response to specific customer requirements;

A comprehensive review of operations strategy in a general application environment was presented by Van Mieghem (2008), who introduced the principles and practices of operations strategy and proposes a framework for operations strategy. Chapter 4 presents in more detail the Van Mieghem proposal.

As it is perceptible, from the different supply chain strategy taxonomies based on the literature presented, independently of the starting point, - the hierarchical view or the functional view - the ultimate goal is to achieve competitive advantage. Hence, the need to address the concept of competitive strategy in order to identify the constructs that are shared and complement the building of supply chain management strategy.

2.2.2. Competitive Strategy

The most widespread competitive strategy work accepted by the supply chain practitioners is the Porter's (1980) taxonomy of competitive strategy in which the author defines three successful generic approaches to outperforming other firms in an industry or market (see Figure 6):

- Overall Cost Leadership – cost leadership requires aggressive construction of efficient-scale facilities, vigorous pursuit of cost reductions from experience in order to maintain a low-cost position in the competition.

- Differentiation – corporations can differentiate the product or service, creating something that is perceived industry-wide as being unique. Approaches to differentiating can take many forms: design and brand image, technology, features, customer service, dealer network, or other dimensions.

- Focus – focusing on a particular buyer group, a segment of the product line, or geographic market. By concentrating on a special target group or niche market, through implementing one or both of the previously mentioned strategies (cost leadership/ differentiation), the corporation rests on the premise that can serve its narrow strategic target more effectively or efficiently than competitors who are competing more broadly.

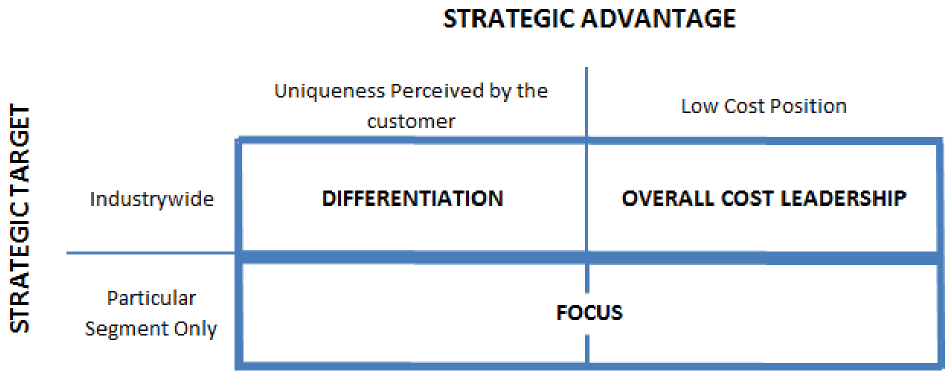


Figure 6 – Porter's generic strategies (based in Porter (1980))

In this work by Porter, manufacturing is firstly viewed as one of the functions to support competitive business strategy and used to enhance the competitiveness of the business.

Simultaneasly, Shapiro (1984) presented another pioneering work. We identified three generic competitive strategies that demand different characteristics to the supply chain:

- Competition in Cost
- Competition in Customer Service
- Competition in Innovation

Table 2 summarizes the main characteristics of the supply chain and the correspondent generic competitive strategies:

Table 2 – Shapiro's Generic Competitive Strategy (based in Shapiro (1984))

Supply Chain Characteristics	Competitive Strategy
Cost	Efficiency
Service	Reliability, Responsiveness
Innovation	Flexibility, Sensitiveness, Adaptability

The generic competitive strategy categories proposed by Shapiro are adequate for a high-level description of the overall supply chain strategy since it features relevant dimensions from the standpoint of supply chain management. In reality, these dimensions are collectively comprehensive, they are straightforward, and empiric evidence supports it (Miller and Roth 1994).

Additionally, if competition in service and competition in innovation are the only two possible ways for differentiation in the supply chain, then this categorization concur with Porter's classic reference that identifies competition in cost and competition in differentiation as the two main generic competitive strategies (Porter 1980).

The literature also presents other categories of competitive strategies. Corbett and Van Wassenhove (1993) argue about cost, quality and time as the main competitive factors. On the other hand, Stock, Greis, and Kasarda (1999) and Minor, Hensley, and Wood (1994) also include flexibility to the previous list.

In reality, the set of generic competitive categories which include cost, service, innovation, quality, time and flexibility have some overlapping areas. It can be argued that quality (understood as delivery conformance) falls in the category of service. Speed, meaning rapid reposition, is related to differentiation in service. Alternatively, in case of speed meaning fast new product introduction, it is differentiation in innovation. In case of the flexibility category; it can be service for the volume, whereas flexibility in functionality or customization can be either service or innovation, depending on the context.

The choice of a specific strategy will demand different characteristics to the supply chain. For instance, the competition in cost will demand very efficient supply chains, resilient enough to avoid costly breakdowns. On the other hand, competition in service will demand the supply chain to be reliable and responsive in order to ensure adequate and timely replenishment. Lastly, the competition in innovation will require an agile supply chain that not only delivers the products, fast and with reliability but that is also able to capture the market trends and expectations and pass it to the design process.

Even though in the past, the main emphasis of functional and competitive strategies relied on finance and marketing, The author Skinner was the first to defend the manufacturing strategy in the empowerment and consolidation of the corporations and supply chain's competitive ability (Skinner 1969, 1978, 1985).

In nowadays it is consensual that the manufacturing strategy is a key factor for the success of a supply chain strategy (Jovane, Westkämper, and Williams 2009) (Zangiacomi et al. 2013) (Li et al. 2008) (Leung 2002).

2.2.3. Manufacturing Strategy in Supply Chain Management

A relevant question arises in the context of networked firms: What is a manufacturing strategy for the entire supply chain? The literature explains that manufacturing strategy is the course of actions to build up the manufacturing competitiveness (Leung 2002). Therefore, it is a way to make use of different types of manufacturing strategies present in the network in order to stimulate the continuous growth of manufacturing competitiveness on the chain, as a whole. This networked reality is an important topic concerning all manufacturing firms.

In a precursor work, Hayes and Wheelwright (1984) defined manufacturing strategy as a consistent pattern in decision-making. They identified eight key areas for the manufacturing strategy definition in which a supply chain manager can achieve a competitive advantage. Table 3 presents the list of key areas identified by Hayes and Wheelwright.

Table 3 – Key Areas for the Manufacturing Strategy Definition (source: Hayes and Wheelwright (1984))

Manufacturing Strategy Areas	
1	Workforce
2	Vertical Integration
3	Facilities
4	Capacity
5	Quality
6	Production Planning & Control
7	Organization
8	Technology

The authors have divided the manufacturing strategy decisions into two categories: *structural decisions* and *infrastructural decisions*. Structural decisions are practices with long-term impact, significant financial investment, and influence physical assets. Examples of structural decisions (usually related to vertical integration) are related to plant location, manufacturing processes investment, and factory capacity.

In contrast, infrastructure decisions apply to the organizations, systems, policies, practices, and procedures which support the manufacturing processes. Infrastructure decisions are linked to practices with relatively short-term effects, usually involve low financial investment and strongly affect physical assets. Examples of infrastructural decisions are connected to organization structure and design, workforce management, production & inventory planning, and control systems, quality management and environmental management systems.

Hayes and Wheelwright (1984) also argued that a good manufacturing strategy should transfer distinctive competencies of business strategy to distinctive competencies of functional areas of manufacturing. Distinctive competencies of a manufacturing system are time, quality, cost, and flexibility. Starting from this premise, the authors classified the manufacturing strategies into four stages according to Table 4.

Table 4 – Manufacturing Strategy Stages (source: Hayes and Wheelwright (1984))

Manufacturing Strategy Stages	
1 – Internally Neutral	Manufacturing simply provides products
2 – Externally Neutral	Manufacturing only meets the requirements from competition
3 – Internally Supportive	Manufacturing tries to be unique and separate from competitors
4 – Externally Supportive	Manufacturing pursues uniqueness worldwide and becomes world-class manufacturing

In her work, Sharma (1987) arguments the existence of two alternate views on manufacturing strategy. The first view considers the strategy to be a pattern of decisions in operations, in which the decision pattern means how decisions relate to one another over time and are embodied in decisions and choices, rather than in formal statements and documents (Skinner 1969) (Hayes and Wheelwright 1984).

The second view focuses on planned strategy supported in formal statements regarding mission, objectives, manufacturing policy and distinctive competence. This view focuses on the choices of alternatives and not so much on how those choices are applied (Schroeder, Anderson, and Cleveland 1986) (Anderson, Cleveland, and Schroeder 1989).

On the other hand, Schroeder and Lahr (1990) add that manufacturing strategy is a vision for the manufacturing organization based on the business strategy, it consists of objectives, strategies, and programs which help the business gain or maintain a competitive advantage.

The authors argue that a manufacturing strategy is more than just a plan and comprises the ten steps listed in Table 5.

Table 5 – Manufacturing Strategy Planning (source: Schroeder and Lahr (1990))

Manufacturing Strategy Planning Process	
1	Business Strategy Summary
2	Manufacturing Mission
3	Manufacturing Objectives
4	External Analysis
5	Internal Analysis
6	Competitive Position
7	Ideal Manufacturing
8	Critical Issues
9	Manufacturing Strategies
10	Manufacturing Programs

Figure 7 presents the sequence of these ten steps, identifying its interrelationships and constraints that precede the outcome which is the manufacturing strategy plan.

In 1994 Miller and Roth (1994) proposed a “numerical” taxonomy for manufacturing strategy applying multivariate statistical procedures and grouping algorithms to measures of the perceptions of manufacturing managers. Their approach tried to identify the constructs that underlie the strategy formation, observe the apparent relationship between group membership, business context, manufacturing choice, and manufacturing performance measures.

Using cluster analysis, the authors identified three manufacturing strategy types from the respondent survey profiles. Table 6 present the outcomes of this taxonomy.

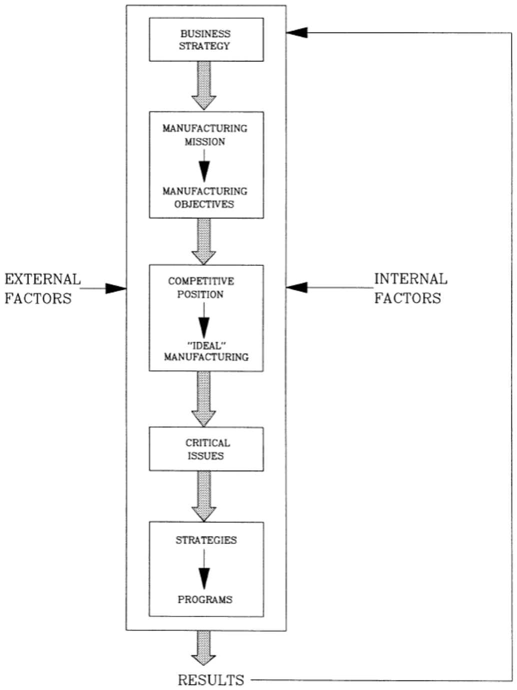


Figure 7 - Manufacturing Strategy Plan Schema (source: Schroeder and Lahr (1990))

A few years latter Frohlich and Dixon (2001) revisited the Miller and Roth taxonomy. Based on the previous survey, Frohlich and Dixon's findings confirmed that parts of the original survey configuration were supported, and others were rejected. In this new study, three clusters of strategy types appeared in each set of data, but the underlying dimensions along which the clusters differed. The survey showed that the clusters of manufacturing strategies shifted over time and differed across geographic regions.

Table 6 – Taxonomy of Manufacturing Strategies (source: Miller and Roth (1994))

Taxonomy of Manufacturing Strategies	
Cluster 1: Caretakers	- low emphasis on the development of competitive capabilities; - minimum standards for competing products; - price is the dominant competitive capability; - ability to meet delivery schedules and fast deliveries; - conformance quality; - low importance to after sales service and high-performance products.
Cluster 2: Marketeers	- seek to obtain broad distribution; - offer broad product lines; - be responsive to changing volume and requirements; - seek to guarantee conformance quality, dependable deliveries, and product performance; - reflected some price consciousness; - take after sales service as important.
Cluster 3: Innovators	- emphasis in the ability to make changes in design and to introduce new products quickly; - price is less relevant; - focus on conformance and performance quality; - dependability is important; - take after sales service as important; - low emphasis on the ability to carry a broad product line and volume flexibility.

Consistent evidence emerged that two of Miller and Roth's original strategy types, the Caretakers and Innovators, endured longitudinally from the 1980s through the 1990s with their core sets of competitive capabilities staying moderately to highly consistent.

Meanwhile, the third, and largest, cluster appeared to change its competitive focus over time. Based on the evidence, Miller and Roth's *Marketeer* strategy no longer exists. Instead, it was replaced in the mid-1990s by a new manufacturing strategy that the authors called the *Designers*.

This new third group put a high degree of emphasis on design flexibility, broad product lines, which reflects in enhanced product design capabilities.

From the Frohlich and Dixon's study results it is possible to identify a link between the three identified manufacturing strategies and Porter's competitive strategy typology.

In the first group, the goal of the *Caretaker'* strategy is to exploit low cost and efficient business operation, seeking Porter's overall cost leadership. When successfully implemented, this approach becomes a potent source of competitive advantage.

For the second group, companies that embrace a competitive differentiation strategy, seek to be unique along multiple dimensions that are widely valued by the customers. This group closely fits the *Designers* approach, which aggressively pursues a wide variety of competitive capabilities. This transformation from the *Marketeers'* to *Designers* group occurred due to the maturation of computers, communications, and ICT processing technologies, which resulted in an explosion of interest in new product development (NPD) capabilities.

Finally, the third group is composed of companies with a focused business strategy. This strategy means they choose a narrow competitive scope within an industry in which to compete. These companies address increasingly sophisticated customer's demand for new product or services with shorter product life-cycles and augmented complexity. This description aptly describes the *Innovators'* pursuit of higher levels of performance, quality conformance, service, and flexibility. In fact, due to these characteristics, Frohlich and Dixon proposed to change the *Innovators* name to the *Specialists*. The new name is adequate to the notion of this cluster following a focus strategy according to the authors.

The subsequent analysis on both studies, in the '80s by Miller and Roth (1994) and the '90s by Frohlich and Dixon (2001) denotes that the manufacturing strategy is static or dynamic depending on the circumstances. For the first group, the *Caretakers* opted for a static manufacturing strategy, anchored around low price, quality conformance and delivery dependability. Similarly, the second group (the *Specialists*), in the two decades studied, present a relatively stable manufacturing strategy with a focus in performance, service level, and quality conformance. Nevertheless, this group in the last decade has been under stress due to the increased sophistication of customers demand and the globalization of the markets. Inversely, the *Marketeers* and subsequently the *Designers* have presented a dynamic manufacturing strategy, shifting over time by changing the manufacturing strategy to suit the business environment. This new dynamic and volatile environment forced companies to improve their design flexibility, reduce the response time and augment the products variety and configurability.

In the face of the literature multitude of testimonies supporting the manufacturing strategies' relevance to achieve a competitive business advantage, it is important to address how the manufacturing strategy aligns with the supply chain operations strategy. The following section focuses on the effects of customer value, product characteristics, and the sales channel on the operations and supply chain strategies.

2.3. Operations Strategies and Practices

At the end of 20th century, Fisher (1997) have defended that the root cause of the problems plaguing many supply chains is a mismatch between the type of the product and the type of supply chain. Based on the nature of the products demand he has classified the products in:

- **Functional products** – products that satisfy basic needs and do not change much over time, are stable, with predictable demand and long lifecycles. Their stability invites competition, which leads to low profit margins.

- **Innovative products** – products that present innovations in fashion or technology to give customers an additional reason to buy their offerings. Although innovation enables the company to achieve higher profit margins, the very newness of the products makes the demand unpredictable and their life cycle short.

According to his product classification, Fisher has identified two types of supply chain operation strategies:

- **Efficient supply chain strategy** – with the predictable demand for functional products, market mediation is easy, enabling a nearly perfect match between supply and demand. The primary purpose of the efficient supply chain strategy is to supply predictable demand at a lower cost efficiently.

- **Responsive supply chain strategy** – with the uncertainty of market reaction to innovative products, the risk of shortages or excess supplies is high. Also, high-profit margins and the importance of early sales in establishing market share for new products increase the cost of shortages. Furthermore, short product life cycles increase the risk of obsolescence and the cost of excess supplies. Hence, market mediation costs predominate for these products, and they should be the manager’s primary focus, not physical costs.

Therefore, according to Fisher, the primary purpose of an efficient supply chain strategy is to efficiently supply predictable demand at the lowest cost for their functional products. On the other hand, the major purpose of the responsive supply chain is to respond as quickly as possible and as flexible as possible to unpredictable demand in order to reduce obsolete inventory and stocks run out.

In 1999 Naylor, Naim, and Berry (1999) referred to two definitions that relate the agile and lean manufacturing paradigms to supply chain strategies. They emphasize the distinguishing features of leanness and agility related to supply chain strategy:

- Agility means using market knowledge and a virtual corporation to exploit profitable opportunities in a volatile market place.
- Leanness means developing a value stream to eliminate all waste, including time, and to ensure a level schedule.

The authors also define the “decoupling point” that separates the part of the organization [supply chain] oriented towards customer orders from the part of the organization [supply chain] based on planning. It is also the point at which strategic stock is often held as a buffer between fluctuating customer orders and/or product variety and smooth production output as in the case of the “Die Bank” in the semiconductor industry. This fact is critical when considering when to adopt agile or lean manufacturing techniques in the supply chain.

Starting from these two paradigms, agility and leanness, Naylor, Naim, and Berry (1999) proposed a new hybrid manufacturing paradigm which combines both of the production paradigms and calls it “Leagility.” The authors argument that the need for leanness or agility depends on the total supply chain strategy, especially considering the market knowledge and the positioning of the decoupling point. The decoupling point in this supply chain strategy is the point that separates the segment of the supply chain oriented toward customer orders (agility part) from the segment of the supply chain (leanness part) which focus on planning a smooth and standard production flow.

In Mason-Jones, Naylor, and Towill (2000a) the authors point out that agile supply chains which exploit the volatility of the marketplace will strive to maximize their profitability. However, in a lean manufacturing environment, the demand should be smooth, leading to a level schedule. The level schedule is a prerequisite for the elimination of all “*muda*” (waste). By eliminating “*muda*” and other inefficiencies, the supply chain will maximize their profit through cost minimization.

In the same direction, Christopher and Towill (2000) defended that the lean paradigm requires that “fat” be eliminated, on the other hand, the agile paradigm must be “nimble” since lost sales are gone forever. Another important difference between these two paradigms is related to information transparency. While in the lean regime it is desirable, it is mandatory for agility.

These last authors also address a hybrid solution for supply chain strategic positioning with the emergence of global supply chain strategies in which companies seek to achieve local differentiation while at the same time standardizing by common ``platforms''. Hence, lean chains are under pressure to become agile, and in some markets, further pressure to become customized. They refer that this is the era of hybrid lean/agile strategies or what may conveniently be designated the “leagile” model.

Another researcher, Morash (2001) published his study about supply chain strategies and proposed a conceptual framework to describe the relationships between supply chain strategies, capabilities, and performance (see Figure 8).

Morash proposed two major classes of supply chain strategies:

- **Operational excellence** – endorses business strategies of overall cost leadership through total cost reduction, efficient and reliable supply, and high levels of basic service. The objective is to lead the industry in price, reliability, convenience, and speed, giving to the customer efficient delivery of reliable products and services at competitive prices with minimal difficulty and inconvenience. The emphasis is to use the total supply chain cost as a marketing weapon.

- **Customer closeness** – supports business strategies of differentiation through high levels of value-added customer service, proactive quality (do it right the first time), and collaborative communications and interactions with customers. Closeness means selling to the customer not just the product or service, but achieve total customer satisfaction through augmented solutions that include ongoing help, high levels of support, and interactive advisory service.

In reality, the operational excellence strategy proposed by Morash includes time-based strategies such as just-in-time deliveries and lean supply chains. In practice, JIT seeks to: reduce buffer inventory and safety stocks; more frequent deliveries of smaller shipments which can increase inventory throughput; cross-dock operations; and synchronization of transportation with production. By turning to lean the supply chain, it is possible to reduce all types of waste, errors and unnecessary assets in order to seek operational efficiency throughout the supply chain network.

On the other hand, with customer closeness as a supply chain strategy, according to Morash, the supply chain has customized logistics and agility (see Figure 8). Agility means flexibility and quickness in adjusting supply chain capabilities and their combinations of changing customer needs and evolving competitor offerings over time. This approach may require a flexible and dynamic supply chain that recombine, reconfigure and re-sequence logistical capabilities and participating firms in changing and creative ways.

At the foundation of is work, the Morash states that specific combinations of supply chain capabilities should support supply chain strategies, and in consequence of such posture, this would have a significant impact on the supply chain performance as is demonstrated by this empirical study (Morash 2001).

On another work, Cigolini, Cozzi, and Perona (2004) have proposed a new framework for supply chain management and identified three types of supply chain strategies:

- **Efficient supply chain** – brings to the market products that are considered as commodities and usually sold in high volumes. With the stability of products flows, it is possible for these companies to invest in large and capital-intensive facilities, and improvement initiatives are focused on operations rather product innovation. This supply chain present high-efficiency levels and low-profit margins.

- **Quick supply chain** – are devised for products whose demand is difficult to forecast. Companies invest in flexible manufacturing systems with a high variable versus fixed costs ratio because they compete mainly on product innovation, rather than on price.

- **Lean supply chain** – have intermediate characteristics because firms do not compete mainly on product price or novelty, but simultaneously on product price, novelty, quality and customer service.

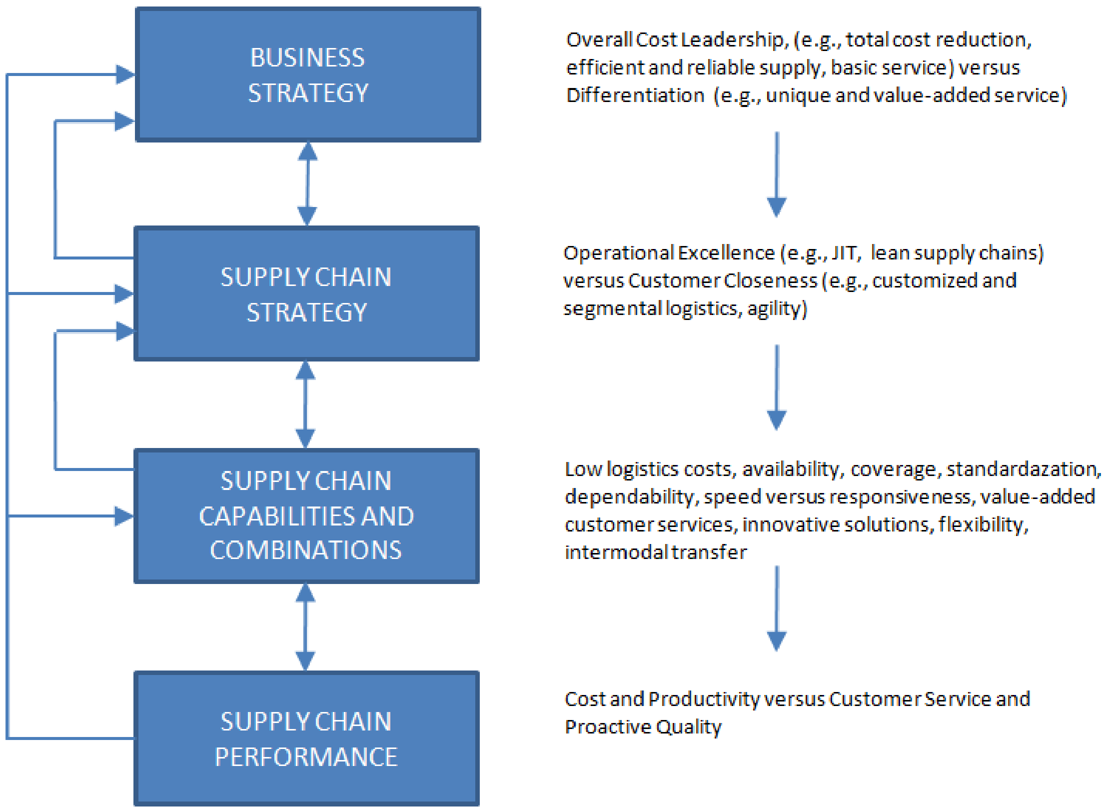


Figure 8 – Model of Supply Chain Strategy, Capabilities and Performance (Morash 2001)

In their framework, the authors also propose two models to describe supply chain strategies:

- **Normative model** – based on empirical usage of the techniques-tools matrix as a normative model, is a set of configuration and management techniques that a company has implemented together with the set of tools that were chosen to support them.
- **Contingency model** – based on the demand-supply matrix which defines the three main concerns that the companies should consider when choosing a supply chain strategy are:
    - Which phase is dominant within the end product's life cycle?
    - What is the inherent structural complexity of the end product?
    - Which type of supply chain?

Besides, the dominant life cycle phase of the end product, the second main determinant of the supply chain management strategy is the structural complexity of the end product, and finally, the third main determinant is the supply chain type (efficient, quick or lean).

It is important to note that the definitions of lean supply chain and efficient supply chain by Cigolini, Cozzi, and Perona (2004) overlaps to some extent since both of them focus on low costs, competitive prices, and high quality. Nevertheless, the authors put the lean type of supply chain in the midterm between efficient and quick supply chains.

Another authors, Cohen and Roussel (2005) have stated that strategic supply chain management is more than just innovation, it is creating a unique supply chain configuration that drives the strategic objectives forward. They explain that in order for the manager get the most from the supply chain, he needs to consider five critical configuration components:

- **Operations strategy** – defines how the staff runs the factories, warehouses, and order desks, as well as how the processes are classified and the information systems. The main operations strategy options are:
    - Make to stock
    - Make to order
    - Configure to order
    - Engineer to order
- **Outsourcing strategy** – is based on the analysis of existing supply chain skills and expertise. It allows companies to focus on their core business and enhance their competitive positioning but also introduces risks and strategic ramifications.
- **Channel strategy** – defines how the products and services reach buyers and end-users and have a direct impact on companies' assets and cost performance.
- **Customer service strategy** – is based on two things: the overall volume and the profitability of customer account and the comprehension of the customer concret needs. Both pieces of knowledge are crucial to the supply chain strategy since they help prioritize and focus the supply chain capabilities.
- **Asset network** – the location, the size, and mission of the company's assets network (factories, warehouses, production equipment, etc.) have a major impact on supply performance.

The authors Cohen and Roussel (2005) also state that the supply chain strategy should directly support and drive forward the business strategy which begins with a core strategic vision. This core strategy vision has four primary supply chain competing strategies:

- **Competing on Innovation** – Companies whose primary strategy is innovation focus on developing innovative products that benefit from significant consumer pull. Moreover, because their products are premium products, these companies can command a price premium, the innovator's advantage.
- **Competing on Cost** – Companies that compete on cost offer low prices to attract cost-sensitive buyers or to maintain share in a commodity market. This strategy demands highly efficient, integrated operations, and the supply chain plays a critical role in keeping both product and supply chain costs down.
- **Competing on Service** – Companies that compete on service tailor their offerings to their customers' specific needs and are known for exceptional customer service. These companies customize their products and services to build customer loyalty and lock in repeat sales.

- **Competing on Quality** – Companies that compete on quality are known for the premium nature of their products and services, as well as consistent and reliable performance.

More recently, Simchi-Levi (2010), proposed three supply chain operational strategies and developed a framework for matching products and industries with supply chain strategies. Simchi-Levi defends that first customer value, product and channel characteristics significantly affect operations and supply strategies.

According to the author, the proposed framework identifies the appropriated manufacturing strategy that the firm should apply, and this strategy is directly related to the degree of operational flexibility and the sales channel. The framework advocates the following strategies:

- **Push-based supply chain** – production and distribution decisions are based on long term forecasts. Therefore, the supply chain is slow to react to the changing market demand, resulting in excessive inventories, inefficient resource utilization.

- **Pull-based supply chain** – production and distribution are demand driven and coordinated with true customer demand rather forecast demand. There is an effort to reduce inventory and only responds to specific customer orders. This strategy is enabled by fast information-flow mechanisms that transfer information about customer demand to the various supply chain participants.

- **Push-pull supply chain** – some stages of the supply chain (typically the initial stages) are operated in a push-based manner while the remaining stages use a pull-based strategy. The interface between these two stages is called push-pull boundary (see Figure 9).

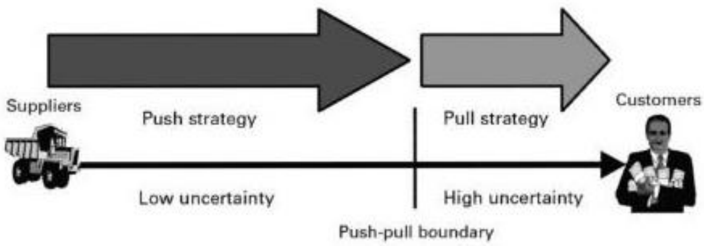


Figure 9 – Push-Pull boundary (source Simchi-Levi (2010))

This last supply chain strategy is, in reality, a hybrid mix of the push-based and pull-based strategies and relies on the perception that aggregate forecasts are more accurate than individual forecasts.

The push-pull supply chain strategy advocates the postponement or delayed differentiation in product design. In postponement, the company designs the product and the manufacturing process in a way that decisions about the manufacturing a specific product can be delayed as long as possible. Through this policy, the manufacturing process starts by producing a generic or family product, which when demand is identified is differentiated to a specific end product. Because the demand for a generic or family product is an aggregation of demand of all corresponding end-products, hence forecasts are more accurate, resulting in reducing inventory levels and diminishing the response time.

In his work, Simchi-Levi provided a framework for matching supply chain strategies with products and industries. This framework mapped information on uncertainty in customer demand vs. economy of scale either in production or distribution (Figure 10).

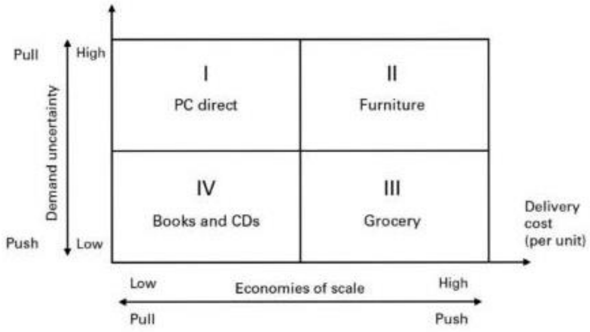


Figure 10 – Matching Supply Chain Strategies with Products (source Simchi-Levi (2010))

In this framework, Simchi-Levi argued that everything being equal, higher demand uncertainty leads to managing the supply chain based on realized demand, therefore the pull strategy. Alternatively, small demand uncertainty leads to managing the supply chain based on long-term forecasts, therefore the push strategy. Likewise, everything being equal, higher importance to economies of scale in reducing cost, the greater the value of aggregating demand and thus the importance of managing the supply chain based on long-term forecasts, therefore a push strategy. On the other hand, if economies of scale are not important, aggregation does not reduce cost, hence a pull-based strategy. Based on the previous literature review, Table 7 summarizes the major findings on supply chain strategies.

Table 7 - Major findings on operational supply chain strategies

Authors	Supply Chain Strategy	Characteristics
(Fisher 1997)	Efficient supply chain	- Functional products - Predictable demand - Choose suppliers primarily for cost and quality - Maximize performance and minimize costs
	Responsive supply chain	- Innovative products - Respond quickly to unpredictable demand - Select suppliers primarily for speed, flexibility and quality - Use modular design in order to postpone product differentiation
(Naylor, Naim, and Berry 1999) **(Mason-Jones, Naylor, and Towill 2000b)**	Lean Supply Chain	- Smooth and predictable demand - Elimination of all non-value adding processes - Efficient processes - Cost minimization - Lead time compression - Minimum reasonable inventory
	Agile Supply Chain	- Rapid reconfiguration - Flexibility - Robustness to variations and disturbances - Responsiveness to customers

(Christopher and Towill 2000)	Leagile Supply Chain	- Lean paradigm applied to the supply chain upstream from the decoupling point - Agile paradigm applied downstream - Decoupling point acts as a buffer
(Morash 2001)	Operational Excellence	- Total cost reduction - Efficient and reliable supply - Standardized products - Time-based strategies (JIT)
	Customer Closeness	- Proactive quality - Value-added customer service and products - Collaborative communications and interactions with customers - Agility in adjusting supply chain capabilities - Flexibility
(Cigolini, Cozzi, and Perona 2004)	Efficient supply chain	- Commodities products in high volume - Stable product flows - Improvement focused on operations - High level of efficiency and low-profit margins
	Quick supply chain	- Products with unpredictable demand - Innovative products - Manufacturing flexibility
	Lean supply chain	- Firms compete on price, novelty, quality and customer service - Low costs
(Cohen and Roussel 2005)	Competing on innovation	- Focus on innovative products - Have innovator advantage on price
	Competing on cost	- Low prices - High efficiency and integrated operations - Cost minimization
	Competing on service	- Tailored customer services - Build customer loyalty
	Competing on quality	- Premium products and services - Reliable performance
(Simchi-Levi 2010)	Push-based	- Demand predictable - Long term forecasts - Economy of scale and cost reduction
	Pull-based	- Reduced demand variability - Production demand driven - Reduced inventory levels - Efficient use of resources
	Push-Pull	- Postponement and delayed differentiation - Aggregated demand before the push-pull boundary - Reduced uncertainty for finished gods demand

Figure 11 presents an overall representation of the supply chain strategies listed in Table 7, graphically correlating them with the product typology and demand predictability. In the graph is possible to notice that the Efficient Supply Chain management strategy from Cigolini, Cozzi, and Perona (2004) is in a large portion coincident with the Lean Supply Chain strategy, but the difference lies in a mass production approach with emphasis on costs. In contrast, the Lean Supply Chain Strategy approach, also from Cigolini, Cozzi, and Perona, introduces emphasis equally on product, price, time, service, with increased manufacturing flexibility.

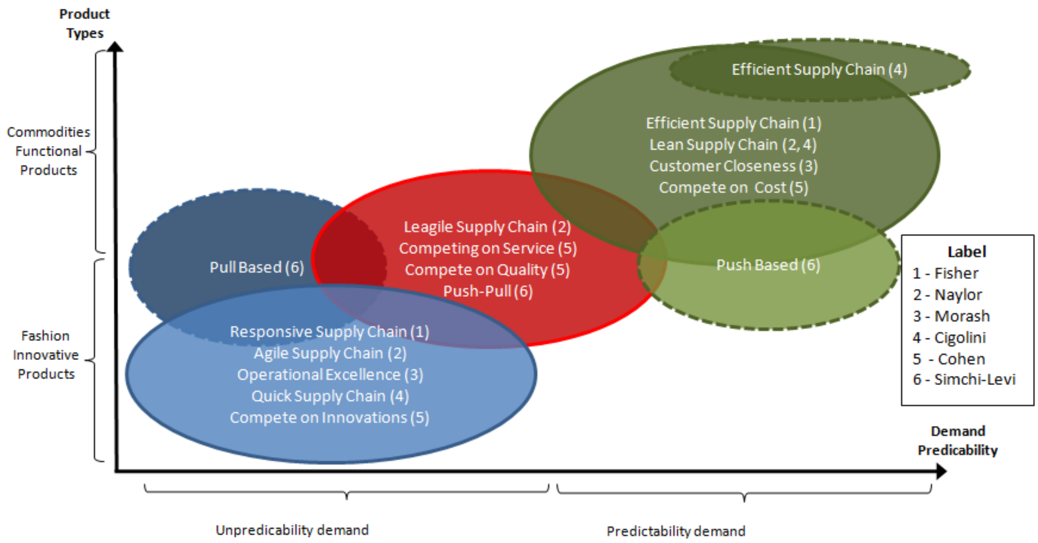


Figure 11 - Supply Chain Strategies Matching Graph

An important aspect to consider from the analysis of the graph is the fact that five of the supply chain strategies follow a diagonal line from the bottom left (high innovative products and great unpredictability in demand) to the upper right (commodity or highly functional products and high demand predictability).

The only exception is the Simchi-Levi three supply chain strategies, which follow a horizontal line covering both types of products (functional and innovative) and only matching the strategies with the variable demand predictability. This conclusion is coherent since the factors behind the Simchi-Levi three supply chain strategies definition were the demand predictability and the economy of scale or production volume.

Another important feature to take in consideration concerns Cigolini's supply chain strategies definition since it relats to the products life-cycle phase. In Figure 12, it is represented the correspondence between the phase of the products life-cycle with the supply chain strategy according to Cigolini's Demand Supply matrix.

From the findings of the Table 7, despite some specific particularities referred from different authors, it is possible to infer from the majority of the studies, that the most commonly used supply chain strategies in today's competitive circumstances are efficient (lean), responsive (agile) or a hybrid form of supply chain strategies (Lin 2004) (Qi 2006) (Vonderembse et al. 2006) (Harris 2007) (McKone-Sweet and Lee 2009) (Perez-Franco 2010) (Goldsby, Griffis, and Roath 2011).

In subsequent sections it will be presented in more detail the three concepts behind efficient/ leanness, responsive/agility and hybrid for the supply chain management strategy approaches.

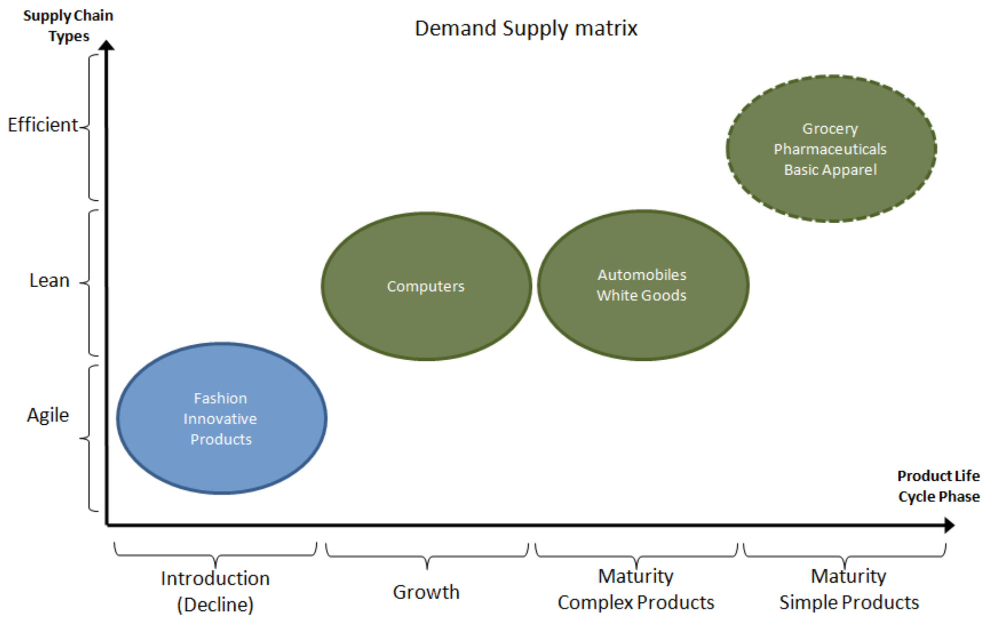


Figure 12 – Demand Supply Matrix (Cigolini, Cozzi, and Perona 2004)

2.3.1. Efficient /Lean Concept Overview

The concept of lean production was first used by the authors of the International Motor Vehicle Project carried out by MIT in the 1980s to describe a different method originally developed in the Japanese automobile manufacturing industry, which was distinguishable to the mass production approach common in the Western producers at that period. This new approach is often called "Just in Time" (JIT) in the industrial world. However, the authors of the book "The Machine That Changed the World," which popularized the term lean production, believed that leanness goes beyond JIT and more accurately describes the organizational and operational production systems used in the Japanese automotive industry at the time (Womack, Jones, and Roos 1990).

According to Womack: ''Lean production is 'lean' because it uses less of everything compared to mass production—half the human effort in the factory, half the manufacturing space, half the investment in tools, half the engineering hours to develop a new product in half the time. Also, it requires keeping far less than half the needed inventory on site, results in many fewer defects, and produces a greater and ever-growing variety of products''(Womack, Jones, and Roos 1990).

When examining the "lean" definition, is obvious a tendency to eliminate the fatness, and a strong emphasis on reducing the use of all resources, not only in the factory but also in activities extending beyond the shop floor such as product development and supplier relations. Womack in subsequent work expanded the concept of lean production to extend the lean enterprise and efforts to apply lean thinking throughout all enterprise activities and supply chain (Womack and Jones 1996).

In reality, the leanness means developing a value stream to eliminate all waste, including time, and to ensure a level schedule (Naylor, Naim, and Berry 1999).

Ever since its beginning, the concept of lean production has gained widespread attention, both in the academic world and in the practitioner's industrial environment. It is acceptable to state that it has become the dominant strategy for organizing production systems worldwide (Karlsson and Ahlstrom 1996).

From the previous literature it is possible to identify the concept of Lean Supply Chain as an established supply chain philosophy and define it as follows:

"A lean supply chain comprises a set of companies forming a network, used to deliver products and services from raw materials to end customers through an engineered flow of information, physical distribution and cash, committed in identifying and eliminating non-value-adding activities in design, production and supply chain management" (based on APICS (2008)).

2.3.2. Responsive/Agile Concept Overview

The agile concept was first presented in a report published by Lehigh University's Iacocca Institute in 1991: "21st Century Manufacturing Enterprise Strategy: An Industry Lead View" (Nagel and Dove 1991). This report highlighted virtual companies as a powerful cooperative strategy for achieving agility.

The "21st Century Manufacturing Enterprise Strategy: An Industry Lead View" report resulted in response to a U.S. congressional request to identify the requirements to U.S. industry return to global manufacturing competitiveness. The study argued that newly coming technologies such as computer-based production systems, information, and communication technologies were merged altogether into a new system of competition. With this system, it was possible to interconnect human, physical, and intellectual resources, distributed among groups of companies that were simultaneously competing and cooperating, which leads to a fundamental redefinition of industrial production paradigm.

Agility pioneers presented this philosophy as a business-wide capability that embraces organizational structures, information systems, logistics processes, and, in particular, mindsets (Christopher 2000). A crucial characteristic of an agile organization is flexibility.

Historically, the origins of agility as a business concept go back to the conception of flexible manufacturing systems (FMS). Earlier researchers thought that the means of manufacturing flexibility was through automation that enabled reduced set-up times and, as a consequence, greater responsiveness to changes in product mix or volume. Afterward, this idea of manufacturing flexibility and variable lot sizes was extended into the overall business context, resulting in the concept of agility as an organizational reference (Nagel and Dove 1991).

According to Nagel and Dove (1991), the new agile, competitive paradigm is driven by the customer-perceived value of information and services embedded in physical products and delivered over a period of time through continuing relationships between vendor and customer.

So, in order to prepare companies for future competitive battles, would be required that companies be able to develop short-lifetime, easily customizable, information-rich products, and services targeted at niche markets, and to do so much more quickly and much less expensively than was possible under the mass-production-based system.

In their book, Goldman, Nagel, and Preiss (1995) have addressed the concept of agility and have defined it as:

"Agility is a comprehensive response to the business challenges of profiting from rapidly changing, continually fragmenting, global markets for high-quality, high-performance, customer-configured goods, and services."

In the subsequent work Goldman, Nagel, and Preiss (1995) have characterized an agility framework through four strategic dimensions that underlie the acquisition by any company of agile competitive capabilities. Succinctly, the four strategic dimensions are:

- Enriching the customer;
- Cooperating to enhance competitiveness;
- Organizing to master change and uncertainty;
- Levering the impact of people and information.

Subsequently, Christopher (2000) defended that for a supply chain be truly agile; it must possess four distinguishing characteristics:

- **Market sensitivity** – means that the supply chain is capable of reading and responding to real demand. This sensitivity means that supply companies need to develop efficient consumer response and use information technology to capture data on demand directly from the point-of-sale or point-of-use, transforming the organization's ability to hear the voice of the market and to respond directly to it.
- **Virtual integration** – requires the use of information technology to share data between buyers and suppliers developing an information-enriched integration. Virtual supply chains are information-based rather than inventory-based.
- **Process integration** – means collaborative working between buyers and suppliers, joint product development, common systems, and shared information.
- **Network** – means that organizations need to better structure, coordinate, and manage the relationships with their partners in a network committed to better, closer, and more agile relationships with their final customers.

2.3.3. Hybrid Concept Overview

The previous two sections have presented two largely investigated and greatly disseminated supply chain strategies. Both approaches address the supply chain specific features and capabilities, posing them appropriated to specific demand and product scenarios. As Fisher (1997) have stated, in order for managers to develop an appropriate supply chain strategy, the first step is to understand the nature of the demand for the product. Aligned with this concept, researchers have identified which scenarios an agile or lean strategy might be appropriate for a supply chain.

However, there are often situations where there is a mix of conditions, where demand and product scenarios indicate that a combination of the two supply chain strategies may be appropriate, i.e., a hybrid strategy. Hybrid supply chain strategies recognize that, within a mixed portfolio of products and markets, there will be some products where demand is stable and predictable, and some products where the opposite is true (Mason-Jones, Naylor, and Towill 2000b).

In reality, elements of the product demand such as predictability, cost, and product life-cycle must be well defined. As Fisher points out (1997), it is important that the characteristics of demand are recognized in the design of supply chains. However, as authors such Naylor, Naim, and Berry (1999); Hoek (2000); Mason-Jones, Naylor, and Towill (2000b); Herer, Tzur, and Yücesan (2002); Stratton and Warburton (2003); Eaton (2003) it is not necessarily the case that a supply chain should be either lean or agile. Instead, a supply chain may need to be lean for part of the time and agile for the remaining time.

Thus, lean and agile practices for supply chain management should not be seen as isolated paradigms but can be combined in a supply chain hybrid strategy to form a new paradigm, i.e., leagility.

Historically, Naylor, Naim, and Berry (1999) in their seminal work proposed a new manufacturing paradigm, combining lean thinking (efficient supply chains) and agile manufacturing (responsive) simultaneously. The authors labeled this new hybrid paradigm as “leagility.”

These authors reasoned that the necessity of leanness or agility is related to the entire supply chain management strategy, particularly by considering product demand characteristics, market knowledge, and the decoupling point. The decoupling point, (supply chain) oriented towards customer orders from the part of the organization (supply chain) based on planning. The decoupling point is also the point at which strategic stock is often held as a buffer between fluctuating customer orders and/or product variety and smooth production output.

Several research works on supply logistics have stressed that a major problem in most supply chains is their limited visibility of real demand. Because supply chains tend to extend with multiple levels of inventory between the point of production and the final marketplace, they tend to be forecast-driven rather than demand-driven (Christopher 1998a) (Mason-Jones and Towill 1999a) (van Donk 2001) (Christopher 2000).

The point till when real demand penetrates upstream in a supply chain is the decoupling point. Nevertheless, the major concern is not how far the order penetrates, but how far real demand is made visible to the upstream nodes of the supply chain.

Logistics managers recognize that supply chain workflow orders are aggregations of demand, often delayed and distorted due to the actions and decisions of intermediaries as Forrester stressed out (Forrester 1958). On the other hand, demand reflects the ongoing necessities in the final marketplace as close to reality and real-time as possible.

In reality, the decoupling point indicates the form and location in which the inventory is held. As stated by Christopher (2000), according to the uppermost example in Figure 13, demand penetrates right to the point of manufacture, and inventory is probably held in the form of components or materials. In the lowermost example, demand is only visible at the end of the chain. Hence, inventory will be in the form of a finished product in this last case.

The positioning of the decoupling point depends upon two factors: the longest lead time an end-user is prepared to tolerate, and the point at which variability in product demand dominates (Naylor, Naim, and Berry 1999).

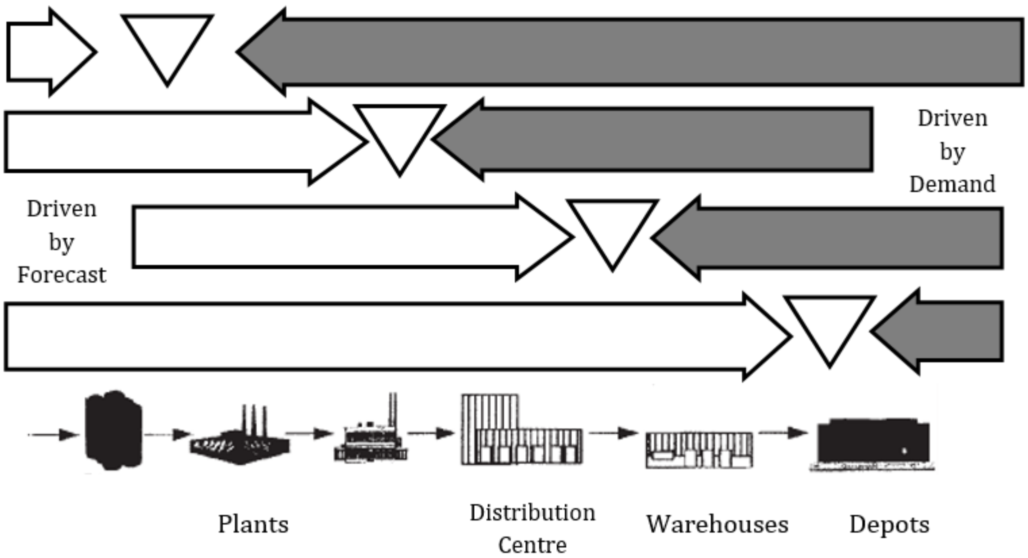


Figure 13 – Decoupling points and strategic inventory (Christopher 2000)

Therefore, downstream from the decoupling point all products are pulled by the end-user, that is market driven. Upstream from the decoupling point, the supply chain is forecast driven.

However, according to Naylor, Naim, and Berry, with the advent of *Kanban* driven supply, this forecast driven approach has become more than simply a push system and introduce the lean pull principles as well. In other words, the process upstream is a "push plan" and "pull execution" downstream. In reality, this could only occur if the demand is stable and predictable, regarding material flow from the upstream of the decoupling point (cf. Figure 14).

Starting from this assertions, Naylor, Naim, and Berry (1999) argued that the lean paradigm could be applied to the supply chain upstream of the decoupling point as the demand is smooth and standard products flow through many value streams. Naylor, Naim, and Berry (1999) also claimed that the agile paradigm should be applied downstream from the decoupling point as demand is variable and the product variety per value stream has increased.

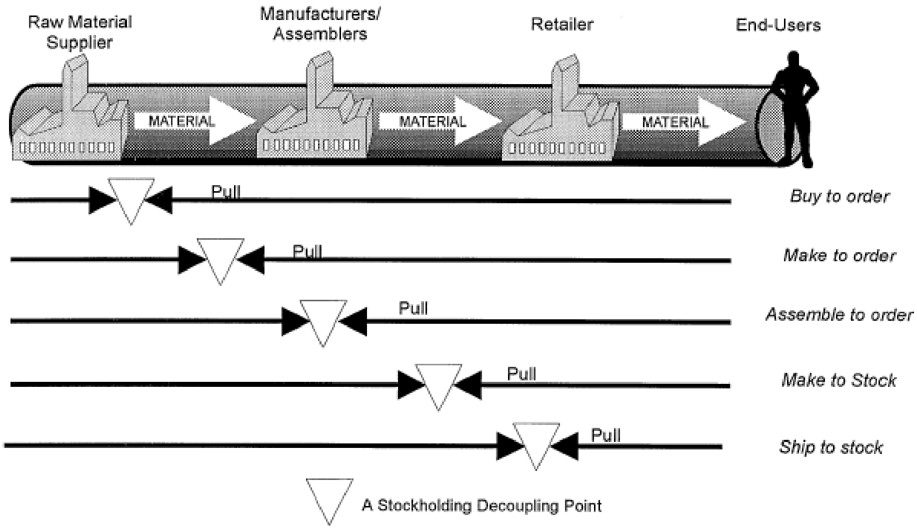


Figure 14 – Supply chain strategies (Naylor, Naim, and Berry 1999)

Aligned with this idea, Christopher and Towill (2001) presented the decoupling point where the two supply chain strategies, agile and lean, interface and synchronize according to Figure 15. Thus, the aim of the agile supply chain should be to carry inventory in a generic form that is standard semi-finished products awaiting final assembly or localization. This approach is the basis of the postponement concept, a vital element in any agile strategy.

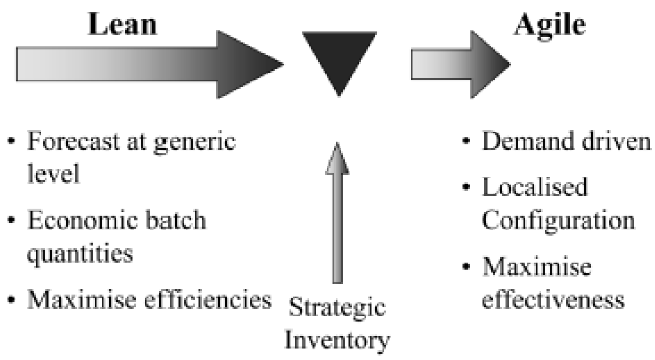


Figure 15 – Decoupling Point (Christopher and Towill 2001)

Several authors addressed the concept of postponement or delayed configuration (Pagh and Cooper 1998) (Ernst and Kamrad 2000) (Christopher 2000). The concept relies on the policy of designing products using common platforms, components, or modules, but where the final assembly or customization does not take place until the final market destination and/or customer requirement is known.

Hoek (1998) pointed out the following advantages from the use of the postponement strategy in supply chain management:

- Delaying customization increases the supply chain's flexibility to respond to changes in the mix of demands from different market segments.
- Inventory can be held at a generic level so that there will be fewer stock-keeping variants and, hence, less inventory in total.

- Inventory is generic, meaning that the same components, modules, or platforms can be embodied in a variety of end products.
- Forecasting is easier at the generic and aggregated level than at the level of the finished item.
- Enables customization of products locally, offering a higher level of variety at a lower total cost.

Such a postponement strategy enables a company to be responsive to variable customer requirements, and yet utilize the cost control aspects of a physically efficient supply chain up to the decoupling point (Lee 2002) (Duclos, Vokurka, and Lummus 2003). With the postponement strategy behind is possible to set off the leagility idea, where the physically efficient leanness strategy is applied upstream of the decoupling point, and the market responsive, agile strategy is applied between the decoupling point and the customer (Mason-Jones, Naylor, and Towill 2000b).

The major challenge that leagile (hybrid) philosophy poses to supply chain managers is to seek how to develop lean strategies up to the decoupling point, but agile strategies beyond that point. Christopher (2000) argues that this is possible through the use of generic or modular inventory to postpone the final commitment, achieving volume-oriented economies of scale through product standardization. Thus, the flow of the product up to the decoupling point can be forecast-driven, and the flow of product after the decoupling point should be demand-driven.

Christopher (2000) stressed out an important aspect. That in reality, in the leagile supply chain, there are two decoupling points. The first is one is the material decoupling point, where strategic inventory is held in a generic form as possible. Ideally, this point should lie as far downstream as possible in the supply chain and as close to the final market place as possible in order to postpone as long as possible the customer customization. The second decoupling point is the information decoupling point. The idea, in this case, is that this point should lie as far upstream as possible in the supply chain. By moving the information decoupling point as upstream as possible, the leagile supply chain increases the market awareness reducing inventories. This information decoupling point is, in reality, the furthest point to which information on real final demand penetrates the supply chain.

Mason-Jones and Towill (1999b) have defined the information decoupling point as “the point in the information pipeline to which the marketplace order data penetrates without modification. It is here where market-driven and forecast driven information flows meet.”

The position of the information decoupling point has a singular impact on reducing upstream amplification and distortion of demand. This point is the point at which information turns from the high-value actual consumer demand data to the typical upstream distorted, magnified and delayed order data. Mason-Jones, Naim, and Towill (1997) have demonstrated through simulation the beneficial impact that information feedback can have on reducing upstream amplification and distortion of demand. This reduction is mainly because of the fact each level can make a far more informed judgment on internal production levels resulting from having a direct insight of the end consumer.

Through the correct management of these two decoupling points in the leagile supply chain is possible to potentiate an overall agile response from the supply chain to the market, and at the same time reducing the "bullwhip," or Forrester effect (Forrester 1958).

Besides the two decoupling points approach for leagile hybrid strategy in supply chain management, Christopher and Towill (2001) explored another two hybrid strategies:

- *Pareto 80/20* – since 80% of total volume will be generated from just 20% of the total product line; therefore how this 20 % are managed should be different from the way the remaining 80% are managed. Usually, the top 20% of products by volume are likely to be more predictable, and hence they are more suitable to lean principles of manufacturing and distribution. On the other hand, the slow-moving 80%, are typically less predictable and will require a more agile approach to management.

- *Surge/base demand separation* – since base demand can be forecast by historical data, whereby surge demand typically cannot. Base demand can be met through classic lean approaches to achieve economies of scale whereas surge demand is provided for through more flexible, and probably higher cost, processes, through agile approaches.

The authors argued that while these three strategies are complementary rather than mutually exclusive, it is likely that each of the hybrid approaches may work better in certain conditions related to market conditions and operating environment.

Mason-Jones, Naylor, and Towill (2000a) argued that the strength of each of the paradigms, agility, and leanness, could be lost if pursued in isolation or independently. The fundamental view that agile manufacturing is adopted where demand is volatile and lean manufacturing adopted where there is a stable demand can be counter-productive. The authors defended that in some situations it is advisable to utilize a different paradigm on either side of the material flow decoupling point to enable a total supply chain strategy. They claimed that the classification of a lean, agile, and leagile supply chain could enable the manufacturers to match the appropriate supply chain strategy type according to the marketplace need. They also, underlined that leagile supply chains are a today's reality, and that is important to recognize when the new paradigm would be the best way to advance for a particular supply chain so that it could be adequaly implemented from the start.

Robertson and Jones (1999) in their work have present a case study of the leagile strategy describing the applicability of this strategy in the telecommunications context.

Another author, Hoek (2000), based upon a one-year study of agility in the supply chain, indicated that the leagility might work well in operational terms as lean capabilities can contribute to agile performance and might often be a prerequisite to successful supply chains.

Aligned with the leagility theme the authors, Herer, Tzur, and Yücesan (2002) have addressed the postponement strategies in the leagile supply chains. The authors argued that postponement strategies pose a cross-functional challenge for implementation. As a tactical solution to achieve leagility without postponement, they endorse transhipments. They sustained that transhipments represent common practice in multi-location inventory systems involving the monitored movement of stock between locations at the same echelon level of the supply chain. Through a series of models, they establish how transhipments can be used to enhance both agility and leanness.

Prince and Kay (2003) described several scenarios where some organizations require the combination of lean and agile characteristics in their manufacturing organizations. They sustained that a decoupling point within a specific factory will enable lean and agile practices to complement each other at the operational level to improve overall performance and profitability of the factory. From the author's point of view, in order to integrate the lean and agile paradigm efficiently, is relevant to the development of the virtual group concept, which is the application of virtual cells to functional layouts. They declared that virtual groups enable the appropriate application of lean and agile concepts to different stages of production in a factory as depicted in Figure 16. In the authors perspective, this micro perspective can be extended to the entire supply chain.

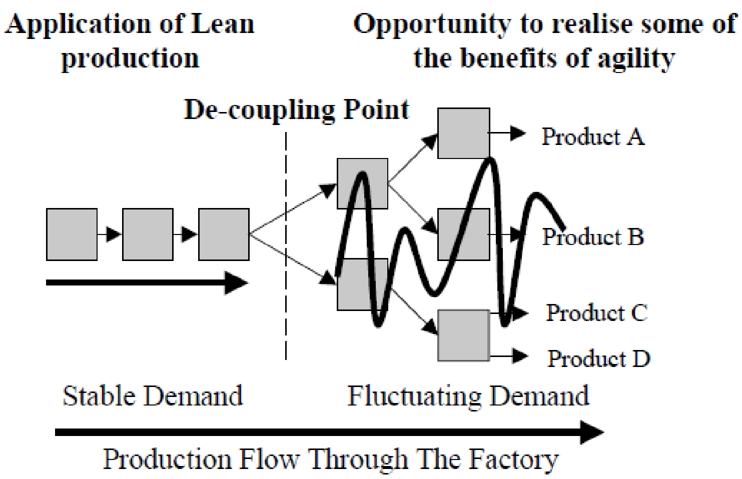


Figure 16 – Lean and agile concepts (based in Prince and Kay (2003))

Bruce, Daly, and Towers (2004) through case studies of textile and apparel companies, studied different approaches to supply chain management and pointed out the existence of leagile supply chains in this sector. They recognized that with the prevailing characteristics of the textiles and apparel sector, a combination of the two supply chain strategies (agile and lean) was evident.

In summary, companies in textiles and clothing need to be able to respond quickly to changing markets and also to be able to provide quick replenishment. On the other hand, they are not able to store large quantities as products because products have a very short life cycle and fashion markets are seasonal. Therefore, the authors claim that the textiles and clothing industry does not neatly fit into either a lean or agile paradigm, but instead it is a combination of the two driven by low margins and volatility of demand. This reality would ensure fast product replenishment, the building, and maintaining supply chain partnerships and flexibility in response to the volatility of demand from retailers. In summary, the main characteristics of a leagile supply chain.

From the survey involving 600 companies in the UK, Yusuf et al. (2004) have studied what relates supply chain practices to competitive objectives. The results show that only a few companies have adopted agile supply chain practices. In contrast, most companies have embraced long-term collaboration with the supplier as well as customer, which this study conceptualized as lean supply chain practices. The authors also concluded that the lean and agile models of supply chains had no negative interaction effects on competitive and performance measures. They suggested that the integration of lean and agile models in supply chains can generate greater synergy in their impacts. Integration would require the lean model to improve on Internet-based data integration, embrace several competitors in lean networks, and emphasize collaborative design and manufacture.

More recently Krishnamurthy and Yauch (2007) have conducted a case study of a company to determine whether the concept of leagility could be applied to a single corporation with multiple business units and whether a decoupling point would be necessary to distinguish the lean and agile portions of the enterprise. In their work, the authors concluded that the study showed how a multi-unit corporate enterprise could apply the concept of leagility. Similar to the other leagile models designed for supply chains and manufacturing facilities, the authors assured that determining whether to call a manufacturing system leagile depends on where a boundary is placed around the system or sub-units within the system. For the case study proposed model, the agile and lean portions of the system are both within the corporate boundary but separated by a decoupling point, fitting with the classical vision of the leagile supply chain.

In 2008 Li et al. (2008) conducted a study on manufacturing supply chain leagile strategy driven factors based on customer value. In this study, the authors recognized that in fact, most enterprises endorse a leagile strategy instead of agile strategy or lean strategy separately. Under this study, the authors reached the matrix represented in Figure 17. This matrix illustrates the directive function on the supply chain's strategy selection by the analysis on the product advanced stage (product lead time) and product demand forecasting. According to this study, the lean strategy is more suitable for the products with a long-term advanced stage and accurate forecasting.

On the other hand, the agile strategy is more suitable for the products with short-term advanced stage and uncertain forecasting. The matrix presents the other two situations where the manager should select a leagile strategy. One is for the products with long-term advanced stage and uncertain forecasting. The other is for the products with short-term advanced stage and accurate forecasting.

The authors argue that in case of the products with long-term advanced stage and uncertain forecasting, although information of market demand is not accurate, it is not necessary to spend high costs in carrying out agile strategy totally because of the long-term advanced stage. Enterprises could start with the product design and move the decoupling point of the standard and diversity forward to the downstream of the supply chain and carry out the delay policy of lean strategy before agile strategy.

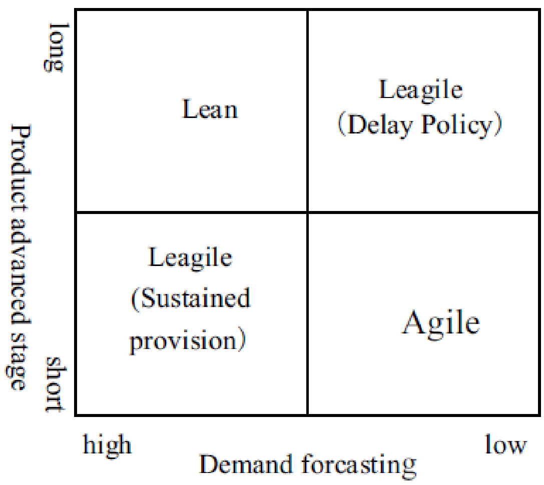


Figure 17 – Driven factors for supply chain strategy (based in Li et al. (2008))

Concerning the products with short-term advanced stage and accurate forecasting, the authors argue that this kind of products could carry out the lean product because of stable market demands. Given the short-term advanced stage, sellers hope manufacture could supplement products continuously, taking the leagile strategy of sustained provision, delivering goods in high frequency and low lot size.

From the literature review about leagility, it is deductible that the leagile supply chain exists at an operational level. Nevertheless, some academic authors dispute the concept of the leagile supply chain as a unique strategy separated from agile and lean strategies. For instance, Hoek (2000) arguments that leagile supply chain can perform well on an operational level but, but it does not fundamentally conflict with the concept of agility. Hoek states that whereas a combination of efficiency and customer responsiveness in the supply chain can be applied in operations, there needs to be an overlying concept. Therefore, the author claims that in the case of leagility this can only be the concept of agility, rather than lean thinking. Consequently, leagility focuses on the reconfigurability of the supply chain in response to transient market opportunities and is a combination of capabilities based on various strategies that include lean and agile capabilities.

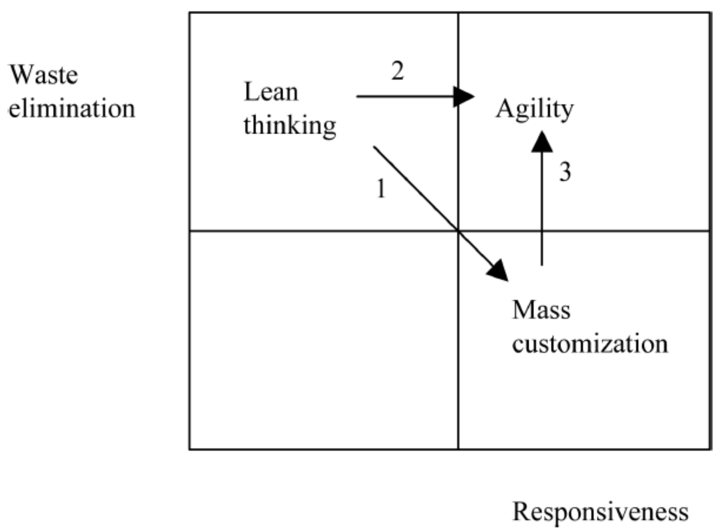


Figure 18 – Supply chain strategies evolution (Source: Hoek (2000))

According to Hoek Hoek (2000) from the Figure 18, the leagile supply chain presents the evolution from the lean thinking to mass customization pursuing responsiveness in the forfeit of waste elimination with the introduction of inventory and capacity buffers. The author also argues that finally, the supply chain should evolve to agility as a responsive and cost-effective structure.

In the same direction pointed out the empirical study conducted by Narasimhan, Swink, and Kim (2006). The empirical results from the study indicated that the prevalence of agile and lean performing plants differs significantly across industry types. Nevertheless, substantial overlap in the content of both paradigms was identified and coined as leagility. In this study, the results also suggest that, when viewed from a performance perspective, leanness is a precursor to agility.

Therefore, according to the previous literature review is possible to infer that although the leagile supply chain is not a strategic concept, nevertheless it can be viewed as a support for the cumulative model of lean and agile practices at the operational manufacturing level.

2.3.4. Products Effects in the Supply Chain Strategy

The previous sections presented two main strategic approaches for supply chain manufacturing. These two base approaches are lean strategy and agile strategy. A third hybrid alternative derived from the merge of the lean and agile concepts was also characterized and presented as a valid alternative for a supply chain manufacturing approach. As presented in section 2.3, when supply chain managers intend to select the most suitable approach to follow, they should consider several factors. In addition to these factors, manufacturers should also consider the major features of the products they present to the market when they choose the appropriate supply chain strategy. This section intends to present a literature review on the product typology effects in the choice of the adequate supply chain manufacturing strategy.

Fisher (1997) was one of the first authors to propose a framework for supporting supply chain managers in their task of deciding which one is the best approach for their particular supply chain management strategy. This framework was intended to help managers understand the nature of the demand for their products and devise the supply chain that can best satisfy that demand. Fisher determined, from his own experience, that there are two types of products: those that are primarily functional, and those that are primarily innovative.

In his work, Fisher suggested that the appropriate supply chain strategy for functional products is a physically efficient strategy and a market responsive supply chain strategy is the best fit for innovative products. Both of these supply chain strategic proposals are discussed in this document in section 2.3.

Figure 19 presents Fisher's framework matrix for matching supply chains with products. The logic behind Fisher's framework fits so closely with common sense that many other researchers in the supply chain field joined the cause of supply chain product alignment as a new area of performance research. Seizing upon the concept of supply chain product alignment, research in supply chain management rapidly moved from the original Fisher's concepts to the investigation of modifications of Fisher's original framework (Harris 2007).

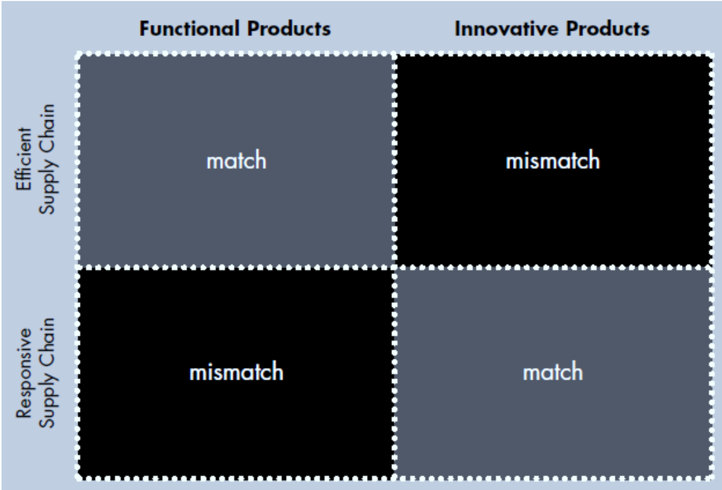


Figure 19 – Fisher matrix for matching supply chains with products (Source: Fisher (1997))

Waller, Dabholkar, and Gentry (2000) in their work addressed that supply chain strategies mostly rely on the product characteristics in two aspects: postponement and product customization. According to these authors, market strategists consistently suggest that organizations must choose among the three divergent strategies of product customization, cost minimization, and concentration (i.e., focus on a few customers, markets, or products). They further suggest that it is very difficult, if not impossible, to succeed at more than one of these strategies at a time.

On the other hand, Huang, Uppal, and Shi (2002) in their paper defended that there are three types of manufacturing supply chains (lean supply chain; agile supply chain; and hybrid supply chain), so the manager faces a problem when deciding which type of supply chain is best suited for his organization. The authors argue that the product the organization manufactures is the single most important factor for the supply chain selection. Therefore, they proposed a conceptual model to assist managers in this decision. This model is represented in Figure 20 and matches products with the desired supply chain type. The authors also proposed a questionnaire to categorize the products as functional, hybrid, or innovative.

Related with Fisher's framework, Childerhouse, Aitken, and Towill (2002) and Aitken, Childerhouse, and Towill (2003) conducted a case study to investigate the relationship between the product characteristics and the supply chain strategy. The company studied was a major UK lighting manufacturer who has sought to remain an international player in a fast-changing business environment. Based on the findings, the authors emphasized the importance of the adequate match between products characteristics and supply chain strategy. The authors stressed that careful matching of products to supply chain pipelines thereby enables maximization of the appropriate order winner and market qualifier characteristics.

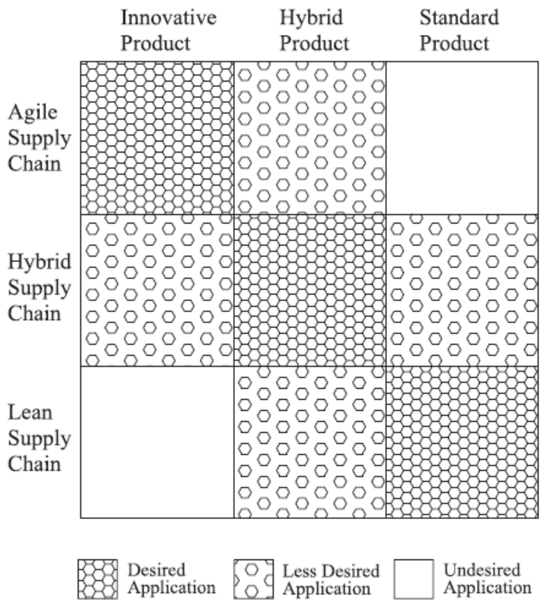


Figure 20 – Matrix matching product with supply chain - (Huang, Uppal, and Shi 2002)

Bruce, Daly, and Towers (2004) have addressed supply chain management in the textiles and clothing industry. They have characterized textiles and apparel as volatile markets, with short product lifecycles and high product variety.

From the Fisher (1997) framework the textiles and apparel products fall in the class of innovative products with unpredictable demand. Moreover, the textile sector has extremely low-profit margins so that producing and even holding small quantities of stock is not commonly a viable option. Therefore, companies in the sector have to produce products rapidly to fulfill these orders. This demand poses a challenge to supply chain managers. Tuned with this reality, Bruce, Daly, and Towers (2004) have stressed the need for future research in order to further understanding of supply chain management for fashion and commodity manufacture and supply.

In their work: "A new framework for supply chain management," Cigolini, Cozzi, and Perona (2004) addressed the supply chain management (SCM) determinants in an empirical study and concluded that three main factors could play a major role in leading companies to adopt a particular SCM strategy are:

- which phase is dominant within the end product's life cycle;
- the inherent structural complexity of the end product; and
- the type of supply chain.

The Cigolini, Cozzi, and Perona (2004) empirical test was performed on more than 100 successful implementations of supply chain management within seven relevant businesses and demonstrated the importance of products in the definition of the supply chain management strategy.

In 2007, Harris (2007) in his Ph.D. thesis addressed the alignment of supply chain strategy with products characteristics problematic, namely the validation of Fisher's framework. The problem that Harris tackled was that the original notion, which Fisher clearly stated was based upon his personal experience and not quantitatively validated.

Harris research based upon a modeling supply chain/inventory optimization and analysis tool quantitatively validate the assumption that the performance of an enterprise is enhanced by the alignment of the appropriated supply chain strategy with products characteristics. From the quantitative study, Harris concluded that the results of his study validated Fisher's original framework. Namely, if a product exhibit mostly a functional product characteristic, the supply chain strategy choice should be an efficient strategy. On the other hand, if the product is mostly innovative in nature, the manager should choose a responsive market strategy.

In his study, Harris pointed out one area, he described as hybrid solution space, in which the product types are not clearly functional or innovative but exhibit characteristics of both. As products progress through the life-cycle, it is likely that their initial characteristics will change, and therefore, the supply chain strategy should also adapt for optimality.

Harris study demonstrated the need for hybrid supply chain strategies to optimally service those markets. Nevertheless, the author recognized that there was very little empirical or quantitative research performed to discover optimal strategies for mixed product types.

Qi (2006) develop another quantitative study that considered the impact of the product characteristics in the definition of the supply chain strategy. The author conducted an empirical study in more than 600 Chinese companies. Using Fisher's definition, Qi classified the products into two groups: innovative products (unpredictable demand and short life cycles) and functional products (stable and predictable demand with long life cycles).

The results from Qi analysis revealed that the innovative products indeed have high demand variability, high product variety, high volume, and short time-to-market, while the functional products have low demand variability, low product variety, low volume, and long time-to-market.

Qi's study also reveals that companies producing innovative products have a higher level of use of the agility supply chain strategy than those producing functional products and the same level of use of the lean supply chain strategy as those producing functional products.

Furthermore, Qi's results have shown that functional products do not need more use of the agile supply chain strategy, but that innovative products need both the lean and agile supply chain (leagile) strategies.

In conclusion, Qi's findings provided empirical evidence for the product classification proposed by Fisher ((1997). Another insight was that innovative products require the same level of use of the agile supply chain and the lean supply chain, while functional products need a higher level of use of the lean supply chain. Therefore, the author results point to the existence of leagile supply chain in reality.

As final remarks, it is possible to conclude from the above literature review that the product characteristics are the most relevant factor behind the supply chain management strategical decision. The research has demonstrated that the first step in devising an effective supply chain strategy is to assess the characteristics of the products and use these characteristics to define the adequate strategy. In reality, the internal infrastructure and process of a firm should be co-aligned with the product it produces in order to achieve high performance.

The empirical studies have sustained that in case of innovative or fashionable products they need an agile supply chain management strategy. On the other hand, in the case of commodities or functional products, the results show the need for a lean supply chain management strategy.

In the specific case of hybrid (mix of innovation and functionality) products, several studies sustain that a hybrid/leagile approach is the adequate strategy for supply chain management, even though several researchers claim the nonexistence of this strategic concept and defining it as an operational term.

From the previous product perspective literature review, there is yet several fundamental questions arising: How supply chains can follow the life-cycle of products in its strategic perspective? With the arrival of the Internet, how can supply chain strategies address the multi-channel revolution? With the empowerment of the customers, how can supply chain strategy address the product customization and customer co-design?

The current supply chain management research has not so far devised an adequate framework to cope with this dynamic phenomenon and arising challenges.

Another complementary subject not yet completely clarified is related to the evolution of the supply chains. Is there a pattern that can explain the migration from one strategic paradigm to another?

This lack of knowledge points again to an updated framework that encompasses this dynamic behavior at the strategic level of supply chain management. The present research work aims to support the research progress in this area of knowledge by addressing these previous questions.

2.3.5. Comparative Studies of Supply Chain Management Strategies

The present section intends to present a literature review on comparative studies of the relevant supply chain management strategies.

Mason-Jones, Naylor, and Towill (2000a) published a paper addressing the hybrid approach for supply chain manufacturing management and presented a comparative study between the lean and agile supply chain distinctive attributes.

Table 8 presents the Mason-Jones, Naylor, and Towill study summary.

From Table 8 is possible to conclude that from one side on the lean supply chain, the emphasis is on the functional or commodities products with predictable demand and overall cost focus. Inversely, the agile supply chain is oriented to innovative fashion products with volatile and unpredictable demand and focused on the product or service differentiation through its uniqueness. Using the comparative study from Mason-Jones, Naylor, and Towill, the authors Agarwal, Shankar, and Tiwari (2006) expanded it to include the leagile supply chain according to Table 9.

Table 8 - Comparison of lean supply with agile supply: the distinguishing attributes (Mason-Jones, Naylor, and Towill 2000a)

Distinguishing attributes	Lean supply	Agile supply
Typical products	Commodities	Fashion goods
Marketplace demand	Predictable	Volatile
Product variety	Low	High
Product life cycle	Long	Short
Customer drivers	Cost	Availability
Profit margin	Low	High
Dominant costs	Physical costs	Marketability costs
Stockout penalties	Long term contractual	Immediate and volatile
Purchasing policy	Buy goods	Assign capacity
Information enrichment	Highly desirable	Obligatory
Forecasting mechanism	Algorithmic	Consultative

According to Agarwal, Shankar, and Tiwari (2006) comparison is possible to observe that lean supply chains addresses volatile and unpredictable demand but with a medium product variety and a moderated profit margin.

Therefore, according to with these authors, leagile supply chain and specifically the leanness in a supply chain is an operative approach that maximizes profits through cost reduction while agility maximizes profit through providing exactly what the customer requires.

Table 9 – Comparison of lean, agile and leagile supply chains (Agarwal, Shankar, and Tiwari 2006)

Distinguishing attributes	Lean supply chain	Agile supply chain	Leagile supply chain
Market demand	Predictable	Volatile	Volatile and unpredictable
Product variety	Low	High	Medium
Product life cycle	Long	Short	Short
Customer drivers	Cost	Lead-time and availability	Service level
Profit margin	Low	High	Moderate
Dominant costs	Physical costs	Marketability costs	Both
Stock out penalties	Long term contractual	Immediate and volatile	No place for stock out
Purchasing policy	Buy goods	Assign capacity	Vendor managed inventory
Information enrichment	Highly desirable	Obligatory	Essential
Forecast mechanism	Algorithmic	Consultative	Both/either
Typical products	Commodities	Fashion goods	Product as per customer demand
Lead time compression	Essential	Essential	Desirable
Eliminate muda	Essential	Desirable	Arbitrary
Rapid reconfiguration	Desirable	Essential	Essential
Robustness	Arbitrary	Essential	Desirable
Quality	Market qualifier	Market qualifier	Market qualifier
Cost	Market winner	Market qualifier	Market winner
Lead-time	Market qualifier	Market qualifier	Market qualifier
Service level	Market qualifier	Market winner	Market winner

Li et al. (2008) published another relevant and extensive comparative study.

Table 10 presents the author's comparative study between the lean supply chain and an agile supply chain.

Li et al. comparison is very similar to the Mason-Jones. However, what makes their work relevant is the inclusion of a table with the tendencies of driven factors of supply chain strategy based on customer value analysis. With this market segmentation analysis of customer value is possible to compare a large number of factors relevant to the supply chain strategy.

Table 10 – Comparison between lean and agile strategy (Li et al. 2008)

Remarkable Characteristics	Lean Strategy	Agile Strategy
Product	ordinary	popular
Market Demand	accurate	changeable
Sorts of Products	few	many
Products Lifecycle	long	short
Customers Driven Factors	cost	attainable
Marginal Revenue	low	high
Main Cost	tangible costs	marketable cost
Shortage Loss(Stock)	under long contract	unstable amd direct
Purchasing Policy	purchasing materials	distribution volume
Message replenishment	highly random	compulsory
Forcasting Mechanism	calculating	consulting

The Li et al. (2008) driven factors study is presented in Table 11 and summarizes the supply tendencies due to four purchasing reasons each one for products and services.

Table 11 – Driven factors for Supply Chain Strategy (Li et al. 2008)

	Purchasing Reason	Driven Factors	Property	Tendency
Product Property	Product Applicability	Sorts of Product	many	AGILE
			a few	LEAN
		Seasonal of Product	strong	AGILE
			weak	LEAN
		District Culture	centralization	LEAN
			decentralization	AGILE
		Relative Stability	strong	LEAN
			weak	AGILE
	Product Demand Property	Product Individual	strong	AGILE
			weak	LEAN
		Product Quantity	many	LEAN
			a few	AGILE
		Un-forecasting Demand	strong	AGILE
			weak	LEAN
		Product Life-Cycle	spreading stage	AGILE
			maturity stage	LEAN
			degenerating stage	AGILE
		Technology Level	high	AGILE
			low	LEAN
		Brand Recognition	high	LEAN
			low	AGILE
	Product Price Index	On-sale	strong	AGILE
			weak	LEAN
		Performance Price Ratio	high	LEAN
			low	AGILE

	Product Dependent Relation	Product Dependence	strong	LEAN
			weak	AGILE
		Feeling Dependence	strong	LEAN
			weak	AGILE
Service Property	Product Popularization (before-sale)	Popularization Speed	fast	LEAN
			slow	AGILE
		Popularization Quality and Methods	high	LEAN
			low	AGILE
		Popularization costs	high	AGILE
			low	LEAN
	Product Availability (in-sale)	Product Lead Time	long	LEAN
			short	AGILE
		Location	far	LEAN
			close	AGILE
		Availability	unification	LEAN
			diversification	AGILE
	Product Maintenance (after-sale)	Guarantee Period	unification	LEAN
			diversification	AGILE
		Content and Scope of Service	unity	LEAN
			broad	AGILE
		Quality and Speed of Service	high	AGILE
			low	LEAN
	Product Recovery (after-sale)	Recycling and Reuse of Product	high	AGILE
			low	LEAN
		Pollution of the Environment	high	AGILE
			low	LEAN
		Enterprise Visualization Interest	high	AGILE
			low	LEAN

From the previous literature review of comparative studies on supply chain management strategies is possible to identify very distinguishing attributes that characterize the different supply chain strategies according to the main operational and strategic factors, namely:

- Market demand
- Product variety and life-cycle
- Costs
- Inventory policies
- Information management
- Forecasting mechanisms
- Reconfigurability and flexibility
- Robustness
- Quality
- Response time
- Service level

Although the literature lists these factors, nevertheless it lacks a coherent model detailing the individual impact of these factors on the supply chain operational performance or their relevance.

Another relevant impact on supply chain management operational strategy arises from the globalization effect. The globalization of markets and manufacturing resources has in the last decades forced the supply chain stakeholders to not only consider business processes in the traditional value chain but rather processes that penetrate and embed networks of organizations.

Due to this trend, the research on supply chain management has changed from an intra-organizational materials focused approach towards inter-organizational integrated materials and data focuses view.

Creating information visibility and providing it extensively enables members of the supply chain to manage their business processes with more efficiency and effectiveness collaboratively. Nevertheless, these new requirements on data management inside the supply chains put high expectations on the new generations of ICT (Information and Communication Technologies) on the integrated management of information.

2.4. Impact of Information and Communication Technologies in the Supply Chain Strategy

As explained in the previous section, the Information and Communication Technologies (ICT) plays a major role in the overall performance of the modern supply chain structures. This section intends to present a literature review on the impact of the information systems in the supply chain strategy.

The breakthroughs of the last decade in the form of Efficient Consumer Response (ECR), and the use of information technology to capture data on demand directly from the point-of-sale or point-of-use, are now transforming the organization's ability to hear the voice of the market and to respond directly to it rapidly and efficiently (Christopher 2016) (Sodhi and Tang 2017).

The strategy of sharing market sales information cements companies together and promotes strong partnership links (Durugbo 2015). In reality, market sensitivity means that the supply chain is capable of reading and responding to real demand. In the past, most of the organizations were forecast-driven rather than demand-driven. This forecast focus happened because they have very little direct feedback from the marketplace, and the data of actual customer requirements did reach them through the supply chain channels. So, they were forced to make forecasts based on past sales or shipments and convert these forecasts into inventory.

According to (Christopher 2016), the use of information technology to share data between buyers and suppliers is, in effect, creating a virtual supply chain. Virtual supply chains are in reality making the transition from inventory-based systems to intensive-information systems.

Historically, conventional logistics systems were designed and implemented based on the paradigm that seeks to identify the optimal quantities of inventory and its spatial location. These logistic systems were supported by complex algorithms that exist to sustain this inventory-based business model. Namely this approach seeks to synchronize the flows by anticipating demand and minimizing disruption and disturbance through the supply chain. Ironically, it was known from the first studies that once the supply chain has visibility of demand through shared information, the premise upon which these approaches are based no longer holds (Forrester 1958) (Fiala 2005) (Chatfield et al. 2004). The main obstacle for the implementation of this visibility resided in the lack of technology solutions for data sharing across the network until recently.

Electronic Data Interchange (EDI) and, now, recent innovations in utility computing, web services, service-oriented architectures, and improved and powerful new Internet sharing data technologies combined with a growing array of ICT skills have enabled partners in the supply chain to act upon the same data, i.e., real demand, rather than be dependent upon the distorted and noisy scenarios.

As Tallon (2008) suggest, IT resources, in isolation, are unlikely to yield superior performance and so as firms try to boost their agility, need to configure IT resources to prepare for, or react to change. The author confirms that recent innovation around web services, utility computing or other technologies are radically improving business process agility and market responsiveness. Nevertheless, from the empirical study conducted by the author, he concluded that managerial IT capabilities are more effective for firms in a turbulent setting, while technical IT capabilities are more effective for firms in a stable setting.

In reality, several research works have shown that especially in the case of agility the role of IT is extremely relevant. For instance, Gallagher and Worrell (2008) conducted a longitudinal case study of an insurance company in order to identify how can information technologies (IT) promote organizational agility. The study confirmed that IT enables enterprise agility or the ability to sense and respond to changes in the competitive environment. Reciprocally, an organization's ability to make changes to the design of its products and services becomes dependent on its ability to design and implement changes to the information systems in which those products and services are embedded. It also demonstrated that achieving agility requires organizations to innovate, organize and integrate information technology and business objectives in often complex settings.

Specifically, Setia, Sambamurthy, and Closs (2008) conducted two case studies related to the development of a framework for organizational value creation from agile IT applications. The focus of their research was on agile capabilities which are beyond the integration efficiency in day-to-day operational performance. The rapid changes in customer demand, more aggressive and demanding customers, greater competition from national and international firms, and overall business uncertainty have caused firms to focus on being responsive, through the use of cutting edge supply chain IT systems. The research used advanced planning and scheduling (APS) systems as an example to study the organizational mechanisms that lead to greater agility from the use of supply chain systems.

According to Setia, Sambamurthy, and Closs, IT applications need to be contextualized according to the organizational conditions and organizational forms through a dynamic mechanism of structuration. Their research investigated three antecedents: assimilation, fit, and network adoption. These antecedents help realize the agile capabilities built into the application-level design of supply chain technologies (cf. Figure 21).

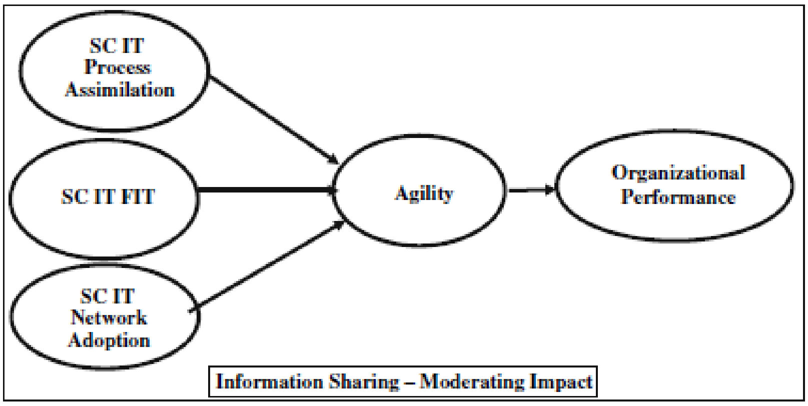


Figure 21 – Model for value creation through agility (Setia, Sambamurthy, and Closs 2008)

In conclusion, the authors deduced that the assimilation of IT systems by overcoming the knowledge and learning barriers is an essential pre-requisite for the realization of their agile capabilities. Similarly, firms should analyze the technology competencies, organizational size, financial slack, and other network dynamics to assess the likelihood of technology adoption by the channel partners. The extent of network adoption of the APS technologies in this case or others in similar cases is a significant determinant of the success of these applications.

From Swafford, Ghosh, and Murthy (2008) study, the authors focused specifically on supply chain flexibility and supply chain agility and addressed the IT role. Swafford, Ghosh, and Murthy explained that supply chain flexibility represents abilities in a company's internal supply chain functions such as those in development, purchasing, manufacturing, and distribution. In order to explain the supply chain flexibility, they proposed the conceptual framework, shown in Figure 22.

This conceptual framework contains IT integration, supply chain flexibility, supply chain agility, and competitive business performance. In this model, IT integration is an enabling mechanism that positively impacts supply chain flexibility and supply chain agility. Therefore, IT provides mechanisms for organizations to effectively gather, store, access, share, and analyze data. For instance, information sharing as a component of a global marketing strategy creates opportunities for increased supply chain agility. Also, higher levels of IT integration and the ability to share information in a real-time manner helps an organization achieve higher levels of supply chain flexibility, conclude the authors.

In a Gartner study, Eschinger and White (2017) have addressed the adoption of Product Information Management (PIM) technologies in the supply chains. They sustained that ongoing requirements for businesses to drive agility, increase efficiency and reduce costs are helping to drive adoption for product information management technologies. They recognize that the technology is still immature but has great potential for enabling efficient and innovative business processes that will drive business growth. The market is still maturing quickly, but while the expectation for growth and applicability are high, it may fail to meet estimated growth or adoption rates because of increasing complexity in user requirements and lack of maturity in knowing how to use the technology effectively.

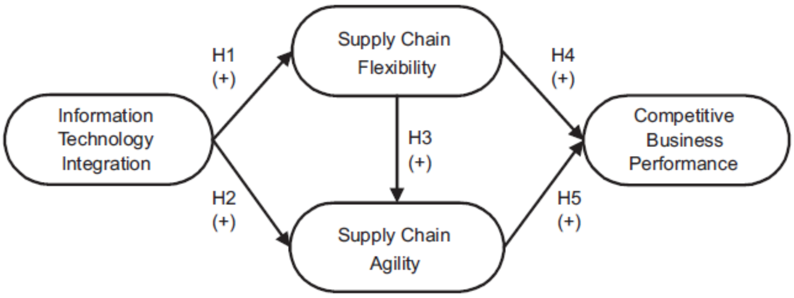


Figure 22 – Conceptual framework for supply chain agility (Swafford, Ghosh, and Murthy 2008)

In another Gartner study, Payne (2016) identified that in times of potential economic incertitude, supply chains use the sales and operations planning (S&OP) process to manage supply chain cost reductions tactically. Nevertheless, the IT department must work with the business to ensure that it has the right technology and data environment to support business S&OP processes and needs. Payne stated that the IT department should take this unpredictability to review the S&OP process and its associated technology support with the business because the business will depend increasingly on the S&OP process to prevent significant mismatches between demand and supply.

The reality shows that today there is yet a gap between what supply chain managers need and what the business application packages offer especially regarding agility mechanisms and functionalities. For instance, the Genovese (2008) study showed that currently, the users are often seeking integrated functionality and that often they find that packages available on the market today may not meet business requirements in industry or horizontal functionality. Moreover, the use of ICT technologies according to Mensah, Merkuryev, and Longo (2015) promotes a more resilient and competitive supply chain.

Furthermore, Azevedo et al. (2004) argue that in complex and dynamic environments such as the automotive and semiconductor industries, managing and coordinating the procurement of materials, their transformation into intermediate and finished products, and the distribution to the final customers, are very demanding tasks regarding information systems. After a field analysis, the authors conclude that in general, currently available software packages do not provide the full support needed for networked and distributed organizations, and are insufficient in what concerns the planning and coordination activities needed in these heterogeneous environments.

Klappich (2016) in a Gartner study has presented another challenge behind the adoption of new supply chain management systems. In the author's supply chain management analysis, it was found that renewing or replacing existing applications was low on the user investment priority scale, and many managers felt that their current portfolios were sufficient for meeting a majority of their organization's basic needs. Although perhaps sufficient, survey managers have indicated the need for greater enrichment of their current supply chain solution portfolios, and approximately one-third feel that their current supply chain application portfolios fail to meet their companies' needs.

Klappich concludes that, although companies feel the existing components of their portfolios address their basic needs, they need to invest in new capabilities versus continuing to invest in upgrading existing capabilities to achieve their future goals and objectives. The study also showed that aggressive adopters of new IT technologies were more satisfied, while mainstream and conservative organizations felt their portfolios solutions of supply chain management lacked the needed capabilities and functionalities.

An interesting document that depicts and analyses key developments in ERP and business process application markets and presents key Gartner predictions in these areas is the "Supply Chain Predictions 2018 from Gardner". This study intends to explain how IT leaders can define their ERP and business process application strategies during a three to five-year horizon.

Key findings indicate that ERP and business application modernization has emerged as the dominant trend affecting supply chain application area. Next-generation ERP will be less about enabling transactions and more about enabling users to change the business. Advances in supply chain management (SCM) will come via enabling users to respond to chaotic market conditions rather than solely through engineered process solutions.

Resuming this literature review on the impact of Information and Communications Systems in the supply chain strategy is possible to conclude that ICT technologies play a major role in the success of the supply chain strategy. Namely in the case of the agile supply chain constructs: responsiveness, reconfigurability and network and process integration are intensively dependent on technology and information-intensive tools and solutions.

Nevertheless, despite this pressing need, the penetration of technology solutions has been insufficient and, in some cases, very limited as shown by the above studies. In the perspective of this research work, it can also possible to refer that the current research has only superficially characterized a suitable reference model to support supply chain managers in the case of innovative and fashionable goods defining requirements to meet the needs of their network.

Alongside with the ICT issues, due to crescent globalization, the sustainability in the supply chains has become a hot topic, both to the business management world, to the academia, but also for the broader elements present in the civil society. There are some reasons for this rising notoriety of sustainability, including supply and demand characteristics surrounding natural resources consumption, increased awareness of the global impacts related with the climate change, and greater scrutiny concerning economic, environmental and the social actions of corporations. The following section addresses the ever-growing sustainability issue in supply chain management.

2.5. Supply Chains Sustainability Policies and Issues

Sustainability definition is presented as 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs' (Dee 2010). According to the UN 2005 World Summit, it was referred that sustainability requires the reconciliation of environmental, social and economic demands - the "three pillars" of sustainability.

In particular, companies' management decisions are increasingly under assessment by their stakeholders (customers, employees and government and regulatory bodies). These companies are asked to consider the environmental and social problems present in their entire supply chain (Seuring and Müller 2008). This lobbying is awakening managers to supply chain management (SCM) policies more sustainable, since they are in a particularly advantageous position to influence economic, environmental and social performance of the companies, through for example product design choices, supplier selection and supplier development, transporter and delivery services, vehicle routing, location decisions, and packaging choices (Carter and Easton 2011).

Supply chain managers realize a critical dimension of risk related to the notion of corporate social responsibility and the extent to which the actions of another member can taint supply chain members' reputation and image. Namely, when those members engage in activities that result in negative public sentiments and damaging environmental actions, where liability extends up and down the entire supply chain. Therefore, corporations are increasingly recognizing that risk management is a part of their sustainability (Spekman and Davis 2004).

At the beginning of the twentieth-first century, in the debate on sustainable development, companies were increasingly seen as central actors. This reality is especially the case for companies that own brands, as they were likely to come under pressure from stakeholders, e.g., customer, governmental and non-governmental organizations. These companies are asked to consider the environmental and social problems observed in their supply chain. Since then, an increasing number of companies has pursued proactive approaches to sustainable supply chain management. Such triggers have increased interest in green/environmental or sustainable supply chain management (MacCarthy and Jayarathne 2012) (Seuring 2012).

In their seminal work, Carter and Rogers (Carter and Rogers 2008) have identified four supporting facets, or facilitators of the Sustainable Supply Chain Management (SSCM), which are:

- Strategy – holistically identifying individual SSCM initiatives which align with and support the organization's overall sustainability strategy;
- Risk management, including contingency planning for both the upstream and the downstream supply chain;
- Organizational - culture which is deeply ingrained and encompasses organizational citizenship, and which includes high ethical standards and expectations along with respect for society (both within and outside of the organization) and the natural environment; and
- Transparency - regarding proactively engaging and communicating with key stakeholders and having traceability and visibility into upstream and downstream supply chain operations.

From the perspective of sustainability, the research literature identifies basically two distinct strategies for sustainable supply chain management practices (Seuring and Müller 2008):

- Supplier management for risks and performance assessment;
- Supply chain management for sustainable products (mainly in the green/environmental aspects).

At the beginning of the twenty-first century, it was visible in the literature the need from the organizations to contemplate the integration of environmental practices into their strategic plans and daily operations, especially for supply networks.

In 2003, Sarkis presented a strategic decision framework for green supply chain management aimed to help supply chain managers assess their external relationships, by identifying and structuring the primary strategic and operational elements that will aid managers in evaluating green supply chain alternatives. These alternative scenarios include the assessment of whom to partner with, what type of technology to introduce, or what type of organizational practice to adopt (Sarkis 2003).

Later on, Srivastava (2007) using the rich body of available literature on green supply chain management (GrSCM) classified by the problem context the supply chain's major influential areas. In his analysis, the author considered the two-following green supply chain management strategic areas:

- Green design - the environmentally conscious design (ECD) and life-cycle assessment/analysis (LCA) of the product. These approaches aim to develop an understanding of how design decisions affect a product's environmental compatibility;
- Green operation - which includes (1) green manufacturing and remanufacturing operations from the perspective of minimum energy and resource consumption, recycling and re-use of products and materials; (2) Reverse logistics and network design, and (3) Waste management.

On the other hand, starting from the perspective of planning and supporting the implementation of sustainable supply chain management strategies, the Supply Chain Operations Reference (SCOR) Model (see Figure 23), which was developed by the experts and practitioners of the Supply Chain Council, is a major framework for supply chain planning that features supply chain management practices and business process reengineering. With version 10.0 of SCOR, the model includes process elements addressing environmental aspects of managing a supply chain called GreenScor. These additions foster the SCOR model to be used as a green supply chain management tool, allowing managers to design and optimize supply chain operations with sustainability in mind (Council 2010) (Akkucuk 2016).

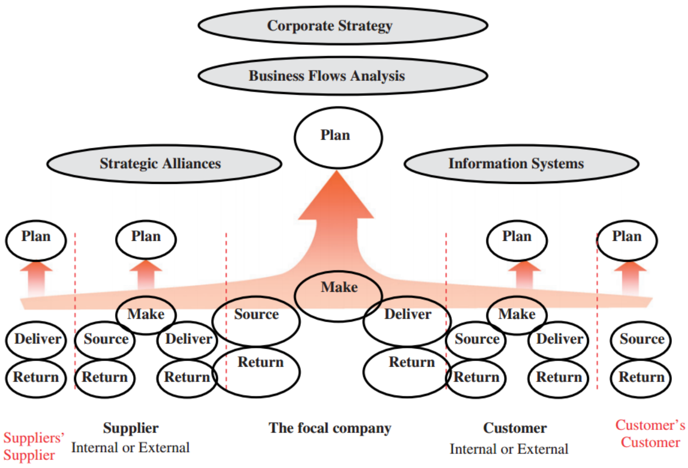


Figure 23 – Overall View of the SCOR model (from (Council 2010)

One of the most recent supply network reference models presented in the literature that addresses the topic of sustainability in the SCM frameworks is the CoReNet reference model (Bastos et al. 2012) based in the SMART model proposed by Filos and Banahan (2001). The CoReNet model presented in Figure 24 allows the definition of practices, technological and performance models for collaborative networks according to the following four main dimensions:

- Knowledge – to map partners' competencies to be shared within the network regarding products and processes;
- Information & Communication Technologies (ICTs) – to support the requirements for the implementation of ICT services at different process levels along the network;
- Organizational – to provide specifications of the organizational changes for SMEs for structuring supply networks in small series production, and
- Sustainability - is intended to support the enterprises in the developing of an eco-compatible approach for their products and processes coherent with eco-efficiency objective of the sustainability dimension.

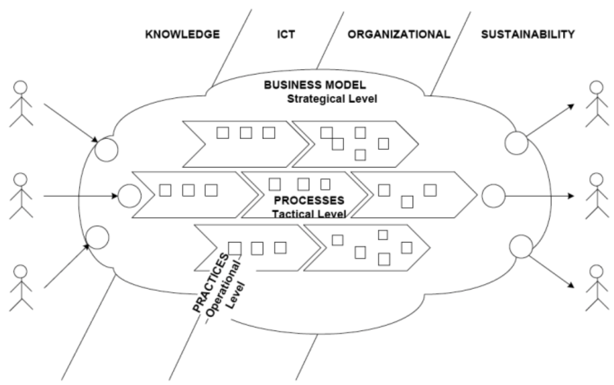


Figure 24 - CoReNet Reference Model Context Diagram

This approach aimed to develop a systematic strategy for the supply network configuration, coupled with a detailed definition and characterization of the operative level of processes and activities along four main dimensions namely the sustainability issues.

In reality, the last decade showed that as manufacturing organizations move toward environmental sustainability, managers need to extend their environmental practices outside of the organization into the supply chain. Due to this pressure from stakeholders, "performance metrics" for the entire network are required not only on the economic value of a business but also in its environmental and social impacts. In the context of supply chains, the performance metrics evaluation represents an important management challenge due to the heterogeneity present in the networks (Almeida et al. 2011). Nevertheless, if successfully implemented, performance and risk assessment enable network managers to create enduring value for the multiple stakeholders in the network.

Alongside with the sustainability issues, the supply chain management building is also facing a metamorphosis of the traditional consumer role with the emergence of a new customer-driven market paradigm. The following section addresses this new market environment paradigm.

2.6. Customer-Focused Supply Chains

This section presents the main concepts that lay the ground for the customer-focused definition of the supply chain strategy management.

Business organizations need to develop and maintain a base of loyal customers, yet a customer-focused organization recognizes customer service and product quality as foundations for competitive advantage. The last decade has taught to company managers, that in customer-focused markets, what matters is not the product or service, but rather the customer's perceived value of the entire relationship with the company.

Many companies have understood that both the quality of their products and services and customer satisfaction is crucial to the survival of the company, and this involves comprehending current customers, their use of products, and their impression of the company's service.

The emphasis on customer value goes a step further by the company identifying the reasons that a customer chooses a specific product and by analyzing the entire range of products, services, and intangibles that constitute the company's image and brand including in many cases, its stance on social and environmental issues (Simchi-Levi 2010).

For instance, Zara studies its customers demand in the stores and tries to deliver their preferences instantly. It is able to introduce more than 12.000 new items per year (300,000 SKU's), which is about 4 times higher than industry average, and has cycle times as short as 3 weeks, 12 times faster than industry average, which allows them to introduce about half of the items in season (Diaz 2001).

Stores receive orders two times per week, and collection renewal can be extremely fast; an example commonly mentioned is how the complete collection of their stores in New York was transitioned towards black-dominated garments in barely two weeks after the terrorist attacks of September 11, 2001. Another example occurred when Madonna gave a series of concerts in Spain; teenage girls were able to dress at her last performance in Spain the outfit she wore for her first concert, thanks to Zara".

However, the example of Zara is not common. Historically, organizations were managed functionally to structure and coordinate different activities. This functional thinking also encouraged the organization to think regarding supply push, meaning, to move stock from processes to customers.

This old view is under stress. The new market trends are changing the paradigm. The overall process of satisfying customer demand is shifting. In the past, manufacturers anticipated the demand and produced it in advance.

Now, in customer-focused supply chains, the process of satisfying customer demand begins with customers signaling demand for specific products and services, and it ends with satisfied customers receiving the products and services they demanded. It is in the marketplace where demand is generated, and markets drive business supply chains to fulfill the customer promise by delivering their requirements. Organizations, therefore, need to be customer-focused to create value through their supply chain strategies. Customers drive markets and market demand.

Customer-responsive supply chain is a recent research topic that has received considerable attention in the recent operations management literature, mostly under the auspices of concepts such as build-to-order, mass customization, lean and agility (Reichhart and Holweg 2007, Storey, Emberson, and Reade 2005, Kapuscinski et al. 2004, Catalan and Kotzab 2003, Holweg 2005b, Roh, Hong, and Min 2014, Hugos 2018).

The literature has shown that effectiveness should take priority over efficiency in the context of customer-focused supply chains, even though efficiency is not neglected. It is through efficiency that better service and more effective use of resources will lead to improvements in the supply chain operation. Efficiency means that more customers can be satisfied with the same resources available. Therefore, supply chain strategies that can achieve high levels of effectiveness and efficiency are desirable (Hines 2004, Diaz 2001, Sodhi and Tang 2017).

As depicted in Figure 25, from the customer perspective, the supply chain needs to generate an output that present specific requirements such as price, quality, response time, service relationship. Therefore, the firm and specifically each of the specific supply chains need to determine how it is possible to deliver customer value after identifying what the customer values and wants from the firm. Delivering customer value is achieved through the definition of the companies correct internal business processes that support the value chain.

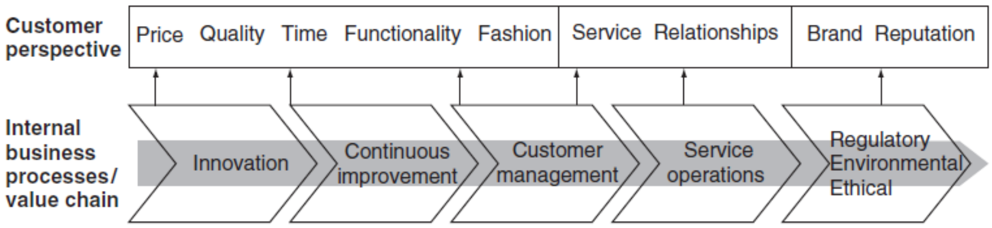


Figure 25 – Business Process Definition for Customer Focused Supply Chains (Source (Hines 2004))

In concordance to the available literature it is possible to define Customer-Focused Supply Chain as:

A customer-focused supply chain is a strategic network, focused not product or technology but on customers, supported by market information and competence that links the voice of the customer to all the firm's value delivery processes (adapted from (Webster 1997)).

As Lyons et al. (2012) explain the main four processes behind the customer-focused supply chain are:

- Elimination of waste;
- Alignment of production with demand;
- Integration of suppliers;
- Creative involvement of the workforce in process improvement activities.

In reality, customer focused supply chains exibit high speed responses by fostering mechanisms at which the system can adjust its output within the available range of the external flexibility types, such as product, mix, volume, and delivery, in response to an external stimulus such as a customer order.

Research in collaborative networks of innovative and fashionable products have identified six key phases in order to organizations address a specific market need to final dispatch the products to the customer (see Figure 26). It also has shown that each one of these phases presents relevant challenges regarding their complexity, time constraints and resources consumption (Bastos et al. 2012).

Figure 26 – Market-oriented manufacturing network phases

In the face of these critical impact phases, the prevailing market environment asks for flexible and reactive organizational structures which rapidly adjust to new manufacturing challenges and revise the business requirements accordingly. These new market characteristics are compelling manufacturing networks to embody shorter life-time existences and take advantage of new infrastructure technologies to support distributed decision making, information sharing and knowledge management (Zangiacomi et al. 2013).

In order to answer to the consumer's pressing needs and expectations, the paradigm of customer-focused value chains is emerging in literature as a collaborative approach (Hines 2014, Christopher 2016, Laari et al. 2016). Based on this new paradigm, new approaches to addressed and engage market demand are required. These approaches are based not only on traditional sales distribution channels (as stores or sellers) but increasingly on an Internet-mediated interaction with consumers covering aspects such as product co-design, product customization till final sale (Gualandris and Kalchschmidt 2014, Christopher 2016).

Exploratory work provided evidence to researchers that responsiveness is intrinsically related to competitiveness. Namely, organizations can increase their ability to compete based on product innovation, low time to market, low price and high delivery dependability by increasing the firms' responsiveness (Thatte, Rao, and Ragu-Nathan 2013, Danese, Romano, and Formentini 2013).

2.7. Summary and Conclusions

The management world recognizes that a strategy is a set of objectives, which act as a bridge between the company and its marketplace. Until these objectives are brought to life and executed as actions, there is little difference between a good or a bad strategy. Nevertheless, it is undeniable that the establishment and the subsequent implementation of an adequate and effective supply chain management strategy are becoming increasingly fundamental for the overall success of networked organizations in a globalized market. The example of companies such as Zara, Apple, and Toyota are proof of that.

As Porter stated, "every organization must have a clearly defined strategy to deliver superior profits"(Porter 1980). Therefore, competitive analysis and strategy are critical to the success of isolated companies as it is for networked organizations. Nevertheless, this is not a trivial neither or an independent process. This analysis means that it is not only necessary to study and comprehend the outside competitors, the market behavior and trends, but also it is crucial to address the internal resources and the internal dynamics of the manufacturing network.

From the presented literature review, it was possible to address the research field of supply chain management, specifically the rationality of supply chain strategy formulation and its fundamental impact on the supply chain strategies for manufacturing networks, especially in highly dynamic and volatile markets.

The relevant and contemporaneous topic of successful manufacturing strategies identification aligned with the supply chain strategy is addressed from the perspective of different authors and researchers. Specifically, the state-of-the-art operational strategies and practices are considered as driven factors for supply chain strategic definition. Namely, the leanness and agility concepts arise as consensual strategic practices at the operational manufacturing level.

Although the conceptual building of supply chain management was in the last decades deeply analyzed, researched and studied, nevertheless there are still unresolved issues.

The first issue is related to the identification and classification of networked organizations in its diversified heterogeneous dimensions. There has been a limited effort in the literature on the development of a comprehensive classification of supply chains or networked organizations. Several research works focused on the development of typologies[4] that specify types of supply chain strategies that are dependent upon product characteristics (Fisher 1997, Lamming et al. 2000) and supply and demand uncertainty (Lee 2002). Concerning taxonomies[5], there has been some effort to develop it in the field of supply chain study networks (Harland et al. 2001, Frohlich and Dixon 2001, Narasimhan, Kim, and Tan 2008), but it is limited to the degree of integration, the manufacturing strategy or the supply chain capabilities, and distinctive competencies. Nevertheless, there is still missing a comprehensive classification of networked organizations in the resources, competencies, organizational context, regulatory aspects, and market approach dimensions.

A second issue is related to the reality present in most of the networked organizations. In 1997, Marshal Fisher proposed a classification of products based on their demand patterns and formulated two main product categories (functional and innovative), each of these categories requiring a distinctly different supply chain approach (Fisher 1997). He proposed that an efficient supply chain should handle functional products, and more innovative products such as fashion clothing and high-technology products, would require a responsive supply chain. Despite straightforward this supply chain management strategy, it raises operational problems for a typical network organization how to address the coexistence of different supply chains inside the network, when some of the products are functional and others innovative. Another issue is related to transient behavior of the market. Changing

---

[4] Typology: a system used for putting things into groups according to how they are similar: the study of how things can be divided into different types - Merriam-Webster Dictionary

[5] Taxonomy: the process or system of describing the way in which different living things are related by putting them in groups - Merriam-Webster Dictionary

market conditions can influence demand patterns and change for instance functional products into different types of products such as innovative that are make available in different ways. Thus, the question: How to address this dynamic behavior of the market demand?

A third issue that arises from the literature review is related to the fast transformation of the market conditions. Companies' managers, facing a competitive market, are constantly challenged to reduce the lead time between technical or market opportunity arising and satisfying the customer need with full-rate production of a quality product. Especially, the time to market in the case of innovative and fashionable goods is a critical factor to achieve competitiveness. The responsiveness of manufacturing networks is becoming an increasingly competitive factor. Therefore, the question: How the present networked organizations can address the new market dynamic conditions and evolve to higher levels of responsiveness?

A fourth issue is related to the ever-growing empowerment of the customer role. More and more consumers want to have a significant voice and impact on the products and services they consume. Increasingly, consumers are involved in co-design relationships with producers participating both in the front-end phase with contributions to the idea generation and conceptualization of new products, and the back-end phase with involvement in the sketch, design and testing cycles of the new product development process by enhancing the innovation process and thus co-creating value. Coupled with this consumer empowerment trend, there is a growing awareness of the market on sustainability issues. The reality shows that the market increasingly values manufacturing networks that endorse sustainability challenges. Taking these relevant aspects valued by consumers into consideration, the following question arises: Which practices and methods should the future networked organizations endorse in order to support the co-creation of value but also the of manufacturing of eco-friendly products?

A fifth issue is related to the recent breakthroughs in the use of information and communication technologies supported in the Internet infrastructure. These innovations are facilitating the different supply network actors' integration and alignment but also revealing new forms of products and services demand such as web-based markets. As a result, the question: How the new methods and tools provided by the ICT innovations, will support the networked organizations in becoming more demand-driven and customer-focused?

Finally, the sixth issue results from the fact that new types of organizational networks are emerging in a large variety of forms, including virtual organizations, collaborative networks, virtual enterprises, customer-focused supply chains, etc. Hence the question: How these new forms of networked organizations will interact with the traditional supply chains and how they evolve in the future.

Chapter Three

CLASSIFICATION SCHEMA FOR SUPPLY CHAINS

Although research in the subject of supply chains has been very abundant and multilayered, there has been limited research into how different types of supply networks can be characterized and classified. This chapter presents a classification proposal for supply networks that take into account the present literature achievements on this subject but also include relevant field data from specific industrial case studies in different sectors and scenarios. The proposed classification schema lays on a three-dimensional axis: demand & sourcing; product & process; and structure. This classification schema is intended to assist supply chain managers in defining the adequate manufacturing strategy for the overall supply network.

3.1. Introduction

The term supply chain arose in the decade of the 1980s, and since the beginning, it was related to the fields of logistics and operations management. The initial definitions for supply chain addressed specifically the interrelations between the firms in order to deliver products or services to the market.

In this classical view, a supply chain is seen as a complex network of suppliers, manufacturers, and distributors delivering goods to end consumers. In this simplistic view, creating and managing a supply chain is a design problem where cost is a major concern, the service level is a given constraint, and placement of facilities, transportation modes, and inventory policies are the main design degrees of freedom left to the overall manager (Geoffrion and Powers 1995).

Encompassing this notion, Michael Hugos defined:

"supply chain as an integrated system which synchronizes a series of inter-related business processes in order to: (1) acquire raw materials and parts; (2) transform these raw materials and parts into finished products; (3) add value to these products; (4) distribute and promote these products to either retailers or customers; (5) facilitate information exchange among various stakeholders (Hugos 2006).

Based on this definition, the focus behind the "label" supply chain is more in the businesses process than in the actual players or the elements of the network. Another consequence of this focus on flows and processes was an ever-present cost reduction policy. This search for "efficiency at all costs" and the search for the balance between cost and service obtained through trade-offs in the chain has filled the thinking of decades of supply chain managers. In line with this thinking, the concept of competitive advantage in the supply chain management by operating it at a lower cost increases efficiency and hence at a greater profit (Stevens 1989, Christopher 2010).

However, this over-emphasis in minimizing the cost of operations instead of maximizing the value delivered can be detrimental at long-term. As Mentzer et al. (2011) stated in their supply chain management (SCM) definition: "As such, SCM is concerned with improving both efficiency (i.e., cost reduction) and effectiveness (i.e., customer service) in a strategic context (i.e., creating customer value and satisfaction through integrated supply chain management) to obtain competitive advantage that ultimately brings profitability".

A major criticism of the omnipresent efficiency in costs policy is the fact that it is biased towards accounting only the obvious costs, excluding those that cannot be easily quantified, such as flexibility, resilience, responsiveness or more intangible concepts such as a brand trust or brand effect.

Efficiency in costs is certainly an important part of creating and delivering value, but it cannot be reduced to it. The approach that minimizes costs is not necessarily the one that maximizes value.

In reality, supply chain managers are now forced to address market and especially individual customers with increased attention by putting more emphasis on the service levels they provide, by reducing response times and by tackling customers' specific needs. This confluence of trends has led managers moving from a traditional functional focus in the way they conduct business into a more holistic approach in addressing the overall supply chain. This competitive scenario is becoming more evident as companies start to seek competitive strategies based on supply chain factors other than costs, such as innovation, quality or service.

As a consequence, it is emerging at the industrial level the adoption of collaborative strategies for the production of small series of high-customized complex products with increased emphasis in the service levels and the reduction of the response time.

A review of supply chain literature reveals that supply chain strategy is increasingly becoming a critical element of a company strategy. Numerous studies present different supply chain strategies namely with its alignment with the manufacturing strategy for companies in different scenarios as explained in the previous chapter (for example (Fisher 1997) (Mason-Jones, Naylor, and Towill 2000b) (Lee 2002) (Towill 2000) (Morash 2001) (Simchi-Levi 2010) (Sukati, Hamid, Baharun, and Yusoff 2012) (Gong 2013)).

A large amount of research focuses on developing typologies and taxonomies that propose specific types of supply chain strategies, each one presenting singular sets of organizational characteristics. For instance, Narasimhan, Kim, and Tan addressed concepts of velocity, variability, and visibility to establish the supply chain strategy taking into account the product life cycle and the management initiatives (Narasimhan, Kim, and Tan 2008). Also, Harland and Lamming proposed a supply chain taxonomy with the focus in the supply network dynamics and the degree of the focal company influence the supply network (Harland et al. 2001).

Another study by McKone-Sweet and Lee proposed a taxonomy that classifies manufacturers with similar combinations of supply chain capabilities into specific supply chain strategy groups based on organizational or IT capabilities (McKone-Sweet and Lee 2009).

Despite these studies, which are focused on specified organizational elements, there has been a limited effort in developing an extensive supply chain classification schema that could help supply chain managers and stakeholders in defining adequate manufacturing strategies for their networks.

The terms classification scheme, taxonomy, and typology have been used interchangeably in several literature studies. Moreover, they have different underlying concepts and purposes. As Doty and Glick detailed in their work (Doty and Glick 1994):

- *Classification schema* – a classification system that categorizes phenomena into mutually exclusive and exhaustive sets with a series of discrete decision rules, allowing organizations to be assigned to mutually exclusive sets based on the level of technological complexity;

- *Taxonomy* - classification system that differentiates organizations into mutually exclusive sets using a series of hierarchical nested decision rules.

- *Typology* - refers to conceptually derived interrelated sets of ideal types.

Therefore, according to Doty and Glick, typologies are not classification systems and do not provide decision rules for classifying organizations. Instead, typologies identify multiple ideal types, each one representing a unique combination of organizational attributes that are relevant to determine the outcome.

In reality, classification systems are intended to provide a set of decision rules for categorically assigning organizations to heterogeneous groups that, in combination, constitute a mutually exclusive and exhaustive set of organizational forms.

Since the primary objective of the present classification effort is to assist managers and decision-makers in the comprehension of the supply chains they integrate, and its positioning concerning other networks in the market, it is presented in the form of a classification schema for supply chains.

For decades, researchers and practitioners have primarily investigated the various processes within manufacturing supply chains from a single perspective. Recently, however, there has been increasing attention positioned on the design, analysis, and performance of the supply chain as a whole.

In order to design and operate customer-driven supply chains with the adequate strategy to achieve the goals, it is necessary to identify and classify the different types of supply networks and subsequently align each type of supply chain with the adequate strategy.

Nevertheless, the literature on inter-organizational networks lacks a truly comprehensive classification framework. Based on different surveys and case study work it is possible to identify several dimensions of networks that could be helpful in the definition a methodological schema for customer focused supply chains (Lamming et al. 2000).

3.2. Classification Dimensions

Taking into account the current literature limitations, the present supply chain classification proposal presented in this work is intended to help to clarify the different network structures, value proposition offers, and market approaches observed in the contemporary supply chains. This classification effort is not intended to assess or benchmark current instantiated forms of supply chains, but only to help network managers, stakeholders and relevant actors, in locating the current position of their network in the defined classification dimensions, and frame theoretical or practical evolutionary exercises for different supply chain strategic positioning.

The present classification proposal also takes into account the literature findings presented in chapter 2 (theoretical foundations), framing the different classification dimensions with the supply chain manufacturing and operational strategies.

The following sections, present three classification dimensions that are recurrent in the supply chain management literature and were identified in the exploratory work performed in our research project.

3.2.1. Product Dimension

As explained in section 2.4, it is argued by several researchers that the product characteristics play a major role in the establishment of the adequate supply chain management strategy.

In reality, the increase in competitive pressure is forcing firms to develop supply chain's organizational approaches that can effectively manage product and market aspects such as increasing of product variety and operational characteristics and simultaneously cost minimization regarding production, inventories, transportation, etc. along the supply chain (Novak and Eppinger 2001) (Pashaei and Olhager 2015).

Several authors, for instance, address the product complexity as a relevant factor for comprehensive supply chain design. Depending on the type of product architecture selected, the product design and the corresponding manufacturing processes, and ultimately the supply chain configuration and operation are significantly affected (Ülkü and Schmidt 2011) (Nepal, Monplaisir, and Famuyiwa 2012).

A large number of researchers argue that it is important to integrate product architecture decisions regarding modular or integral design, with manufacturing and supply chain decisions during the early stage of the product development (Eppinger 2002) (Fixson 2005).

Historically, several research analyses considered the product characteristics fundamental in the determination of the supply chain configuration. For instance, Fisher (1997) declared from his analysis, that there are two types of products: those that are primarily functional, and those that are primarily innovative.

According to his classification, functional products are products that satisfy basic needs, which do not change much over time and have stable, predictable demand and long-life cycles. As an example, Fisher pointed staples sell in a wider range of retail outlets as a functional product.

On the other hand, Fisher identified innovative products, products which the manufacturers introduce innovations in fashion or technology that give reason to customers spend more in order to acquire these products. Examples are fashion apparel or high-tech technological devices.

Aligned with Fisher framework, Huang, Uppal, and Shi (2002) in their paper go a little further and propose to categorize the products as a functional, hybrid, or innovative. In this classification, the hybrid product consists of either different combinations of standard components or a mix of standard and innovative components.

Although, Harris (2007) has described a hybrid solution space, in which the product types are not functional or innovative but exhibit overlapping characteristics. As the author recognized, there is very little empirical or quantitative research performed to discover optimal strategies for mixed product types.

This hybrid concept presented by Huang, Uppal, and Shi and studied by Harris is intrinsically related with the product parameterization domain, and in the perspective of others researchers, it does not justify a distinctive class concerning innovative products classification (Simchi-Levi 2010) (Vonderembse et al. 2006).

A recent concept that researchers have embraced as research object is the customized products. This type of products are now becoming a new phenomenon in a customer-focused marketplace. The production of small series of high-customized products in which the limit can be a one-of-the-kind product is now becoming increasingly visible (Duray 2002) (Stark 2011) (Zangiacomi et al. 2013).

These singular or one-of-the-kind products pose significant challenges for the industry, forcing supply chain managers the adoption of collaborative strategies for the production of small series of high-customized complex products with increased emphasis in the service levels and the reduction of the response time.

The fourth class of product type present in the literature is the commodity. The commodity is a product with a very predictable demand from known customers, easily managed through tight collaboration between manufacturers and customers. Examples of commodity products are daily bread or newspapers (Gattorna 2010).

Taking into account the published contributions, Table 12 presents the product type classification.

Table 12. Product Type Classification

Product Type	Commodity	Product with high predictability demand; easily managed with a focus on customer relationships
	Functional	Product with predictable demand; managed with a focus on efficiency
	Innovative or Fashionable	Product with unplanned and unforeseen demand; managed with a focus in the service-cost function
	Singular	Project or custom-made product; focus on the requirements

Besides the product type classification, the literature also addresses the production positioning regarding the manufacturing phases. Namely, Sen, Pokharel, and YuLei (2004) explain that according to manufacturing strategies, the positioning regarding each product can amplify the effects of supply chain dynamics such as information delay and capacity allocation.

Therefore, the choice of which product positioning regarding the production strategies need to be optimized and evaluated in order to achieve maximum customer satisfaction and profit levels. Hence, the authors argued in favor of four product positioning options regarding the manufacturing strategy.

Table 13 presents the four identified options for the product positioning regarding manufacturing or production strategies.

Table 13. Product Positioning Classification

Product Positioning	BTS/MTS	Build or make-to-stock manufacturing
	BTO/MTO	Build or make-to-order manufacturing
	ATO	assemble-to-order manufacturing
	ETO	engineering-to-order manufacturing

A relevant concept directly linked with the product positioning classification is the postponement. Several authors discuss the value of postponement as a mechanism to introduce flexibility in developing different versions of the product as needed. Waller, Dabholkar, and Gentry (2000) discuss the three types of postponement strategies depending on the product characteristics. These postponement strategies are:

- Upstream postponement - extends up in the supply chain, manufacturers can wait to order raw materials from suppliers until they receive customer orders;
- Downstream postponement - delays some sort of physical change to the product after the primary manufacturing stage, delaying the addition of product features, or performing some other value-adding function to the product;
- Distribution or place postponement - the manufacturer waits to ship the product until the order is received, directly influencing inventory carrying and transportation costs.

A third product characteristic referred to in the literature is the product life cycle stage. Namely, in a pioneer work by Anderson and Zeithaml (1984), the authors point out the relevance of the product life cycle in the supply chain strategy. Their research work in strategic management indicated that the product life cycle is likely a fundamental variable affecting business strategy.

Based on the literature, Table 14 depicts the five alternatives for the classification of the product life cycle stage.

Table 14. Classification of the Product Life Cycle Stage

Product Life Cycle Stage	Introduction	Market introduction stage - reduced initial sales
	Growth	Product acceptance stage - increase in sales volumes
	Maturity	Growth stabilizes and reaches maximum volume
	Saturation	Growth extinguishes, and the decline starts
	Decline	Demand continuously shrinks till depletion

In line with this thought, Aitken, Childerhouse, and Towill (2003) argued that in order to the supply chains compete in today's highly competitive marketplace; they must seek to match the product characteristics with the customer requirements. However, since the products progress through their life cycles, these requirements dramatically change, and in consequence, the supply chain must also dynamically adjust in order to maximize their competitiveness.

Parlar and Weng (1997) on the other hand addressed a growing reality that arises because an increasing number of new products introduced in the market have shorter product life cycles. This reality is a consequence of the increasing competition and the shift from the traditional market demand to newer and innovative products. The authors argue that the growing competition on short product life cycle products and the shrinking of profit margins is impelling companies to consider and implement adequate supply chain strategies.

In reality, this trend of shortening of the products life cycles is deeply linked with the concept of mass customization where the objective is to provide products and services that best meet individual customers' needs with near mass production efficiency. Customized products as such present as critical features short product development cycles, and short product life cycles (Piller and Tseng 2003) (Tseng and Hu 2014).

In summary, Table 15 presents the literature references regarding the three axes present in the product classification dimension.

Table 15. Summary of product dimension literature

Dimension		Definition	Literature
Product	Product Characteristics	Details the products innovativeness, fashionability, seasonality and functional use;	(Fisher 1997) (Huang, Uppal, and Shi 2002) (Lee 2002) (Corsten and Gabriel 2004) (Harris 2007) (Gattorna 2010) (Stark 2011) (Duray 2002) (Zangiacomi et al. 2013)
	Product Positioning	Categorizes the product production positioning regarding its manufacturing phases;	(Kaul and Rao 1995) (Sen, Pokharel, and YuLei 2004) (Kwong, Luo, and Tang 2011)
	Product Life-cycle and Stage	Specify the longevity of the product life-cycle and identifies the product life-cycle stage in the supply chain;	(Anderson and Zeithaml 1984) (Parlar and Weng 1997) (Aitken, Childerhouse, and Towill 2003) (Christopher and Lee 2004) (Lee, Padmanabhan, and Whang 2004) (Bin et al. 2006) (Tseng and Hu 2014)

3.2.2. Demand and Sourcing Dimension

A second classification dimension identified in the present research work is the demand and sourcing dimension. This dimension addresses three main perspectives: the demand, the supply uncertainty, and the market environment.

The academic literature when examining the market concept and specifically, the market orientation has consistently found that market-oriented organizations achieve higher levels of sales and higher performances (Narver and Slater 1990) (Singh and Ranchhod 2004) (Gheysari et al. 2012).

The company's market orientation has, according to different authors, the need to include two primary factors: the customer orientation, which is a focus on the needs and desires of the customers; and the competitive orientation, which stresses the focus on competitive threats (Kohli and Jaworski 1990) (Kirca, Jayachandran, and Bearden 2005).

The literature in supply chain strategy and market orientation points out the benefit from faster product development, but also stress to managers the need to analyze their firm's competitive settings. This environmental analysis is crucial, since innovation speed may be more or less critical under different market conditions (Bayus 1997) (Lambert and Slater 1999) (Gheysari et al. 2012).

Competitive viability often mandates the rushing of speed in product development and the pursuit of innovation. The academic and practitioners studies show that a company when facing intense competitive pressures, speed is often one of the few options it can choose to differentiate its offering (Carbonell and Rodriguez 2006). For instance, the Cross et al. (2007) study argues that the higher the level of competition in an industry, the more likely firms will use speed as a basis for competitive advantage.

The literature is rich in references concerning the description of market environment by addressing the concepts of competitive intensity, market dominance, openness, turbulence and market uncertainty (Bayus 1997) (Harland et al. 2001) (Singh and Ranchhod 2004) (Carbonell and Rodriguez 2006) (Simchi-Levi 2010) (Christopher and Holweg 2011) (Gheysari et al. 2012). Taking into account the research literature contributions, Table 16 presents the market environment classification.

Table 16. Market Environment Classification

Market Environment	Monopoly	Dominant market leader
	Open with low competition	Open market with a low level of innovation and competition
	Competitive with a high degree of innovation	Open market with a high level of innovation and competition
	Turbulent with aggressiveness	Extreme aggressiveness with competition based on innovation or cost

A second component present in the demand and sourcing dimension for the supply chain classification is the demand uncertainty. This component tries to characterize the demand in aspects such as predictability, variety, volume, and seasonality.

Several authors address the subject of demand in the supply chain perspective. For instance, Fisher (1997) in his seminal work addressed the complexity of predicting the demand and their nature. Fisher sustained the importance of managers perceive for each one of their supply chains the demand predictability, the product variety, and markets standards for lead times and services. He then identified two scenarios: predictable and unpredictable demand. In his subsequent work, Fisher addresses the product variety as an obstacle to the manager's effort in matching the supply with the demand, naming it as demand uncertainty (Fisher et al. 2009).

On the other hand, Christopher (2000) introduces the concept of "volatile demand" as the demand of customers for ever-shorter delivery times, combined with the need to ensure that supply can be synchronized to meet the peaks and troughs of demand.

On his Ph.D. work, Tan (2006) studied the different strategies to manage demand uncertainties and variations adopted by various industries and companies. The author presented the collaboration with the customer as a mean of reducing demand uncertainties.

Another form of the strategy includes everyday low-price, promising long fulfillment lead-time. A third form results in having an agile organization to better respond to changing demand in volume and variety, ensuring smaller production batches and the use of postponement.

The literature is rich in references concerning the description and characterization of demand uncertainty and their relevant factors (Childerhouse, Aitken, and Towill 2002) (de Treville, Shapiro, and Hameri 2004) (Bonnefoi 2005) (Jüttner, Christopher, and Baker 2007) (Setia 2008) (Hilletofth 2011) (Rexhausen, Pibernik, and Kaiser 2012).

Based on the literature analysis, Table 17 presents the demand uncertainty classification.

Table 17. Demand Uncertainty Classification

Demand Uncertainty	Continuous flow	Continuous and highly predictable demand
	Predictive wave	Semi-predictable demand
	Unstable surge	Highly unpredictable demand
	Cavitation	Isolated and unforeseen demand

The third component present in the demand and sourcing dimension for the supply chain classification is the sourcing uncertainty. This component addresses the upstream complexity of the supply chain and tries to characterize its relevant aspects such as reliability, responsiveness, and upper stream suppliers' relationships.

The first authors to stress the need for sourcing to be supportive of the competitive priorities was Watts, Kim, and Hahn (1992). In a framework proposal, they linked strategic sourcing to corporate goals.

Another set of authors that address the relevance of the sourcing strategy was Carter and Narasimhan (1995). In their study, they highlighted the impact of customization and flexibility demands on sourcing strategies.

In subsequent work, Narasimhan and Das (1999) argued that the strategic reach of sourcing, its role in gaining competitive advantages, and its emergence as a core competence is underscored by the dependence of firms on sourcing for attaining differentiation advantages.

In the same line of thought, Kouvelis and Milner (2002) argued that when managers face greater supply uncertainty, this increases the need for vertical integration policies, while higher demand uncertainty increases the reliance on outsourcing. They claim that within environments where investment in the supplier is possible, supply variability may be addressed by increasing such investment and so increasing the reliability of outsourcing.

The literature shows that a company's supply chain strategy is closely linked to its operations strategy, namely encompassing decisions about sourcing, management of partners' relationships, outsourcing policies and material flows (Nishiguchi 1994) (Lee 2002) (Narasimhan, Kim, and Tan 2008).

A relevant aspect stressed by Lee (2004) was the need to supply chain managers to develop collaborative relationships with suppliers. The author claimed that by developing collaborative relationships with suppliers so that companies work together to design or redesign processes, components, and products, is the only way to align the interests of companies in supply chains.

Gottfredson, Puryear, and Phillips (2005) for instance focused on a new concept, the capability sourcing. The authors sustained that a company to source capabilities strategically must also decide which partners can best perform on which capabilities. Therefore, rather than selecting suppliers based only on cost, the new approach is based on the establishment of relationships with suppliers which could sustain competitive costs, high quality, and efficient delivery.

More recently, Weigelt (2013) studied the effect on companies gains with the establishment of contractual arrangements with suppliers with higher IT capabilities. Her findings show that companies with weaker operational capabilities benefit from outsourcing their own activity to the supplier and may even be able to reduce their capability disadvantage through outsourcing. Based on the literature analysis, Table 18 presents the sourcing uncertainty classification.

Table 18. Sourcing Uncertainty Classification

Sourcing Uncertainty	Short term subcontracts	Cost based on low reliability and responsiveness
	Long term subcontracts	Trust-based subcontracting with higher reliability and responsiveness
	Loose partnerships	Risk share and partial involvement in product development
	Tight partnerships	Full business partnerships with risk share, product design, and decision making

In summary, Table 19 presents the literature references regarding the three axes present in the demand and sourcing classification dimension.

Table 19. Summary of product dimension literature

Dimension		Definition	Literature
Demand and Sourcing	Market Environment	Features the market dominance, openness, turbulence, innovation and competitors' aggressiveness	(Bayus 1997) (Zheng et al. 1998) (Harland et al. 2001) (Singh and Ranchhod 2004) (Kirca, Jayachandran, and Bearden 2005) (Carbonell and Rodriguez 2006) (Cross et al. 2007) (Simchi-Levi 2010) (Christopher and Holweg 2011)
	Demand Uncertainty	Characterizes the demand predictability, variety, volume and seasonality	(Fisher 1997) (Christopher 2000) (Childerhouse, Aitken, and Towill 2002) (de Treville, Shapiro, and Hameri 2004) (Bonnefoi 2005) (Jüttner, Christopher, and Baker 2007) (Mason-Jones, Naylor, and Towill 2000b) (Tan 2006) (Setia 2008) (Fisher et al. 2009) (Hilletofth 2011) (Rexhausen, Pibernik, and Kaiser 2012)
	Supply Uncertainty	Details the outsourcing approach, and the reliability and responsiveness of upper stream suppliers	(Watts, Kim, and Hahn 1992) (Nishiguchi 1994) (Carter and Narasimhan 1995) (Narasimhan and Das 1999) (Lee 2002) (Kouvelis and Milner 2002) (Narasimhan and Mahapatra 2004) (Lee 2004) (Gottfredson, Puryear, and Phillips 2005) (Liu and So 2008) (Narasimhan, Kim, and Tan 2008) (Weigelt 2013)

3.2.3. Infrastructure Dimension

The third and last classification dimension identified in this research work is the infrastructure[6] dimension. This dimension addresses three main components: the network design & conception, the participation & relationships among the supply chain, and last the competences & capabilities.

The design & conception component seeks to characterize the way the network is created, how its actors are arranged or organized, their link stability, ownership, dynamism and growth direction. As Lambert and Cooper (2000) claim, "one of the most significant paradigm shifts of modern business management is that individual businesses no longer compete as solely autonomous entities, but rather as supply chains." This interdependency means that business management has entered a new era where the competition shifted from individual to networked organizations. In this emerging competitive environment, the survival of the single business now depends on the managerial its ability to integrate the company's intricate network of business relationships (Christopher 1998b).

As present by Grandori and Soda (1995), in this context, the term network is an abstract notion referring to a set of nodes and relationships which connect companies, specifically in this context, "networks refers as modes of organizing economic activities through inter-firm coordination and cooperation."

Historically, Henry Ford was one of the first to conceive and create a fully vertical and proprietary network. Ford envisioned an industrial empire which was entirely self-contained and fully independent, relying on no other organization. To support his auto manufacturing facilities, Ford invested in coal mines, iron-ore deposits, and steel mills. He bought land to grow soybeans used in the manufacture of paint and rubber plantations for tires. Ford owned railroads and ships for transporting materials and trucks for distribution of finished automobiles. He envisioned the world's first totally vertical integrated network. Ford Motor Company would be a highly integrated organization from raw material sourcing all the way to the final consumer (Bowersox, Closs, and Cooper 2002). Eventually, as time passed, Ford discovered that specialized firms could perform much of the essential work as well as or better than his centralized structure and the Ford strategy shifted from ownership-based control to one of the coordinated channel relationships.

In reality, the more recent studies show that the vertical bureaucratic structure that prevailed for centuries is giving way to horizontal approaches that focus on managing key processes and where the managing focus is transverse, not up and down (Bowersox, Closs, and Cooper 2002) (Simchi-Levi, Kaminsky, and Simchi-Levi 2004).

Similarly, the most recent analyses show that organizations are drastically revising traditional paradigms and developing new organizational forms with the goals of adapting to

---

[6] The term infrastructure in context of this classification schema is used to characterize decisions applied to organizations, systems, policies, practices, and procedures which support the manufacturing processes as presented by Hayes and Wheelwright (1984). These authors offer as examples of infrastructural decisions the ones connected to the organization structure and design, workforce management, production & inventory planning and control systems, quality management and environmental management systems. In agreement, the APICS Dictionary 12th Edition defines infrastructural elements as the elements of a strategy which includes decision rules, policies, personnel guidelines, and organizational structure.

new environmental threats and opportunities. This adaptation favors the migration from proprietary solutions to more dynamic environments where a number of independent organizations perform various business functions in the supply chain (Quinn 1992) (Parlar and Weng 1997) (Persson 2011).

In this new coordinated or collaborative scenario, the network is in general a relatively flat or horizontal organization, depending for its operations on interaction with the other network partners, rather than the conventional approach where most of the functions are owned and managed by a central organization (Ford and Group 1990) (Camarinha-Matos and Afsarmanesh 2008a) (Grefen et al. 2009).

In reality, a significant number of businesses in dynamic sectors such as innovative and fashionable products are forming tangible business networks along the value chain and for enduring purposes.

In fact, in an increasing number of market conditions, the demand is asking for flexible organizational structures which can quickly adapt to new business requirements and sustainability challenges. These new requirements are forcing business networks to have much shorter lifetime existence and take advantage of new infrastructure technologies supported in distributed information systems and knowledge (Bastos, Azevedo, and Almeida 2012) (Zangiacomi et al. 2013).

The current dynamism foster new forms of network characteristics such as flexibility and adaptability in the face of change, and the responsiveness of the customer-focused network guided by the needs and preferences of buyers.

The new landscape in the inter-organizational network relationships may involve vertical relationships for example linking suppliers to end-users, but also, horizontal relationships for example among actual or potential competitors and complementary service providers such as consultant companies or R&D institutions (Cravens, Piercy, and Shipp 1996) (Loss and Crave 2011).

In distinguishing the different forms of dynamic relationships, Camarinha-Matos and Afsarmanesh (2006) detailed the concepts of coordination, cooperation, and collaboration. For these authors, coordination requires communication and information exchange between the network partners for mutual benefit, but also to achieve more efficient results involves the aligning and the altering of each partner activities. In short, coordination is the act of working together harmoniously.

Regarding the cooperation concept, the authors state that it involves not only information exchange and adjustments of activities, but also includes resource sharing for common goals seeking.

Cooperation can only be accomplished through the splitting of work among network members. Furthermore, collaboration is a form of relationships in which networked entities share information, resources, and responsibilities to jointly plan, implement, and evaluate a set of activities to achieve a common and shared goal.

Table 20 presents the design & conception axis classification based on the related literature findings and the present research work.

Table 20. Infrastructure Design & Conception Classification

Design & Conception	Proprietary	Vertical network totally or predominantly owned by a single enterprise
	Coordinated	A focus enterprise establishes complementary goals with network partners
	Cooperative	Individual companies establish compatible goals
	Collaborative	Joint companies work together for joint goals

The second infrastructure component is the participation & relationship axis. This component aims to characterize the way the network structure evolves, their membership's participation and involvement, role uncertainty, risk sharing, and actors' rotation.

Cravens, Piercy, and Shipp (1996) in their classification framework for network forms correlated the scope of the environmental volatility change to the inter-organizational types of established relationships. They argued that the network formation relies on the development of trust between organizations. Notably, in the early stage, the logic is that under conditions of high risk, on inter-organizational trust organizations, each member of the network may be impelled to assume joint risks and engage in recurrent business transactions or not, depending on the trust he lays on each partner.

Indeed, many researchers argue that the critical management issue is not whether to establish relationships with other organizations, but rather how and with which partners (Webster 1997) (McKnight, Cummings, and Chervany 1998).

The economic studies show that organizational volatility has an essential influence on how organizations decide to compete, stating that environmental volatility increases uncertainty and risk and makes forecasting difficult (Kren 1992). Therefore, in a highly volatile scenario, usually, the organizations require a more flexible internal structure that can rapidly adjust to new market conditions.

It follows that when the competitive environment has low volatility, the need for flexibility and adaptation is likely to be reduced, then long term agreements are established. Similarly, it suggested that in volatile scenarios, external relationships with other organizations must also be flexible enough to allow for alteration - and possibly termination - over a relatively short period leading to short term contracts or agreements (Cravens, Piercy, and Shipp 1996).

In the last decades, due to an all-pervading global competition and an accelerated technological revolution, the traditional scenario where large corporations vertically integrated multiple stages of an industry chain, from raw materials to final product delivery, leading to increased direct control over operations is diminishing.

Instead, since the 1990s, a rapidly growing number of firms are shifting their networked strategies, entering into a series of alliances with other organizations as part of their objective to lower overhead costs, access know-how and new technologies, increase responsiveness to customers, enter new markets and ultimately, increase their flexibility.

As consequence of this trend, numerous companies are downsizing to their core competencies, leveling their network management structures and strategically outsourcing a wide range of activities from manufacturing to research and development (R&D) (Buono 1997) (Christopher and Juttner 2000) (Hudson 2004).

Hagedoorn (2002) describes a significant aspect related to the contractual types of partnerships in networks. This author analyzes the organizational setting of the joint development of new products or services historically through R&D projects. The author states that joint ventures are undoubtedly one of the older modes of inter-firm partnering. Joint ventures include in many cases specific R&D programs. This tight form of partnerships became well known during the last decades. Nevertheless, these joint ventures seem to have become gradually less popular probably due to the organizational costs of joint ventures in combination with their high failure rate.

Recent studies have established that non-equity, loose contractual forms of R&D partnerships, such as joint R&D pacts and joint development agreements, have become fundamental modes of inter-firm collaboration as their numbers and share in the total of partnerships has far exceeded that of joint ventures.

Aligned with this trend, Camarinha-Matos et al. (2005) described in his work this new form of organizational relationship. He describes this kind of partnerships as a specific type of collaborative consortium, where it creates an entity (new company) using a partnership agreement. The new company establishes a contract with the customer and only the new company is committed to the customer. The partnership agreement may be loose and extinguish after the business or tight by continuing after the end of the initial customer contract. From the literature contributions and the present research work, Table 21 presents the network infrastructure participation & relationships classification.

Table 21. Infrastructure Participation & Relationships Classification

Participation & Relationships	Interfirm subcontracting	Subcontracting participation in focal company supply chains. Centralized coordinated transactional relationships.
	Interfirm cooperation	Cooperative relationships between companies in non-hierarchical supply chains.
	Joint ventures	Company participation in business arrangements with another partner (s) with the sharing of resources, profits, losses, and costs
	Collaborative consortium	Cooperative relationships with firms sharing capabilities, resources, and knowledge through informal and/or formal conditions

The third and last infrastructure component is the competences & capabilities sharing across the supply chain. This component aims to characterize the network structure regarding competences alignment, focus sharing, flexibility commitment, and collaborativeness. The role of the focal company in the operation of the supply chain is well established in an empirical study performed by Harland et al. (2001). In their study, it is visible that the degree of focal firms' influence over their supply networks related to the networking activities of partner selection, risk and benefit sharing, motivation, decision-making, and conflict resolution are critical to the performance of the network.

In today's competitive environment, markets are becoming more dynamic, and customer focused, customers are increasingly demanding more variety, better quality, and service, with fast and reliable delivery. Combined with this reality, technological developments are happening at an incredible speed, resulting in innovative products and radical transformation of manufacturing processes. These changes are shifting the way businesses, and manufacturing operations are conducted in networked organizations (Ojha 2008) (Vanteddu 2008) (Fantazy, Kumar, and Kumar 2009).

During the 1990s, companies realize the need for looking beyond the borders of their firm to their suppliers and their customers to improve market value through complementarity of competences & capabilities. This movement changes the company's focus from internal management of business and manufacturing processes to managing across the supply network (Chase, Aquilano, and Jacobs 2004).

Christopher and Peck (2012) commented that one of the most profound changes in the recent years was the recognition even from the most significant business organizations, such as corporations, that they have only relatively few competencies in which they can be said to have a real differentiation. This recognition has resulted in a focus upon core business and a trend to seek the other competencies from outside partners. The growth of partnerships has placed increasing emphasis on managing relations between partners in the organizational network.

Chase, Aquilano, and Jacobs (2004) summarized this new paradigm by pointing out that recent trends such as outsourcing and mass customization are forcing companies to find flexible ways to meet customer demand. This flexibility is forcing companies migrating from traditional forms of functional commitment with focal companies in a network to scenarios where the focus is in the optimization of core activities for each partner in order to maximize the speed of response to changes in customer expectations.

The requirement for flexibility across the supply chain and the capabilities alignment between the different actors in the supply chain, is becoming a significant element to respond to market demand specially in scenarios of high volatility and high product variety (Swafford, Ghosh, and Murthy 2008) (Wang 2008, Fantazy, Kumar, and Kumar 2009).

Recently the literature is addressing a new type of supply chain. This new form of a supply chain was branded by several authors as a customer-focused supply chain (Hines 2014) (Christopher 2016) (Sezhiyan, Page, and Iskanius 2011). A customer-focused supply chain enhances the complementarity of capabilities and competencies throughout the entire set of network members. It is continuously assessing its memberships roles in the value chain and is committed to attend customer requirements of innovative products or services with quality on time. These high-performance customer-focused supply chains are distinguishable from the remaining by having remarkably reduced response times to customer requests of customized products. In reality, the ramp-up process from the design phase, through the manufacturing stage, and the final delivery to the customer is the main priority for this kind of supply chains (Wang, Liu, and Li 2009) (Christopher and Holweg 2011) (Ávila et al. 2014) (Gattorna 2015).

Table 22 presents the infrastructure competences & capabilities classification based on the literature contributions and the present research work.

Table 22. Infrastructure Competencies & Capabilities Classification

Competencies & Capabilities	Transactional coordination	Sharing of capabilities, resources, and information through hierarchical transactional agreements (product development centralized in focus company)
	Strategic cooperation	Competitors share resources to cooperate on specific activities that create a competitive advantage (modular product development)
	Collaborative partnerships	Competitors share resources and capabilities in common goal opportunities ranging from medium to long term involvement (distributed product development)
	Customer-focused	Competitors align and share resources, competencies, capabilities, and knowledge on interdependent activities to address rapidly the customer request (fully shared product development)

In summary, Table 23 presents the bibliographical references used to identify the components of the infrastructure dimension.

Table 23. Summary of network dimension literature

Dimension		Definition	Literature
Infrastructure	Design & Conception	Characterizes the way the supply is created, how its actors are arranged or organized, their link stability, ownership, dynamism, and growth direction (vertical; horizontal)	(Ford and Group 1990) (Quinn 1992) (Grandori and Soda 1995) (Cravens, Piercy, and Shipp 1996) (Parlar and Weng 1997) (Christopher 1998b) (Lambert and Cooper 2000) (Klaas-Wissing 2002) (Bowersox, Closs, and Cooper 2002) (Simchi-Levi, Kaminsky, and Simchi-Levi 2004) (Li, Chen, and Li 2005) (Camarinha-Matos and Afsarmanesh 2008b) (Grefen et al. 2009) (Loss and Crave 2011) (Bastos et al. 2012) (Zangiacomi et al. 2013)
	Participation & Relationships	Characterizes the network infrastructure relationships, their membership's participation and involvement, role uncertainty, risk sharing, and actors' rotation.	(Kren 1992) (Cravens, Piercy, and Shipp 1996) (Buono 1997) (Webster 1997) (McKnight, Cummings, and Chervany 1998) (Christopher and Juttner 2000) (Hagedoorn 2002) (Hudson 2004) (Camarinha-Matos et al. 2005) (Johannessen 2005) (Chang, Chen, and Su 2008) (Sukati, Hamid, Baharun, Yusoff, et al. 2012)
	Competencies & Capabilities	Characterizes the network focus, competences alignment, focus, resource and knowledge sharing, flexibility	(Christopher and Juttner 2000) (Harland et al. 2001) (Chase, Aquilano, and Jacobs 2004) (Cousins and Spekman 2003)

		commitment and collaborativeness.	(Hines 2004) (Narasimhan, Kim, and Tan 2008) (Ojha 2008) (Vanteddu 2008) (Swafford, Ghosh, and Murthy 2008) (Wang 2008) (Fantazy, Kumar, and Kumar 2009) (Ávila et al. 2014) (Gattorna 2015) (Knoppen, Christiaanse, and Huysman 2010) (Christopher and Peck 2012)

3.3. Classification Schema Proposal

The proposed classification schema departs from the previously identified dimensions retrieved from the literature and field work, by aggregating them in a single multidimensional classification that intends to be comprehensive but not conclusive. This integration of different dimensions, represented in Figure 27, derives from the effort of signaling and identifying critical features necessary for the description and comparison of different supply chains organizational forms.

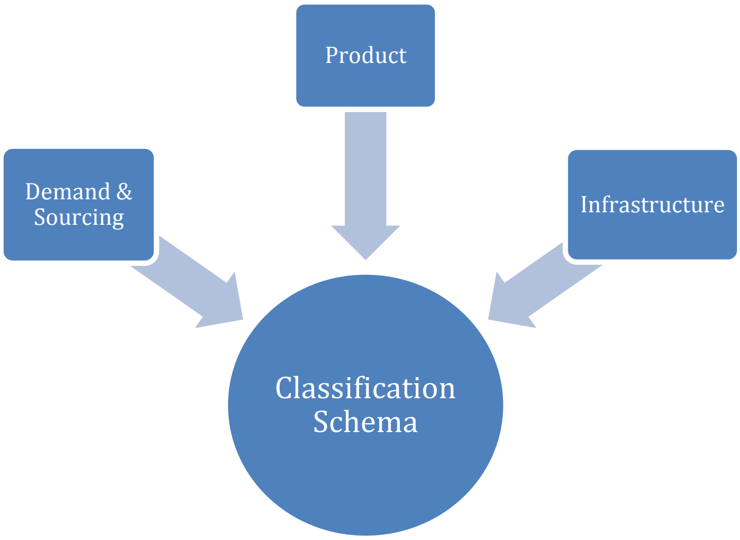


Figure 27 – Dimensions Integration

As a result of this comprehensive search for completeness, the realities considered were very diverse and heterogeneous, which in many cases represents not reconcilable realities or part of evolutionary trends. An observed consequence of the classification effort based on product, demand & sourcing and network dimensions is the existence of overlapping borders between the different dimensions. Nevertheless, this overlap is not harmful to the classification effort because historically and functionally the reality of supply chains is too rich and diverse to be reduced to a modal structural analysis.

Starting from the dimensions, the classification schema is then refined into a set of components that form together what is designated as the classification building blocks.

Figure 28 represents the set of components for each of the three dimensions on the analysis proposal.

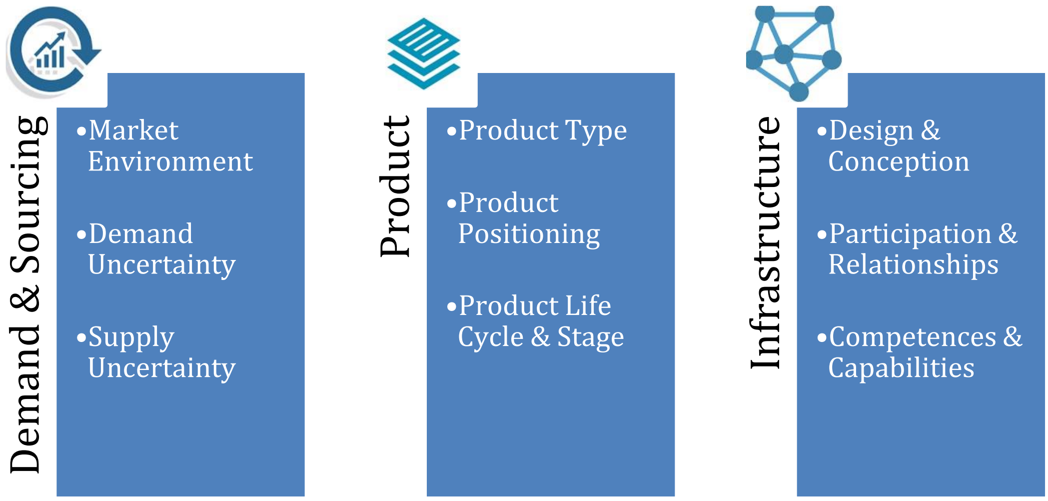


Figure 28 - Classification Schema Building Blocks

For each of the classification dimensions, it was identified three specific and relevant independent components that covered the full range of the dimension considered.

Table 24 presents the definition for each component on every dimension.

Table 24. Supply Chain Classification Dimensions

Dimension		Definition
Product	Product Type	Details the products innovativeness, fashionability, seasonality and functional use
	Product Positioning	Defines the manufacturing positioning of the product regarding the demand
	Product Life-cycle Stage	Specify the longevity of the product life-cycle and identifies the product life-cycle stage in the supply chain
Demand & Sourcing	Market Environment	Features the market dominance, openness, turbulence, innovation and competitors' aggressiveness
	Demand Uncertainty	Characterizes the demand predictability, variety, volume and seasonality
	Sourcing Uncertainty	Details the reliability, responsiveness, and risk sharing of upper stream suppliers
Infrastructure	Design & Conception	Characterizes the network structure inception, links stability, ownership, dynamism, and growth direction (vertical; horizontal)
	Participation & Relationships	Features the organizational volatility, membership's participation and commitment, risk share and actors rotation
	Competencies & Capabilities	Characterizes the supply chain focus regarding competences gathering and alignment, development of internal and external flexibility, cooperation commitment and collaborativeness

3.3.1. Application Example

In this section the classification model was applied to a set of supply chains abundantly described and studied in the literature with the purpose of explaining in a more practical way the application of the classification schema. Table 25 presents the classification model applied to a set of supply chains.

Table 25 – Selected companies' supply chain classification

Company	Classification Dimensions		References
DELL	Product	- Functional product managed with a focus on efficiency - Make-to-order pull system - Short product life cycle time horizon (the majority of products in the growth and maturity stages) - Main feature: responsive approaches to high-value customers	(Roy 2005) (Christopher 2005) (Robinson and Malhotra 2005) (Zhou and Benton Jr 2007) (Power 2005) (Perez-Franco 2010) (Govil and Proth 2002) (Diaz 2001)
	Demand & Sourcing	- A market environment with a high degree of innovation - Due to high modularity at component level demand is semi-predictable - Outsourcing with mainly long-term contracts - Outsources warranty and repair service systems	
	Infrastructure	- A coordinated supply chain with a multi-tier configuration - Dell as a focal company has a centralized, coordinated transactional relationship model - Dell hierarchically coordinates the supply chain competencies and capabilities	
HP	Product	- Functional product managed with a focus on product variety - Make-to-stock push system - Short to medium product life cycle time horizon depending on customer segment - Main feature: Expanding portfolio of products solutions	(Christopher and Holweg 2011) (Simchi-Levi 2010)
	Demand & Sourcing	- A market environment with innovation and proliferation of new products - Demand behavior dependent on target customer segment (usually semi-predictable in functional products) - Outsourcing with mainly long-term contracts with suppliers from developing countries - Partnerships with retailers and distributors - Outsources in procurement, manufacturing, logistics, transportation, and fulfillment.	
	Infrastructure	- A global network that supports multiple supply chains, each one associated with a specific type of customer and sales channel; - Centralized inventory and logistics management with partial VMI implementations	
Wal-Mart	Product	- Commodity and Functional product managed with focus every day low prices, complemented with a high variety of product - Suppliers make-to-stock push system - Long to medium product life cycle time horizon depending product type - Main feature: focus on efficiency improvements in all areas of its operations, which lowers costs. - Ensure on-shelf availability of a variety of products in a convenient location at low prices	(Robinson and Malhotra 2005) (Chiles and Dau 2005)
	Demand & Sourcing	- Demand behavior dependent on the type of products (usually semi-predictable in functional products; stable on commodity products) - Uses cross-docking and hub-and-spoke distributions centers. - Have its satellite communication network to monitor orders and shipments with all stores and suppliers. - Deep integration with manufacturers and suppliers with long term subcontracts	

	Infrastructure	- A fully coordinated approach in managing the supplier's supply chain; - Centralized coordinated transactional relationships with supply chain suppliers; - Sharing of capabilities, resources, and information through hierarchical transactional agreements - Gives better payment terms to suppliers for their use of electronic ordering and information sharing between Wal-Mart and the supplier.	
Amazon	Product	- Products ranging from Commodity, Functional, to Innovative and Fashionable - Functional products managed with a focus in achieving the most extensive offer catalog - Usually implements suppliers make-to-stock push strategy founded on long-term forecasts, - Short to medium product life cycle time horizon depending product class - Main feature: Customers benefit from an unparalleled array of products	(Cohen and Roussel 2005) (Chiles and Dau 2005) (Folinas et al. 2004)
	Demand & Sourcing	- Demand is satisfied based on the individual request, through a pull strategy; - The inventory is managed based on a push strategy founded on long-term forecasts; - The vast majority of products are offered through partner companies or purchased from distributors when needed to satisfy a customer order; - Simultaneously for high demand products, Amazon establishes long term contracts with suppliers; - Implemented warehouses around geographical areas where they keep stock of most of the titles they sell.	
	Infrastructure	- Direct sale through online shops - Builds and operates its own warehouses; - Operates a multi-tier supply chain design, using innovative inventory management techniques, and a focus on cost-effective processes. - Customers order through a website that serves as a virtual storefront. The products are delivered through a network of distribution that are operated by Amazon.com, through a wholesaler and suppliers' partners, or third-parties. - Uses suppliers, partners and third-parties service providers to procurement, transportation, and fulfillment.	
Zara	Product	- Majority of products classified as Innovative and Fashionable; - To customers are offered the latest designs in limited quantities that ensure a sort of exclusivity. - It produces complex products in-house and outsources the simple ones. - Usually implements suppliers make-to-order pull strategy based on short term demand, - Short product life cycle time horizon and heavily dependent on seasonality; - Main feature: Customers benefit from an unparalleled array of products	(Garro 2011) (Ferdows, Lewis, and Machuca 2004) (Tokatli 2008) (Sull and Turconi 2008) (Diaz 2001)
	Demand & Sourcing	- Open market with a high level of innovation and competition; - Highly unpredictable demand - Zara outsources the labor-intensive operations (such as garment sewing) to a network of local subcontractors, or global suppliers for simpler models, with long term subcontracts. - In order to keep the delivery cycles stable, orders are not delayed if quantities do not reach a certain economic order quantity.	

	Infrastructure	- Vertically integrated with the integration of retailers' channels and own shops. - Zara is heavily dependent on logistics and short lead times, and their logistics operations are centralized in two distribution centers in Spain. - Retailer's network of stores worldwide—preferably directly owned. - Relationship with suppliers based in interfirm subcontracting.	
Apple	Product	- Invest significantly in innovation and new product development and technologies; - Apple has make to stock approach with high responsiveness at launching new products. - Implemented product design modularity approaches in order to enhance flexibility and responsiveness to market; - Provide early technology adopters with high price products	(Prater, Biehl, and Smith 2001) (Satariano and Burrows 2011) (Bush, Tiwana, and Rai 2010)
	Demand & Sourcing	- Develop a responsive supply network to emerging market opportunities; - The flexibility of its supply chain IT infrastructure allowed Apple to replace suppliers rapidly, integrate new ones, and reassign existing ones to alter production mix without compromising production costs; - Apple has built a closed network where it exerts control over nearly every piece of the supply chain, from design to retail store. - Outsources manufacturing (in many cases), logistics, transportation, and fulfillment.	
	Infrastructure	- Apple retails stores and traditional distribution channels - Apple have assembly plants in low labor cost parts of the world supported by local material and components suppliers; - Apple has tight control over suppliers and requires many key suppliers to keep two weeks of inventory within a mile of Apple's assembly plants. - Aggressive tactics ensure suppliers availability and low prices. - Apples operational edge enables them to handle massive product launches without having to maintain large, profit-sapping inventories. - Due to is high-value products is usual to resort to air transportation for fast deliveries in the distribution channels.	
Toyota	Product	- Present low variety for functional products with a limit set of customization options. - Implements a pull approach to satisfy demand; - Applies lean principles all over the supply chain - Only produce what is pulled from the customer just-in-time and concentrate only on those actions that create value flow; - Focus on the elimination of waste in all operational processes, internally and externally; - Offer innovative technology products combined with a very loyal customer base and the company's consistent, high-ranking quality marks assures a sufficient competitive advantage.	(Cox 1999) (Brintrup et al. 2011) (Goldsby, Griffis, and Roath 2011) (Iyer, Seshadri, and Vasher 2009)
	Demand & Sourcing	- Toyota operates in a global open market with a high level of innovation and competition; - Demand usually with a high level of predictability; - All participants in the supply chain are stakeholders, and they must add value for everyone in the business; - Implement long-term relationships with partners and seeking common geographic locations to support JIT production.	

	Infrastructure	- Establish long term partnership with highly local vendors - Develop close, collaborative, reciprocal and trusting relationships with suppliers; - Work with suppliers to create a lean and demand-driven logistics process; - Outsources the component manufacturing; - Establish long-term relationships with partners in order to generate technological know-how development; - Implement a network of suppliers nearby for the Toyota assembly factories; - Chooses multi-sourcing for risk avoidance.	
GM	Product	- GM has pursued in the past, segment markets by introducing new vehicles to target niche markets and by offering extensive customization options; - Reduce the car life-cycle by launching new models every year; - Provide a high variety of models and highly customized cars; - Make-to-stock push approach by addressing the demand through forecasting; - It seeks to reduce manufacturing complexity, and tier-1 providers struggle to improve their tight margins by offering more value-added functionality in their products and services.	(Diaz 2001) (Braese 2005a)
	Demand & Sourcing	- GM operates in a national and global open market with a high level of innovation and competition; - A push MTS production; - Manufacturing is almost entirely driven by a forecast, and the only people in direct contact with the customer, the dealers, have limited freedom to order according to their best interest; - Focus in capacity utilization and a push-based downstream supply chain flow. - Address the demand through vehicles in stock at the dealers parking lot; - Sales through a large network of local dealers (in many cases multi-brand), other distributors and retail customers (direct or Internet); - Fleet sales to large customers. - Outsources the component manufacturing and parts that are not core competencies;	
	Infrastructure	- GM own and other suppliers provide the main components for the assembly plants, which then deliver by rail to vehicle distribution centers, and then by truck to the dealerships. - Establish long-term relationships with partners and suppliers; - Dealers are also out of the design loop and GM and do not contribute to new product design.	
Nike	Product	- Invests extensively in R&D for new technologies and their applications for existing product lines, depending upon consumer preferences. - Product customization to meet specific country needs. - Lean manufacturing lines for better labor productivity and lower waste; - Make-to-stock push approach by addressing the demand through forecasting; - NIKE's footwear is manufactured outside the US by independent contract manufacturers that often operate multiple factories; - Also has license agreements that permit unaffiliated parties to manufacture and sell using NIKE-owned trademarks.	(Kumar and Malegeant 2006) (Christopher 2016) (Sridharan, Royce Caines, and Patterson 2005) (Distelhorst, Hainmueller, and Locke 2016)
	Demand & Sourcing	- Open market with a high level of innovation and competition - 80% of sales are made to wholesalers; - 20% are DTC (direct-to-customer) sales through company-owned retail outlets and e-commerce sales. - Most raw materials in NIKE's supply chain are sourced in the manufacturing host country by independent contractors; - Nike uses five primary distribution centers in the US and 16 distribution centers outside the US. - Outsources nearly 100% of its production;	

		- Retain in-house manufacturing for only a few patented vital components.	
	Infrastructure	- NIKE owns no factories for manufacturing; - The enterprise establishes complementary goals with network partners - Its footwear manufacturing is outsourced to third parties; - Nike implements interfirm subcontracting and cooperation; - Nike establishes policies for sharing capabilities, resources and information through hierarchical transactional agreements.	
Adidas	Product	- Focus on speed and brand recognition of innovative products; - Adidas offers customization of its shoes through its online platform; The product positioning is pushed MTS approach for functional products, and a pull MTO for customized products; - Includes several "Speedfactory" owned facilities to add rapid manufacturing to its bespoke product offering of customized products.	(Roscoe and Baker 2014) (Sodhi and Tang 2017)
	Demand & Sourcing	- Operates in an extreme aggressiveness market environment with competition based on innovation or cost; - Adidas outsources most of its production working with more than 1,000 independent factories; - The demand predictability ranges from semi-predictable to highly unstable.	
	Infrastructure	- Owns physical and online retail stores; - Independent retailers who account for 50% of sales; - Franchise partnerships. - e-Commerce channels - Adidas have main suppliers to manufacture and supply products for export or domestic market consumption; - Raw materials are sourced in licensed subcontractors; - Outsourced logistic channels. - Adidas predominantly holds direct contractual relationships with its core suppliers who have centralized supervision; - Adidas also establishes an indirect supply chain sourcing to complement direct sourcing.	

A subsequent effort was directed to expand the usability of the classification model by adding a set of indicative guidelines for the definition of adequate manufacturing or operational strategy for each component on every dimension of the classification schema. These guidelines to expand the classification model use are based in the concepts present in the classification schema, literature findings, and fieldwork analysis. The next section presents this complementary work.

3.4. Operational Strategy Positioning

As explained in the previous section, a unique and relevant question arises in the context of networked companies concerning the overall operational strategy, namely in the definition of the manufacturing choices for the entire supply chain. Related with this question, in the literature and fieldwork research, it is identified two main types of supply chain operational strategies (Fisher 1997) (Simchi-Levi 2010).

The first, an efficient operational supply chain strategy with the main focus on efficiently supply predictable demand at a lower cost. Many authors stamped this operational strategy as "*Lean*," where leanness means developing a value stream to eliminate all waste, including time, and to ensure a level schedule that suppliers demand.

The second type of supply chain operational strategy is the responsive supply chain strategy or agile supply chain. In this case, the principal purpose of the responsive supply chain is to respond as quickly as possible and as flexible as possible to unpredictable demand in order to reduce obsolete inventory and stocks run out.

Although, these two types of strategic approaches are well studied by researchers and numerous case studies can be signalized as examples of each one of these singular strategic approaches, several authors have identified and proved that in many real case scenarios, a mix or hybrid approaches could simultaneously coexist (Naylor, Naim, and Berry 1999) (Mason-Jones, Naylor, and Towill 2000b). In reality, these research studies have shown that it is possible to introduce simultaneously different levels of efficiency and responsiveness in the same supply chain operational strategy. Authors as Mason-Jones, Naylor, and Towill (2000a) argued that the need for efficiency or responsiveness depends on the overall supply chain strategy, especially considering the market, product and customer characteristics.

Based on the previous findings, it is possible to state that a "good" operational supply chain strategy should stipulate which competencies are critical and which are of lesser importance. Moreover, in the previous operational supply chain strategies, the search for operational excellence and simultaneously customer closeness is adversarial. One cannot have it all, operational competencies exhibit trade-offs, and enhanced performance requires making choices and compromising. In reality, since the early days of the industrialization, the definition of an adequate operational strategy has been a choosing problem between several options. A well-known example is the Hayes & Wheelwright product-process matrix (see Figure 29).

In the case of the Product-Process matrix, the authors have proposed a matrix to examine market-manufacturing similarity issues and to explain the strategic decisions that company managers handle. The matrix consists of two dimensions: product structure & product life cycle stage and process structure & process life cycle stage.

In this matrix, the authors argue that the production processes range from a highly flexible, costly process, passing through an increased standardization process with a specialization of equipment and operations, and concluding with a very inflexible but cost-effective process. Hence in the matrix, the process structure & process life cycle axis describes the process selection (job shop, batch, assembly line, and continuous flow) and process structure (jumbled flow, disconnected line flow (batch), connected line flow (assembly line) and continuous flow). On the other hand, the product structure & product life cycle axis describes the four stages of the product life cycle (low volume to high volume) and product structure (low to high standardization) (Hayes and Wheelwright 1979).

The Hayes and Wheelwright work show that based on product and process decision factors, which are not attainable at the same time, the company's managers have to make choices based on giving up on one of the choices in return for another. Besides the trade-off compromising decision-making, Hayes and Wheelwright's work have also revealed that managers also have to take into consideration an indicative area described as the appropriate process choice which is located on the diagonal of the matrix. This matrix diagonal depicts the fitting or alignment axis between the "right" or appropriate process structure vs. product structure.

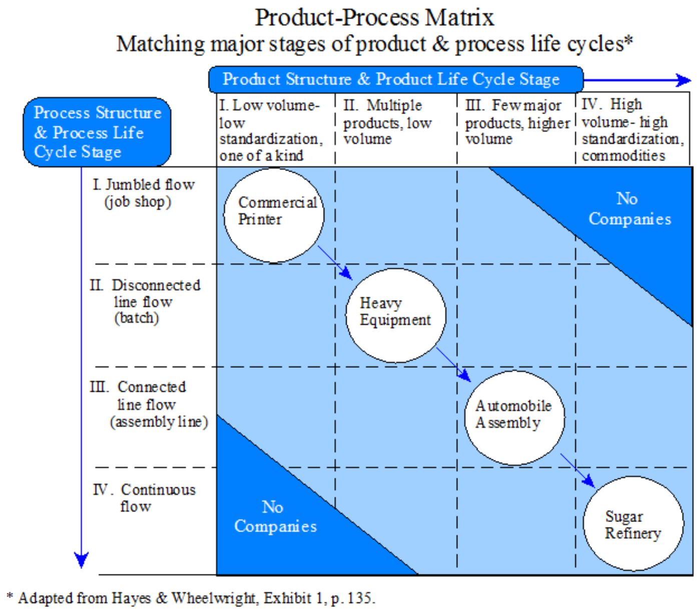


Figure 29 - Hayes & Wheelwright product-process matrix

Correspondingly, in the case of the operational supply chain strategies definition, the search for operational excellence and at the same time customer closeness are antagonistic; forcing supply chain managers' trade-off or a balancing of factors, all of which are not achievable simultaneously. Trade-offs are at the heart of operational supply chain strategy because they determine, for instance, market segmentation, prioritize operational competencies and affect networks structure.

Starting from the proposed supply chain classification schema and taking into account the literature references and cross-case analysis it was possible to establish an empirical correspondence between each of the classification dimensional axes and a suitable or fit operational strategy for a supply chain. In Table 26 it is presented the proposed empirical correspondences.

The principles behind the established correspondence between classification dimensions and operational strategies derive from the Morash (2001) and Simchi-Levi (2010) conceptual frameworks. In these proposals, efficient operational strategies endorse business strategies of overall cost leadership through total cost reduction, efficient and reliable supply, and high levels of essential service. On the other hand, responsive operational strategies support business strategies of differentiation through high levels of value-added customer service, proactive quality, and collaborative communications and interactions with customers. Finally, hybrid operational strategies are devised for products whose demand is difficult to forecast and manufacturers compete mainly on product innovation, rather than on price.

One aspect to highlight on this proposed supply chain classification fitting to an operational strategy is the fact that these correspondences are not univocal. Meaning that a specific classification axis is not bond to a single operational strategy classification option (example: an innovative or fashionable product type supply chain can have both a hybrid or a responsive operational strategy as best fit approach).

Table 26. Supply Chain Classification Fitting with Operational Strategy

Classification Dimension			Operational Strategy		
Product	Product Type	Commodity	Efficient		
		Functional	Efficient		
		Innovative or Fashionable		Hybrid	Responsive
		Singular			Responsive
	Product Positioning	BTS/MTS	Efficient	Hybrid	
		BTO/MTO	Efficient	Hybrid	
		ATO		Hybrid	Responsive
		ETO		Hybrid	Responsive
	Product Life Cycle Stage	Introduction			Responsive
		Growth		Hybrid	Responsive
		Maturity	Efficient	Hybrid	
		Saturation	Efficient		
		Decline	Efficient		
Demand & Sourcing	Market Environment	Monopoly	Efficient		
		Open with low competition	Efficient		
		Competitive with high degree of innovation		Hybrid	Responsive
		Turbulent with aggressiveness			Responsive
	Demand Uncertainty	Continuous flow	Efficient		
		Predictive wave	Efficient		
		Unstable surge		Hybrid	Responsive
		Cavitation			Responsive
	Sourcing Uncertainty	Short term subcontracts	Efficient		
		Long term subcontracts	Efficient		
		Loose partnerships	Efficient	Hybrid	
		Tight partnerships	Efficient	Hybrid	Responsive
Infrastructure	Design & Conception	Proprietary	Efficient		
		Coordinated	Efficient	Hybrid	
		Cooperative		Hybrid	Responsive
		Collaborative		Hybrid	Responsive
	Participation & Relationships	Interfirm subcontracting	Efficient		
		Interfirm cooperation	Efficient	Hybrid	
		Joint Ventures	Efficient	Hybrid	
		Collaborative Consortium		Hybrid	Responsive
	Competencies & Capabilities	Transactional Coordination	Efficient		
		Strategic Cooperation	Efficient		
		Collaborative Partnerships	Efficient	Hybrid	
		Customer-Focused	Efficient	Hybrid	Responsive

A further step in helping managers in establishing an adequate operational strategy for each supply chain from the classification schema can be obtained from applying a similar approach as the Hayes and Wheelwright Product-Process matrix.

Since the literature and the research work as present in chapter 2 establishes that supply chain operational strategies fluctuate from efficient to responsive approaches, it is possible to characterize the supply chain operational strategy in a single axis. This axis representing the supply chain operational strategy range from an efficient supply chains value in one side of the axis, to a responsive supply chain figure on the other side with mixed or hybrid values of supply chain strategies in the middle.

Using each of the supply chain classification schema dimension axis, it is possible to build a second axis which can be related to the supply chain operational strategy axis. Figure 30 presents an example of this appliance by correlating the product type dimension axis with the operation strategy axis.

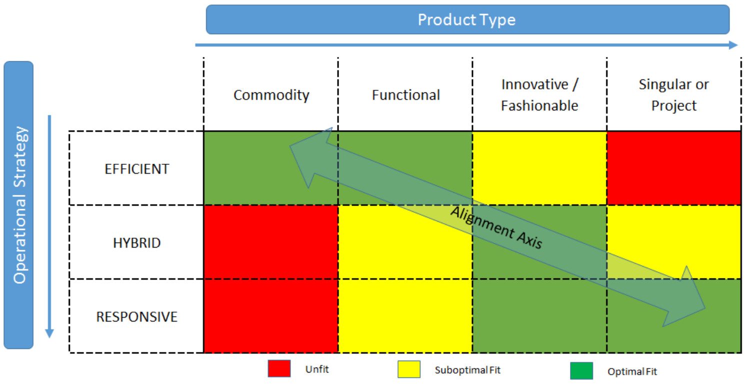


Figure 30 - Product type fitting matrix

As in the Hayes and Wheelwright Product-Process matrix, it is possible to depict the fitting or alignment axis between the "right" or appropriate product type vs. operational strategy for the supply chain.

It is important to refer that in Figure 30 with the fitting matrix example, the values identified for each axis are discrete and singular, making the overall correspondence between the two axes a bit rough and abrupt in the transition between each of the classification values. However, if this analysis were performed using a continuous range of values for each axis, in this case, it would be possible to attenuate the transitions between adjacent values and make identification of the alignment or fit area of the graph easier.

The same exercise can be performed with the other classification dimensions present in the classification schema. This effort will help the decision makers to visualize the diagonal fitting or alignment axis between the classification dimension in analysis and the appropriate supply chain operational strategy or strategies. Figure 31 and Figure 32 present the demand uncertainty and network structure example exercises.

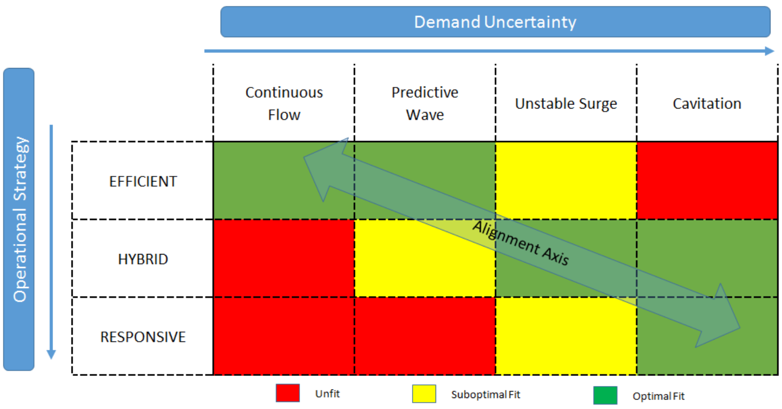


Figure 31 - Demand uncertainty fitting matrix

In reality, an excellent operational strategy clearly defines which competencies are critical and which are less critical. A decision-maker cannot have it all; operational competences display trade-offs. Superior performance requires the making of choices which impose compromises between different factors. Trade-offs decisions are at the core of supply chain strategy because they constrain which processes, resources, and competencies are more suitable for a specific supply chain instance and determine market segmentation decisions and specific operational competencies.

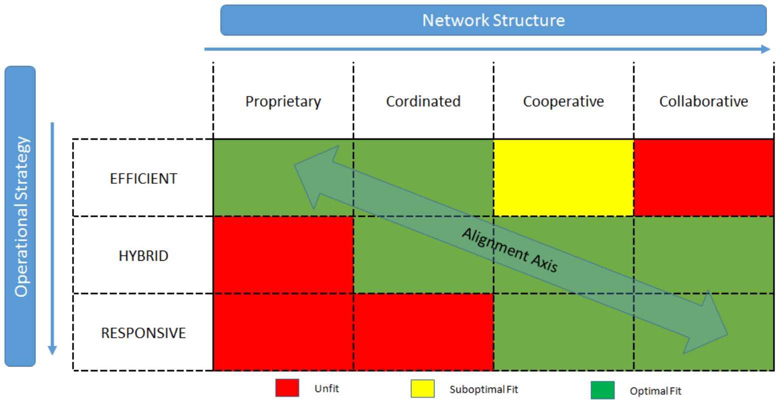


Figure 32 – Infrastructure design & conception fitting matrix

Behavioral and economic studies have demonstrated that the decisions of a rational consumer facing a choice of products or services can be modeled through a reasonable utility maximization function. Each consumer, formally or informally, creates a utility function that assigns to each attribute the level of personal fulfillment. Based on this construct, consumers select from the different options the product or service that within their budget gives them the highest fulfillment (Corbett and Van Wassenhove 1993) (Hausman 2004).

Usually, customer trade-offs are represented through iso-utility curves that represent the combinations of factors levels that yield a constant utility value. Different trade-off curves, therefore, represent different consumers' preferences which support the strategic definition of market segments, as an example.

As in the case of individual consumers, organizations and specifically complex organizations such as supply chains face trade-offs. Limitations in resources, processes and time condition the fostering of specific common goals in networked organizations. The extent and the number of objectives that an organization can attain simultaneously are subjected to constraints, forcing the decision-makers to a trade-off between different goals or objectives. As in the case of the consumer trade-offs which can be represented by iso-utility curves, the operational tradeoffs in supply networks can be represented also by iso-NPV[7] curves. These iso-NPV curves represent the competence combinations that generate a net present value (NPV). In reality, this means that for a specific organization, when considering the different scenarios of a specific iso-NPV curve, it would be indifferent the choice between the different combinations.

The iso-NPV curves trade-off analysis has been widely used in the literature, ranging from economic analysis to resource consumption assessment (Yang 1992) (Osmundsen 1998) (Vanhoucke 2009).

Since in complex organizations such as supply networks it is challenging to characterize iso-NPV relationships, usually researchers in these cases choose to represent operational trade-off curves showing the process cost to deliver a specific combination of product or service

[7] NPV - Net Present Value is defined as the sum of the present values of incoming and outgoing cash flows over a period of time. Incoming and outgoing cash flows can also be described as benefit and cost cash flows, respectively (Berk and DeMarzo 2007).

attributes such quality, response time and variety. Using this approach, the costs are specific to each operational system and therefore shaped by the correspondent operational strategy (Van Mieghem 2008).

In line with the traditional trade-off analysis principles which state, that operational competencies are ruled by trade-offs that are defined by the operational system of resources and processes, it is possible to expand this analysis further. Since organizations cannot achieve every goal at the same time due to the limited abilities of its resources and processes, it means that the operational strategy can shape and change the trade-offs by choosing the adequate resource setting and network activity. This adequate or "right" operational strategy must be aligned with the overall supply chain strategy, and through the trade-off curves analysis, it is possible to assess it quantitatively (by NPV increase or cost reduction) or qualitatively (by evaluating if supply network competencies are aligned with the customer value proposition).

For the present exercise of proposing a comprehensive supply chain classification schema, the trade-off analysis helps every stakeholder inside a specific network organization understand their positioning regarding other competing organizations in the market. It also helps to understand which compromises or trade-offs are required in the strategic repositioning of the supply chain on the classification dimensions. Hence, using this elevated view, it is possible for a specific network manager when defining its competitive strategy use the ability to shape the trade-offs and choose an appropriate competency positioning point for their network.

For instance, based on the characteristics of each of the product type classification in the classification schema, it is possible to infer the trade-off curves regarding the two-operational strategy axis; efficiency vs. responsiveness. Figure 33 presents a possible conceptual example of the correlation between each one of the typical product types (commodity, functional, innovative/fashionable and singular/project) and the previously identified manufacturing or operational strategy stance. By using this trade-off axis representation between the opposed operational strategies, it is possible to assess how sensitive each one of the products types is, related to the two opposing operational strategies.

The product type trade-off curves diagram represented in Figure 33 presents in the horizontal axis the cost-efficiency operational positioning. In this axis, the efficiency (lesser costs) values growth from left to right; which means that the right positions in the axis are the most cost-effective. The vertical axis represents the agility or responsiveness strategic operation positioning. In this y-axis the responsiveness (agility) values growth from bottom to top; which means that the most elevated positions in the axis are the most responsive or adaptable.

In reality, an excellent empirical practice in the construction of the trade-offs curves diagrams is to locate the most "desirable" area of the diagram in the upper-right corner (north-east). That representation leads to a view where going out to the upper-right corner is always desirable, yet the trade-off curves restrict the decision maker from getting it all.

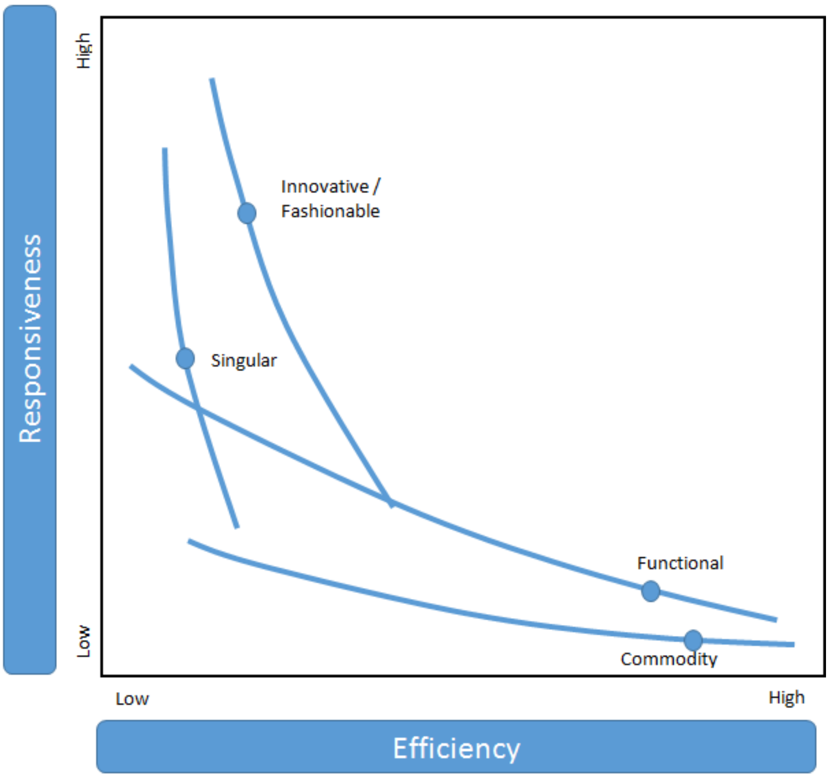


Figure 33 - Product type trade-off curves

In the present product-type trade-off analysis, it is possible to weigh up how sensitive is the compromise for which product type, between the efficiency vs. responsiveness. For instance, considering the commodity product type is possible to observe that the increase of responsiveness in the respective utility curve, results in a dramatic degradation of the efficiency due to the high sensitivity of this curve.

On the other hand, an inverse effect is observed for the singular/product type curve. The search for an increase of efficiency on a "one-of-kind" or single product leads to a rapid reduction of responsiveness and degradation of the flexibility.

This product type trade-off analysis conducted in the two outermost values is also replicable to the functional and innovative/fashionable product types. In these cases, the trade-offs curves show that the functional products are highly sensitive to the loss of efficiency when pursuing an increase of responsiveness or flexibility; and inversely innovative/fashionable products degrade their positioning regarding the responsiveness when considering the pursuit of a more cost-efficiency positioning.

The practice shows that it is the trade-offs in operational competencies that provide competitive protection to an organization's strategic position. A primary reason why organizations implement processes they do in order to address the demand is to ensure consistency in the execution of its activities. Therefore, when one particular operational network system is in place, other competing organizations can only duplicate its performance by copying it in its entirety, which is quite complicated and costly.

The structural constraints are easily explained for each of the product type classifications. For example, operational systems that produce functional products are most efficient in making larger quantities of identical products. Their product designs allow lesser selection and customization, and its manufacturing processes are more rigid and with less flexibility. On the other hand, in the case of innovative/fashionable products types, the excel is in flexibility. Flexible design and manufacturing capabilities are in order, usually leading to product design processes and flexible and responsive job-shop production processes, all performed by highly capable resources. In both cases, the processes and their associated resources have strengths and weaknesses that are manifested in their utility trade-off curve.

Using the trade-off analysis as a starting point enables the establishment of a comprehensive strategy that integrates different dimensions of the classification schema of the supply chain. For instance, Figure 34 intends to depict the correlation between the product type dimension and the market uncertainty regarding the manufacturing or operational strategy. For instance, in case of a lean (cost-efficient) positioning, is possible to frame the correlation between the functional product classification and the market uncertainty dimension as a predictive demand wave as a best fitting positioning.

Similar trade-off analysis can be accomplished to other dimensions of the classification schema. Annex A presents some examples.

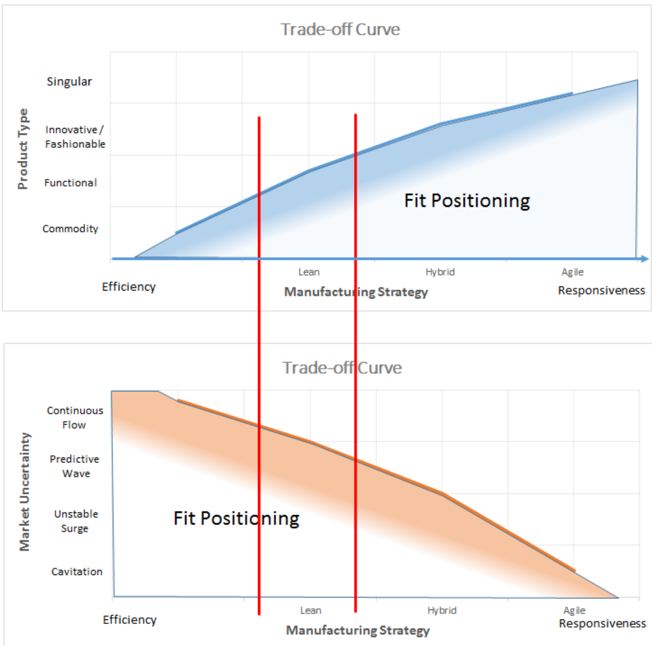


Figure 34 - Operational fitting based on type of product

Another significant aspect of the trade-off curve analysis results in the fact that trade-off curves are snapshots of particular moments in time of the organization positioning. Therefore, as the organization improves its operations, its trade-offs curves move outwards, which creates an area of new options of positioning. For instance, if an organization improves its operations, this improvement can be used to increase its cost efficiency, or deliver a more responsive operation, or achieve a better combination of both. This strategic decision must be made taking into consideration the different elements of the supply chain strategy and the positioning of the competitors in the market.

3.5. Summary and Conclusions

The present chapter proposes a comprehensive supply chain classification model based on previously published classification studies, exploratory surveys, and related literature review. The present proposal identified three main dimensions: product; demand & sourcing; and network. With the integration of these three dimensions in a single multidimensional structure, it was intended to present a comprehensive analysis which the literature on inter-organizational networks lacked to present.

For each of these classification dimensions was identified specific and relevant independent components that covered the full range of the dimension considered and help the analyst in framing the different possibilities behind each dimension and component considered for the supply chain classification.

Using as support the dimensions classification of the supply chain, the present classification schema additionally presents a guide or decision support framework for the definition of the "most suitable" operational strategy for each of the classification dimensions. Departing from the Hayes & Wheelwright product-process conceptual matrix, it was proposed a similar operational matrix that establishes the correspondence between each one of the classification schema components and the adequate(s) operational strategy(eis).

A further step in helping managers establishing an adequate operational strategy for their supply chain present in the classification schema results of the use of trade-off curve analysis. The trade-off curve analysis assists the network decision-makers in understanding which compromises or trade-offs are necessary in the strategic repositioning of the supply chain in the classification dimensions. It also helps the network actors to understand their positioning as an organization regarding other competing firms in their business environment.

From the present exercise in proposing a new classification schema for supply chains, it was clear the emergence in the recent years of new forms of network organizations that intend to tackle a novel and demanding competitive factors that mold the present and future global market landscape. In reality, companies' managers are increasingly challenged to reduce the lead time between technical or market opportunities arising and subsequently to satisfy the customer need with full-rate production of quality products.

This "time to market" obsession, especially in the case of innovative and fashionable goods is a critical factor to achieve competitiveness and endure in a globalized market environment. Currently, stakeholders of networked organizations are increasingly facing these new and unforeseen challenges. The trend is here to stay, and the future will reward the ones who adapt more rapidly. Decisions makers, facing this reality, are seeking new solutions, tools, and methods to tackle this new trend. The following chapter addresses how networked organizations can address the new market dynamic and customer-focused conditions and evolve to higher levels of responsiveness and flexibility.

Chapter Four

CUSTOMER-FOCUSED SUPPLY CHAIN – A FASHION FOOTWEAR STUDY

In the previous chapter, it was presented a supply chain classification model based on a literature review and field work. It was also identified main areas of research regarding new forms of network organizations that intend to tackle a novel and demanding competitive factors that mold the global market landscape. Indeed, in the first stage of this research project, it was critical to clearly understand which should be the areas of research that should be addressed regarding customer-focused supply chains, as well to cover the main gaps and opportunities of research identified in the state-of-the-art review.

Consequently, in this chapter, it will be explored how the companies' managers can adapt their supply chains to these challenging scenarios of reducing the lead time between technical or market opportunities arising and subsequently satisfying the customer need with full-rate production of quality and innovative products. The methodological approach selected to perform this stage of the research was a multiple design science research analysis of the fashion footwear industry sector. The conclusions retrieved from the requirements study analysis will be used as a reference to show the main enhancements that are expected to be introduced within the current state-of-the-art on the supply chain management namely for customer-focused and innovative next generation of supply chains.

4.1. Context

The current evolution in the design approach has a significant impact on the product configurations, product volumes and response time, changing the landscape of traditional supply chains. A significant example of this impact is observed in the fashion footwear sector where in order to stay competitive, footwear companies need to enter new markets implementing innovative production methodologies based on a networking economy.

In reality, the footwear sector has become a global industry where competition is global and key players are no longer concentrated only in Europe and North America but also in emerging low labor cost countries. Moreover, the overall performance of this industry sector is deeply affected by unpredictable and seasonal demand as well as emerging consumers' needs in terms of comfort, health, and environmental constraints.

This context forces companies to rethink their strategies. In order to design, develop, produce and distribute such products, new approaches and related supporting services for collaborative networking are increasingly mandatory in order to footwear companies succeed on addressing the market demand through customer-focused value chains. Due to its unique characteristics, the fashion footwear industry sector offers valuable insights to the next generation of supply chain management strategic approaches. In order to study this sector, the research approach followed included comparing literature and multiple case studies from the fashion footwear supply networks. This fashion footwear research study aimed at highlighting the guidelines for designing an innovative reference model for customer-focused supply chains.

The remaining of this chapter is organized as follows: first, it is presented the research methodology approach relating it with the existing literature and the research questions, followed by the research study data and analysis results. Afterward, the final section outlines the conclusions retrieved from the case analysis.

4.2. Methodology and Research Topics

The design science research paradigm is highly relevant to Information and Communication Technology systems research because it directly addresses two of the critical issues of the discipline, the need to model complex real-world processes and their use and application. Design science supports a pragmatic research paradigm that calls for the creation of innovative artifacts to solve real-world problems. Thus, design science research combines a focus on the ICT artifacts with a high priority on relevance in the application domain of complex organizations (Hevner and Chatterjee 2010a).

The design science research is a body of knowledge concerned with the design of artificial; man created objects and phenomena ("artifacts)" designed to meet specific desired goals. Design can be described as a mapping from functional space, a functional requirement constituting a point in this multidimensional space—to an attribute space, where an artifact satisfying the mapping constitutes a point in that space.

As Vaishnavi and Kuechler (2015) explained, "design science is knowledge in the form of constructs, techniques, and methods, models, well-developed theory for performing the mapping, and the know-how for creating artifacts that satisfy given sets of functional requirements." Design science is a research method that creates this type of missing knowledge using design, analysis, reflection, and abstraction.

Figure 35 presented the research process model followed in the Design Science Research (DSR) methodology and applied to the present requirements analysis of fashion footwear supply chain.

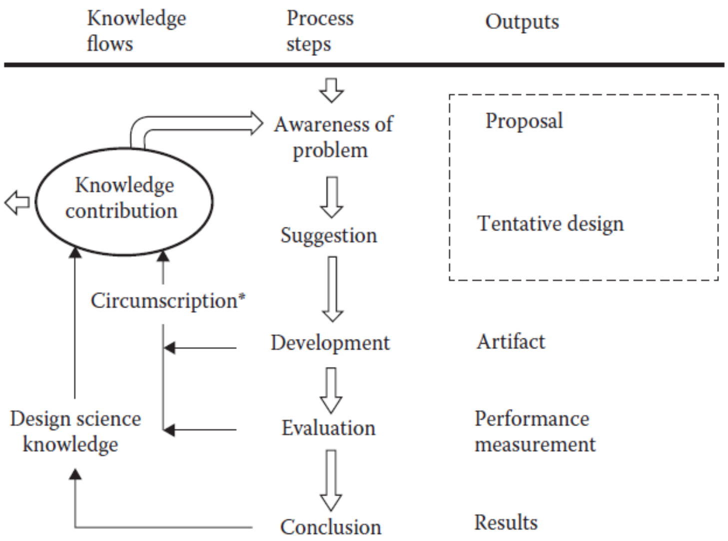


Figure 35 - Design Science Research methodology cycle (from Vaishnavi and Kuechler (2015))

According to Hevner and Chatterjee (2010a) typical DSR effort proceeds with the following phases:

- **Awareness of Problem** - awareness of a research problem may come from multiple sources including new developments in industry or in a reference discipline which may provide the opportunity for application of new findings to a researcher's field. The output of this phase is a proposal, formal or informal, for a new research effort;
- **Suggestion** - is a creative step wherein new functionality is envisioned based on a novel configuration of either existing elements which lead to the development of appropriate constructs that operationalize the phenomena and an appropriate research design for their measurement;
- **Development** – a tentative design is developed and implemented at this phase with the purpose of establishing a formal proof to show the artifact view correctness;
- **Evaluation** - once constructed, the artifact is evaluated according to criteria that are always implicit and frequently made explicit in the proposal. Any deviation from expectations, both quantitative and qualitative, are carefully noted and must be tentatively explained;
- **Conclusion** - this phase could be just the end of a research cycle or is the conclusion of a specific research iteration. The conclusion of a research effort is typically the result of satisfying the expected behavior of the artifact from the (multiple) revised hypothetical predictions. Simultaneously, the knowledge gained in the requirements

design effort is categorized as the fact that has been learned and can be repeatedly applied or behavior, or that can be repeatedly invoked.

In summary, the primary purpose of the Design Study Research is the creation of knowledge that can be used for the development of or the improvement/innovation of information and communication technology (ICT) artifacts.

In the current study, in order to identify and model the main collaborative business processes tailored for responsiveness and efficient use of knowledge in ICT environments for customized manufacturing environments namely customer-focused supply chains, it was naturally selected the Design Study Research approach.

From the literature review on supply chain research was possible to identify a set of known networked business processes that present relevancy to the present generation of the supply chains management — the “awareness of the problem” phase of the DSR research methodology.

Subsequently, it was performed a cross-case sectorial qualitative analysis to investigate "how" and "why" companies interact with their supply chains. This phase corresponds to the “suggestion” stage where the potential for deduction, triangulation of perspectives from multiple, similar cases; abduction from multiple, similar cases are performed.

The qualitative approach methodology followed, in contrast to the quantitative approach, is based on the ontological question that social reality exists and is subjectively and not uniquely interpretable by the participants in its study, and the researcher thus assumes an active and committed role in interaction with the object of study.

The peculiarity of the present study is to be able to carry out a very detailed and contextual analysis of a well-defined number of events and situations and possible relationships that exist between them. A rewarding feature of using the design study is its easy adaptability to very different contexts: from the organizational-management context to the social field, it is always possible to apply a sufficiently standardized model without this leading to a decline in the results themselves.

The DSR method chosen is appropriate since, as evidenced by the analysis of the literature, there are few studies in the scientific research landscape that have thoroughly investigated business models of specific sectors concerned by adopting a network perspective. In particular, by developing reference models, the method supports companies to develop and sell innovative and fashionable products thanks to responsive approaches based on ICT solutions.

As explained by Vaishnavi and Kuechler (2015) the expected outputs for DSR are constructs, models, methods, and instantiations. Constructs are the conceptual vocabulary of a problem/solution domain. Constructs arise during the conceptualization of the problem and are refined throughout the DSR cycle.

Specifically, the intended output of the present Design Science Research project is a framework intended to assist supply chain stakeholders in understanding their current supply chain business processes and help them in adapting them to the future challenges.

Figure 36 describes the system development research model used to collect the requirements necessary for the definition of a customer-focused framework.

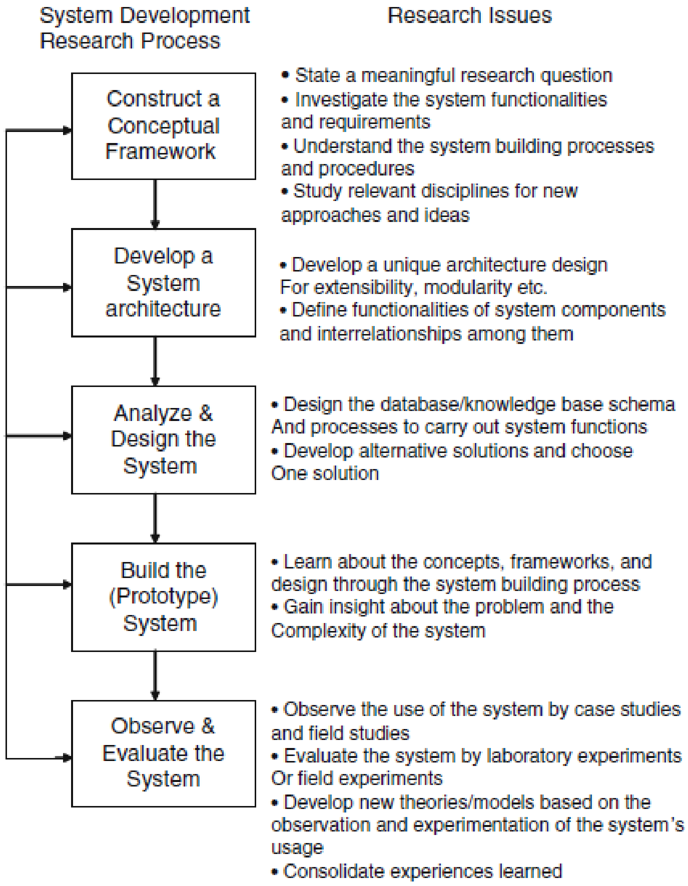


Figure 36 - System development research model (adapted from (Nunamaker Jr, Chen, and Purdin 1990))

Systems development model consists of five stages: conceptual design, constructing the architecture of the system, analyzing the design, prototyping (may include product development), and evaluation.

This sectorial design study has two stages. The first stage focused in an "as-is" description of the current business processes, identifying its main actors, production processes, available ICT tools and systems, organizational strategic and operational decisions, and sustainability policies and processes.

The second stage, through a set of interviews, focused on the "to-be" scenarios. These future business processes scenarios were analyzed through brainstorming techniques and using as starting point the data collected during the first phase as well as concepts coming from the analysis of the relevant state-of-the-art literature. This second stage analysis focused on the business processes required for the qualification and selection of potential partners, the network formation, operation, and the necessary ICT tools and functionalities to support these customer-focused supply chains.

The research covered in this work falls in the *theory-building* category through in-depth field studies (particularly regarding the comprehension of the business processes sustaining the supply chain - Research Questions 1) and *theory testing* through multiple case studies (mainly in the development and testing of the Reference Model in response to Research Question 2).

Regarding the cases selection process, the literature emphasizes that random selection of cases is neither necessary nor desirable. Especially, given the limited number of cases that can usually be studied, it is appropriate to choose those that represent polar or extreme situations in which the process of interest is readily observable. This sampling leads to visible pattern recognition of the central constructs, relationships, and logic of the focal phenomenon (Eisenhardt and Graebner 2007).

4.3. Study Preparation

As explained in Chapter 1, since in nowadays business environment there is a multitude of distinct supply chains operating in a large variety of industrial sectors, special attention was applied in the selection, first of the industrial sector to be addressed, and secondly the selection of the industrial cases to be studied.

The choice of the Footwear industry sector was based on the following reasons:

- The Footwear industry is highly globalized, and competition arises from countries with low labor cost and less-regulated working conditions;
- Shoemakers manufacturers are undergoing a severe restructuring of strategies and policies in order to produce innovative, fashionable and high added value products;
- Consumers are increasingly willing to buy products not only for low price but also for their performance in terms of design, innovation, comfort, health care, and environmental attention;
- The Footwear industry sector is strongly pulled by a highly unstable and rapidly changing demand, due to fashion-related and seasonal fluctuations;
- The footwear distribution system is also changing, by giving more bargaining power of the distributors and putting pressure on product prices;
- Sustainability issues are becoming more and more critical in this sector due to public attention;
- Technological investments are streamlining operations, improving customers' service and knowledge, and enabling new ways of innovating products and speed up distribution.

In sum, the present conditions that the Fashion Footwear sector is facing, namely a competitive market, the challenge to reduce the lead time between technical or market opportunity arising, and the need to satisfy the customer of the innovative, fashionable, sustainable and added-value quality product, present itself as an adequate study object.

For the study itself, two phases were designed. In the first phase, a set of companies' cases present in the literature were selected with the goal of isolating the industry's best practices and the market leader's approach, focusing on subsequent case studies on specific, often context-sensitive, best practices.

The first analysis proved to be particularly useful in the development of the research protocol used in subsequent interviews. In particular by focusing on questions about the most critical issues for the case study companies and investigating the transferability of practices used in different contexts.

An extra benefit of this first phase of analysis was the ability to study the industry as a whole, i.e., understanding of the best practices adopted by reference companies in the international market landscape. It will also play a pivotal role in defining the research protocol and the case study interviews, as it did highlight the areas of most significant interest to focus on the following survey.

Additional support in the construction of the research protocol was taken from the definition of “SMART organization” in the reference model of Filos and Banahan (2001).

The term "SMART organization" was coined to represent a new form of knowledge-driven, internet-working and dynamically adaptive organization ready to observe, learn and exploit new market opportunities offered by the digital age. The concept of SMART network, was understood as a legal entity network, describes a collaborative approach by considering tangible and intangible assets as well.

The model proposed by Filos and Banahan represented in Figure 37 identifies three main dimensions of networking in order to analyze and support the design and coordination of the network and related collaborative systems:

1. **Knowledge** Dimension - this dimension is used to map the competencies of partners to share within the network in terms of products and processes;

2. **Information & Communication Technologies** (ICT) Dimension - to support the implementation of ICT services at different process levels along the supply network;

3. **Organizational** dimension - to support the organizational change of the SMEs in order to structure their supply network.

This modeling approach supports aspects of analysis, design, implementation, and management of collaborative networks, considering the three major dimensions of networking: Knowledge, ICT, and Organizational.

Also, the model allows the study of existing networks by analyzing existing branch structures and comparing them with the structure of a target organization. It is essential to emphasize how the performance achieved by collaborative structures needs to be taken into account in order to analyze them from a perspective of overall effectiveness. The resulting implications involve both organizational/structural and operational aspects of individual processes developed along the network.

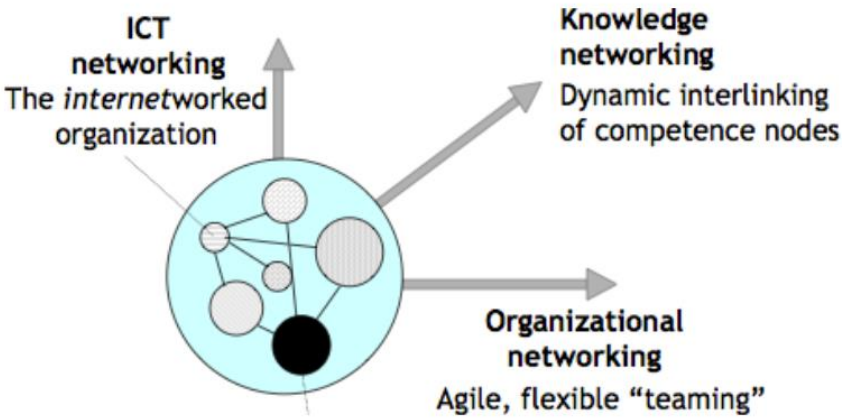


Figure 37 – SMART reference model (from: (Filos and Banahan 2001)

In addition to the three main dimensions proposed by the SMART network model (Knowledge, ICT, Organizational), the research protocol consider a fourth dimension. Consistent with the objectives of the research, the Sustainability dimension.

Sustainability is defined as 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs' (Dee 2010). According to the UN 2005 World Summit, it was noted that sustainability requires the reconciliation of environmental, social and economic demands - the "three pillars" of sustainability.

At the fourth quarter of the twentieth century, comes to public attention the topic of sustainable development, placing companies as central actors in this discussion and debate. This topic was mainly an issue in the case for companies that are more visible to the final consumer, as they were likely to come under pressure from stakeholders, e.g., customer, governmental and non-governmental organizations.

These companies are asked to consider environmental and social problems observed in their supply chain. Since then, an increasing number of companies have pursued proactive approaches to sustainable supply chain management. Such triggers have increased interest in green/environmental or sustainable supply chain management (Bowen et al. 2001, Seuring 2004, van Bommel 2011).

4.3.1. Data Collection

After the selection of the cases to be studied, it was necessary to choose the tools with which the data would be collected. Usually, in this type of qualitative research, the source of direct data interviews. Other sources may include observations, informal conversations, attendance at meetings, questionnaires, review of existing documents, etc.

Analyzing the common practice of DSR requirement studies is recognized that most of the data collected are qualitative, although it is not so rare to observe a quantitative data collection or both. Qualitative data is useful to understand the underlying logic of quantitative data or suggesting an emerging theory that can then be amplified through quantitative data.

At this stage, it was crucial to identify the various sources for data collection, both in terms of origin and in terms of the type of data collected, in order to obtain a "triangulation" of information, i.e., to be able to confirm a single event from multiple surveys. The importance of this phase is high because the correct choice of data collection and processing methods allow the researcher to validate his research. For the current design study research, the approach selected for data collection and to analyze the selected case were predominantly the interview with the support of digital documents.

4.3.2. Research Protocol Definition

As a first step, a research protocol was design in two different sections: a first section addressing the current situation (as-is-analysis) of the different companies belonging to the footwear sector. The preceding section was intended to characterize the current state of the company, their strengths and limitations, technical and operations difficulties and strategic guidelines. This first analysis supported the second section focused on identifying future scenarios and trends behind it.

Particular attention in the drafting of the protocol was intentional in order to analyze at the same time the four dimensions of interest (Knowledge, ICT, Organizational and Sustainability), covering the main research topics identified through literature studies and preliminary analyses on literature published company cases.

In order to validate the developed research protocol, a first pilot interview was conducted at Company B where the context analyzed was broader than planned in the initial protocol. This preliminary step was useful to integrate into the protocol any missing information not considered at the first stage. Table 27 presents the final version of the research protocol followed in the multiple case study analysis.

Table 27 – Research Protocol

RESEARCH PROTOCOL		
1. Introduction	1.1 Company characterization	
	1.2 Product structure	
	1.3 Position in the supply chain	
2. Organizational	2.1 Strategic Decisions	2.1.1 Key business partners and networks
		2.1.2 Type of relationships
		2.1.3 Strategies
		2.1.4 Performance evaluation
	2.2 Operational Decisions	2.2.1 Business processes
		2.2.2 Sourcing strategies
		2.2.3 Channel strategy
		2.2.4 Buffering strategy
3. Knowledge	3.1 Customer requirements	3.1.1 Standard product
		3.1.2 Configurable product
		3.1.3 Best fit

	3.2 Production process	3.2.1 Activities
		3.2.2 Resources
		3.2.3 Processes
		3.2.4 Manufacturing Strategy
		3.2.5 Order fulfillment strategy
4. ICT	4.1 Market and customer interfaces	
	4.2 Design of products and services	
	4.3 Production and control	
	4.4 Integrated systems	
5. Sustainability	5.1 Product sustainability	
	5.2 Process sustainability	
	5.3 Supply chain sustainability	
6. Future scenarios	6.1 Qualification of potential partners	
	6.2 Network design	
	6.3 Networked order fulfillment	
	6.4 Operations planning	
	6.5 Execution	
	6.6 Network dissolution	

The first part of the interviews, according to the research protocol, consisted of an analysis of the "as-is" situation of the company. This analysis started with a visit to the company site, followed by a set of interviews of informants that could provide more knowledge about the company in question, and in particular the Supply Chain Manager and Operations Manager.

The second part of the interview focuses on the "to-be" situation (future business scenario), analyzed by brainstorming techniques and using as starting point the data collected during the first phase as well the ideas coming from the analysis of the related “state-of-the-art” literature. Annex B presents the developed questionnaire used in the design study interviews.

4.4. Characterization and Analysis

For the overall analysis of the Footwear industry supply chain, it was necessary special care in the multi-case requirements gathering and integration. The following paragraphs, as well as to the previously considered literature of interest for the research objectives highlight this care.

In order to properly investigate the sector, significant study supply chains were selected, which were first analyzed individually by an in-house design study and later compared with a cross-case analysis.

The manufacturing approach observed in all the cases does not change, as most fashion-based companies adopt a Make-To-Order strategy, and store only for a small set of standard products.

Following it is the description of each of the company subject to the study.

Table 28 - Case Companies List

		A	B	C	D
Company dimension (turnover) m€		820	43	50	100
Company dimension number of employees		17,500	96	135	374
Number of shoes produced per year		10,000,000	750,000	200,000	1.000.000
Number of suppliers and outsourcers		More than 50	More than 50	From 20 to 50	More than 50
Relationships	time	Mid	Mid	Mid	Mid
	Space	Global	Local	Local	Local
Customers		Retailers	Retailers	Retailers	Retailers
Average dimensions of customized orders		0	More than 500	0	0

Company A

It is an international company that invoices annually around 800 million euros and has a staff of over 17,000 operating employees in more than 50 countries. Its founder has shaped the company in order to industrialize footwear production, which he had been working at a young age, especially developing high-tech machinery that supported the large-scale production process while at the same time ensuring high-quality standards. The company quickly became international, opening branch offices in countries where labor costs were lower, in order to compete in the globalized market.

Company B

It is an Italian shoe factory whose headquarters are located in the industrial district of the Marche, a shoe-making tradition area in which several international companies make use of small and medium-sized local suppliers who over time have gained experience in producing materials and components of the highest quality.

The company started as a small artisan workshop, and in the following years, thanks to the introduction of state-of-the-art production technologies and processes, it is distinguished on the market with the highest quality but at the same time innovative products.

The company mainly produces women's fashion and casual footwear, but in recent years has decided to diversify its production by integrating men's footwear and accessories. Each model comes from a significant focus on quality, creativity and Italian style, all of which represent the deepest root of fashion recognizable everywhere internationally.

Through the use of highly specialized local suppliers who can offer state-of-the-art materials and components, as well as their design experience together with company expertise, it made possible the existence of long-term networked collaborations. Thanks to the creation of the latest generation management software, the company can know in real time know the inventories of each supplier/third party as well as the work-in-progress of each component.

Company C

The company is located in Portugal and produces about 200,000 pairs a year of fashion women's shoes under proprietary brands which are distributed throughout the world thanks to many retailers located in various countries.

The production strategy adopted is Make-to-Order, and only outsources the sewing of footwear. Relationships with chain partners are long-term and highly collaborative in order to allow the creation of innovative products without compromising on quality. Betting in quality, coupled with product diversification, are the success factors for the company.

For each component or type of material purchased, the company uses multiple suppliers to get the highest yield in terms of quality and specialization.

Like many companies in the industry, the company has recently adopted software to optimize the management of its suppliers/third parties through real-time monitoring of inventory stocks and advances in the different manufacturing processes.

Last generation technology tools have also been implemented on the sales side, making it possible to use a web-based platform to purchase their products from customers, businesses, and agents.

Customized order management is made possible for customers of vital strategic importance. The customization is possible without the ability to modify the structural part of the footwear but leaving open the choice of materials and colors used.

Company D

A medium sized company (about € 30 million in annual sales) was founded in the '80s in Portugal and initially produced 50 pairs of footwear per day, mainly delivers for the European market, using a force work of 50 employees. Over the next few years, the company has invested in increasing production lines and implementing innovative technologies in order to expand the quantity produced daily without sacrificing the quality and cost-efficiency of the process.

Today, the company employs around 600 people and is the leader in the export of Made in Portugal footwear, and today's core business focus on elegant and juvenile women's shoes.

However, the company's strategy sees the future goal of pursuing new market niches by diversifying the company's product catalog and to gain more and more experience in the production processes in the industry. Innovation and quality of service are the keywords that drive the strategies of the company.

Company D works mainly with highly specialized local suppliers with significant experience in the production of components and in obtaining valuable materials. They are also used mainly for the cutting and stitching phases of footwear, traditional bottlenecks of the entire production process.

The company customers are retailers all over the world, and the company works with agents across the country to place sales. Has recently been introduced to the possibility of online shopping, although generally tied to reorder.

The production strategy is Make-to-Order, but also provides customized products (retailers), only for high volume orders and for strategic customers.

4.4.1. Cases Analysis

As a result of the multiple-case analysis, a cross-case analysis for the Fashion Footwear sector was carried out, in which the most relevant features for the sector were analyzed, in terms of supply network management for the dimensions identified previously.

Organizational

Companies in the fashion footwear sector predominantly establish long-term relationships with both raw material suppliers and their outsiders, involving them in the design and industrialization process of footwear.

Each partner must make products and components based on the specifications received from the manufacturer. Suppliers generally provide both standard materials and products made exclusively for the company, and whose design are done collaboratively.

Many phases of the production process are outsourced, usually, the ones that result in a bottleneck for the process, such as cutting, sewing, and grooving. The resort to outsourcing is mainly present in cases where the demand has high volumes.

The relationship with external partners usually is of a long-term collaborative type. In order to support these relationships, many companies integrate their management software with that of outsourcers in order to monitor the entire production process, even when a specific phase is outsourced. In this way, footwear factories can guarantee their customers a high standard of quality with the same high flexibility.

It is usual for companies to encounter difficulties in the search and selection of suppliers, both of materials and "know-how." Thi difficulty is especially true when the time frame for the business opportunity is narrow.

Knowledge

Fashion shoe industry innovation is predominantly customer-driven, and especially in recent years, companies have begun to work with ever smaller production batches by offering their customers growing footwear customization, especially for the aesthetic features of the footwear industry. In order to compete in this global market, footwear companies are compelled to deliver innovative and fashionable products with an increasing added value rate. Consumer needs, however, are rapidly evolving especially in terms of novelty, style and comfort requirements.

Structural customization in the footwear sector is a long-term aspiration. However, the introduction of structural personalization and customization affects the entire production process, as well as the structure of the footwear, including the components and the materials that make it.

Recently, an evolution in product customization has been observed for shoe factories. Companies are seeking the ability to cooperate closely with its suppliers and external partners, as well as with their designers and modelers, by designing modular footwear that can meet the required flexibility, bringing companies a competitive advantage on the market.

According to analysis carried out, the supply chain managers in the footwear sector face two most significant challenges. The first is external and is related to the need to collect knowledge of the market and its trends in order to design the new products accordingly. The second challenge concerns to the gathering of competencies and knowledge that supports the structural customization of the product in a short period.

ICT

The manufacturing process of companies belonging to the fashion footwear sector is increasingly supported by technological tools that can ensure the manufacturing of footwear more efficient and effective, bringing a higher competitive advantage to the companies. The design environment resort widely in footwear specific CAD/CAM tools that uses for the construction of virtual prototypes in 2D and 3D along the production chain.

From the network point of view, most companies organize the design so that each component provider also participates in the design of the component model with the use of different design tools.

The requirement to integrate the various CAD components that need to be "assembled" in a single model makes it necessary to improve the interoperability of these tools used in the network. Such CAM tools are also of crucial importance in linking the design phase to the process planning as they can configure and setup machines (i.e., laser cutting and leather markers) in order to guarantee the production of footwear planned for production.

Nevertheless, the potential for technological innovations that could be introduced in the industry are so many, and most companies are moving only the first steps in this still largely unexplored world.

Many phases of the production process still are handicraft processes, characterized by traditional and manual approaches, and many efforts still need to be pursued for the structuring of footwear companies with a higher degree of automation and control in real time of the production process.

At the same time, the footwear sector presents significant gaps the proliferation of ICT tools, with particular emphasis on production planning tools in a collaborative environment and the distributed design and process planning of new products in networked environments.

All of the companies presently implement an efficient/lean supply chain management strategy for standard products by following a make-to-stock relationship with the customers. In the case of customized products, there has been an incipient appearance of agile/responsive and hybrid practices, depending on the importance of the customer.

Sustainability

From an environmental sustainability point of view, fashion footwear companies do not show particular attention to specific and innovative practices, especially when referring to medium to small sized companies. Although pollution control can be said to be complying with the terms of respecting the limits imposed by local laws, a sound pollution prevention strategy is usually not implemented.

The outlook is slightly different when considering larger companies for which environmental attention becomes a true marketing factor to ensure added value to the final customer. The ongoing business development demonstrated that the corporate responsibility does not start and end with each own core business but extends upstream through the whole supply chain from the raw materials manufacturer up to downstream, the end user. With this in mind, larger companies are becoming more and more examples to be copied for SMEs in how they address the sustainability issues.

4.4.2. Supply Chain Infrastructure

The case analysis supported the identification of the different actors and their relationships. Figure 38 presents the graphical supply network of the Fashion Footwear sector. This graphical representation allows the analyst to capture the diversity of actors and the complexity in the chain relationships. Colored ellipses represent both product providers and service providers. It is important to emphasize the existence of heterogeneous actors with different roles in the network. These actors include different types of suppliers (suppliers of raw materials, technologies, and components), but also a diversity of product and service network agents (providers to the rest of the chain).

The service network agents can provide services to both manufacturing companies and upstream or downstream companies. For example, logistic services may be the same as those used by the assembly companies and the supply companies. As far as the distribution side is concerned, it can be noticed that the manufacturing companies resort to both distributors and retailers directly, in some cases also have owned shops.

Of crucial importance is the role of modelers, designers, and stylists which provide the design services (orange ellipses). These designers and modelers are not always an integral part of the manufacturer/assembler company. The competences of these designers present a competitive advantage that is recognized and incentivized by the management boards of companies. Their role goes beyond the simple design of footwear, but also, they are involved in very advanced stages of the production process in order to ensure the correct implementation of the product concept.

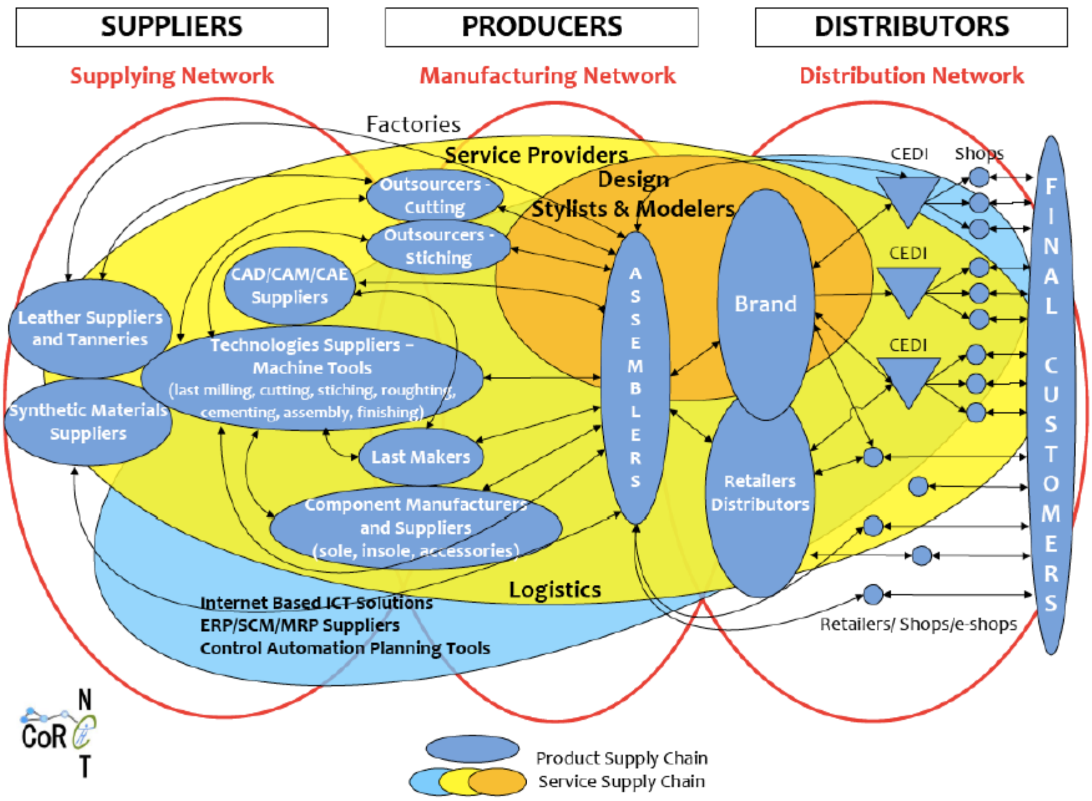


Figure 38 - Fashion Footwear Supply Chain

4.4.3. "As-Is" Business Processes

Using the information gathered from the as-is analysis it was possible to identify the following main processes:

- Product Concept
- Product Design
- Service Suppliers
- Process Planning
- Order Management including (online) product configuration
- Production Planning
- Production
- Replenishment Management
- Outsourcing Management
- Delivery

These main processes are interrelated according to Figure 39.

One of the significant outcomes from the business requirements as-is analysis was the need from the companies to differentiate their products from those of competitors by offering individualized products. This effort is in line with the concept of mass customization presented by Stanley Davis in the book Future Perfect (Davis 1996). The author has presented the concept of Mass Customisation as the customization and personalization of products and services for individual customers at a mass production price.

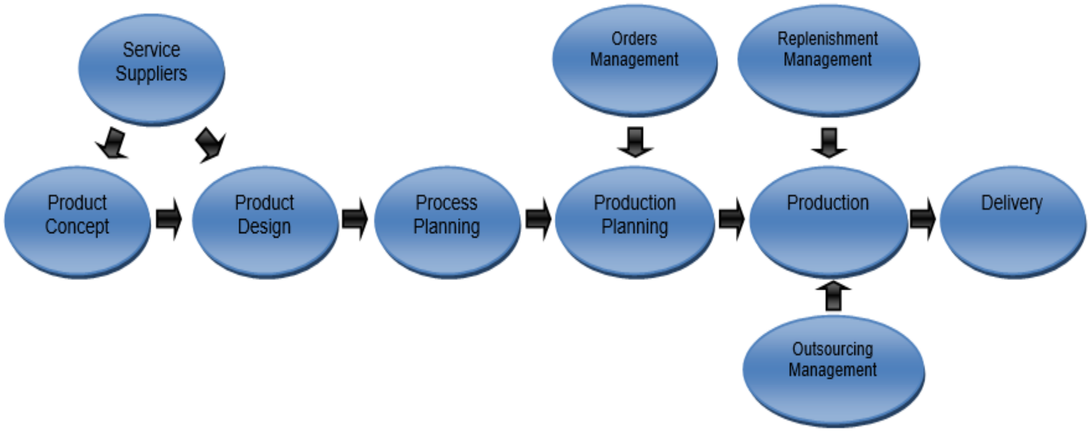


Figure 39 “As-is” analysis main processes interrelation diagram

In reality, the “as-is” analysis has shown that the competitive situation of companies in the footwear sector is characterized by a solid orientation towards product individualization, especially in the case of the customer segment groups.

The new reality of the markets has shown an increase in the customer power, which has driven companies to differentiate their products from those of competitors by providing personalized solutions.

In the past, customization and low cost were mutually exclusive. Since the industrial revolution, the mass production provided low cost at the expense of uniformity. On the other hand, customization was expensive since it was the result of expensive designers and valuable craftsman. Its expensiveness generally made it forbidden to the general consumer.

Today, the technology plays an essential role in enabling the adoption of the new business model approaches as the current as-is analysis has shown, at all levels in the companies. This technological emergence allow the modification of all relevant processes to become customer orientated with materialization of new interactive ICT technologies, that allows customers to interact with a company and specify their unique requirements which are then manufactured by automated systems.

Another pressing issue addressed and identified by the current as-is analysis is the explicit need for the track and trace of the product and process monitoring in the network. Since in many cases, companies are limited to evaluating the sustainability of their business operations and are unable to extend this assessment to their suppliers and customers, this is a pressing constraint.

The appearance of an integrated approach allows the visibility of supply chain in terms of quality and sustainability and also supports the managers in better determining their true environmental costs throughout the entire supply chain especially in the footwear industry.

4.4.4. "To-Be" Business Processes

During the second part of the case study interviews, the focus was on the "to-be" situation (future business scenarios). These scenarios were analyzed by brainstorming techniques and using as starting point the data collected during the first phase as well as literature related inputs.

The characterization of the relevant business processes present in the Fashion Footwear industry was possible through scenarios description collected using different approaches. These scenarios directly linked the major stakeholders' activities related to the footwear companies supply chain.

Through a scenario description approach, it was possible to perform an efficient and effective business process characterization during the elicitation phase.

This analysis had a particular focus on the supply chain constellation of each partner, regarding all involved actors in their specific design, development, production and distribution processes.

The result of this "to-be" business process analysis is a company-specific supply chain topology, describing the different types of business partners and their respective activities, the material flow all along the supply chain, and information and knowledge flow between all involved partners in the form of information objects and message types exchanged.

Figure 40 presents the high-level graphical representation of the "to-be" business process model using the BPMN notation language (Annex C presents the detailed business processes diagram).

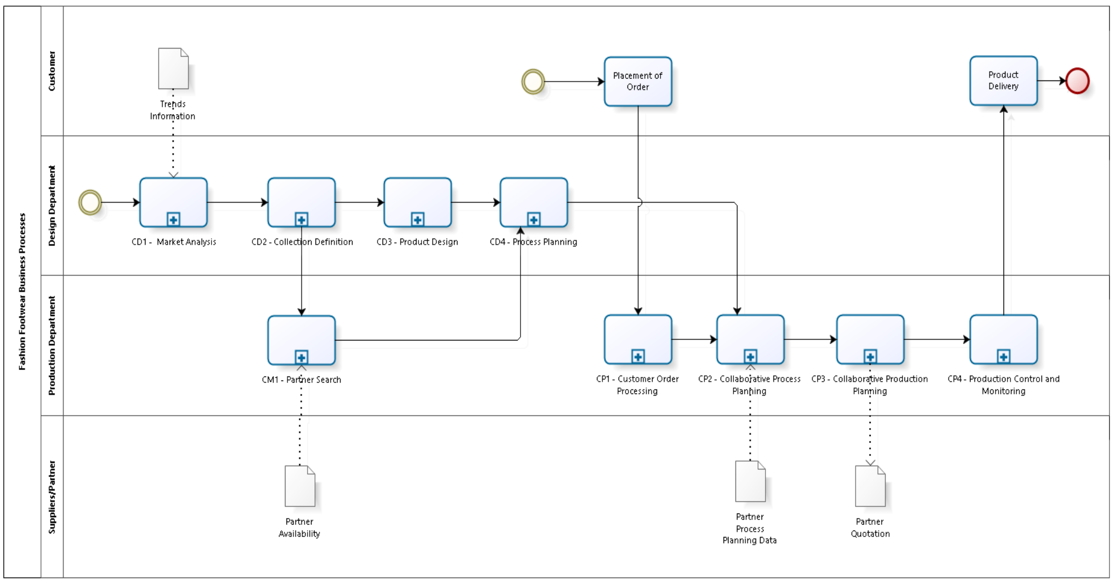


Figure 40 - High level "to-be" business process diagram

The processes identified, and previously outlined within the macro-process, are briefly described in Table 29.

Table 29 - Fashion Footwear Business Processes Description

ID	Processes	Description
CD1	**Market Analysis**	By identifying and managing consumer trends and needs, market segments are selected to focus on. These needs and preferences will be managed to be implemented within new products to be developed.
CD2	**Definition of Collection**	Define new product collections targeting the customer segments previously selected on CD1. Redesigning the process of improving collaboration by involving different types of actors (both internal and external), with different roles and competencies, can lead to the definition of collections that meet the needs of identified consumers.
CD3	**Specific Product Design and Modelling**	This process is carried out by designers and modelers who develop product concepts in line with the CD2-defined collection. It includes the selection of materials and components, but above all the identification of the variants and the configuration space (customization) of each product during the collection definition phase.
CD4	**Collaborative Process Planning**	Preliminary process planning is closely related to product engineering and defines how it will be produced. The process also creates a distinct base (BOM) of each model, defining the cycle and production time. The process is particularly important because it allowed the production of all product modules, both standard and customized so that when orders arrive, production can be more efficient. At this stage, the partners (suppliers and outsiders) who are identified with the CM1 process are also activated, defining with them a maximum schedule of each phase and the related costs.
CM1	**Partner Search**	The process involves the identification and selection of partners to be participating in the various production phases: suppliers, outsourcing and service providers.
CP1	**Customer Order Processing**	This process supports the automatic pre-processing of each custom order, which is verified, confirmed, and partially disassembled in administrative and production activities. This order management process needs to be perfectly coordinated with the CD4 where the production process is defined for the models and with the CP2 where the production plan is defined for the specific order.
CP2	**Product Specific Collaborative Process Planning**	Depending on the specific customer order (considering model, variables and configuration space chosen), the production process is characterized by creating the optimal sequence for the desired product. The resulting output consists of the planning process identified for different production orders.
CP3	**Collaborative Production Planning**	The production planning process envisages a series of collaborative iterations between the partners involved in the production. The manufacturer can interact with its partners in order to negotiate and define the best possible scheduling.

CP4	**Production Control and Monitoring**	The process responsible for the execution of the production orders. The production orders are monitored, and their KPIs in terms of quality and efficiency measured and controlled during each production phase. The output includes any reports and errors that occurred while processing the orders.

From the collaboration processes, it is possible to identify which are the main actors and their interactions that support the collaboration mechanisms between the different stakeholders of the supply chain network.

For the footwear industry, it was identified as the following critical information interexchange:

- Market trends report;
- Collection data;
- Materials solution;
- Outsourcing data;
- Customization data;
- Production and control data.

In sum, to support the future supply chain operation is necessary to define and implement new services and functional activities to support a new level of collaborative interactions among the supply chain stakeholders.

The present research project envisions such collaborative mechanisms through the conception and design of a framework which support the required services, methods and tools for innovative management of collaborative supply networks based on distributed planning.

For example, the management of the production partners, which is one crucial field, requires, e.g. interoperable and flexible production planning, formalization of external production orders or control of suppliers external to the production steps.

4.5. Results Analysis

By starting the case study analysis from the "As-Is" perspective, it was possible to formalize the main business processes in the Fashion Footwear industry. From this starting point, thanks to the comparison with the reference literature and the best practices identified in the different companies, both the literature and the multiple-case study, it was possible to characterize and describe the critical business processes of the supply chain in detail aiming to make them more efficient in the perspective of the whole supply chain.

On the other hand, the “To-Be” business processes descriptions resulted from the analysis carried out previously in the multiple case study. This second phase of the analysis, aimed towards identifying for the decision-makers how they can: better understand the market, design innovative products, plan production in networked environments, re-engineer the entire manufacturing activities and underline designing processes in order to foster better efficiency, increased innovation and productive responsiveness for the entire supply chain.

The analysis provided the following conclusions:

Knowledge

The knowledge representing the behavior and preferences of the customers should be obtained from the companies' transactional systems including retailers and sales departments databases, but also consumers' communities and social networks such as Facebook, Pinterest, Twitter, etc. The need for market knowledge means the need for data sharing agreements between retailers, manufacturers, and designers but also the involvement of consumers through specific online communities of consumer groups.

Manufacturers and especially stylists and designers need to fully comprehend market trends in advance and identify specific consumer groups in order to design and develop the appropriated products and accessories for these market niches and not address the market as a whole.

Collaborative Product Design

Facing an increasingly competitive scenario, Footwear companies, need to collaborate in order to supply differentiated products with shorter time-to-market responses and competitive prices and quality levels. Footwear companies are overcoming the present limitations by establishing dynamic and non-hierarchical collaborative networks (CN). These collaborative networks allow Footwear companies, especially the SMEs, to achieve the critical mass required to offer unique solutions to the customers complex requirements arising in the nowadays market business opportunities.

The present and future demand for complex and innovative products in shorter periods require the support of tools that effectively allow the use of distributed resources and the management of the derived knowledge and information. These collaborative tools need to consider the constraints and the requirements from the different product development cycles in the early development phases and fully support the concept of design-for-manufacturability.

Collaborative Planning

A significant obstacle for networked organizations delivers the appropriated products and services surfaces from the complexity of planning the individual tasks of the different operational processes. Networked planning decisions include order releasing for procured material; lot-sizing; production planning and scheduling; manufacturing execution control; and detailed definition of distribution flows, routes and transport loads. Numerous occurrences of these activities are performed in different locations along each node of the supply chain. This scenario means that each planning system must be aligned with the remaining systems in the network in order to deliver feasible plans.

During the business requirements case analysis conducted with the industrial companies, it became clear that there is a need for an overall vision and management of planning in the supply network for the footwear industries. This concern seeks three main objectives:

- Accurate analysis and plan development (collaboratively with partners) of operations required to manufacture and distribute a given product;
- Ensure the feasibility of a shared plan;
- The ability to react to unexpected events.

The business process analysis resulted in the diagram present in Figure 41.

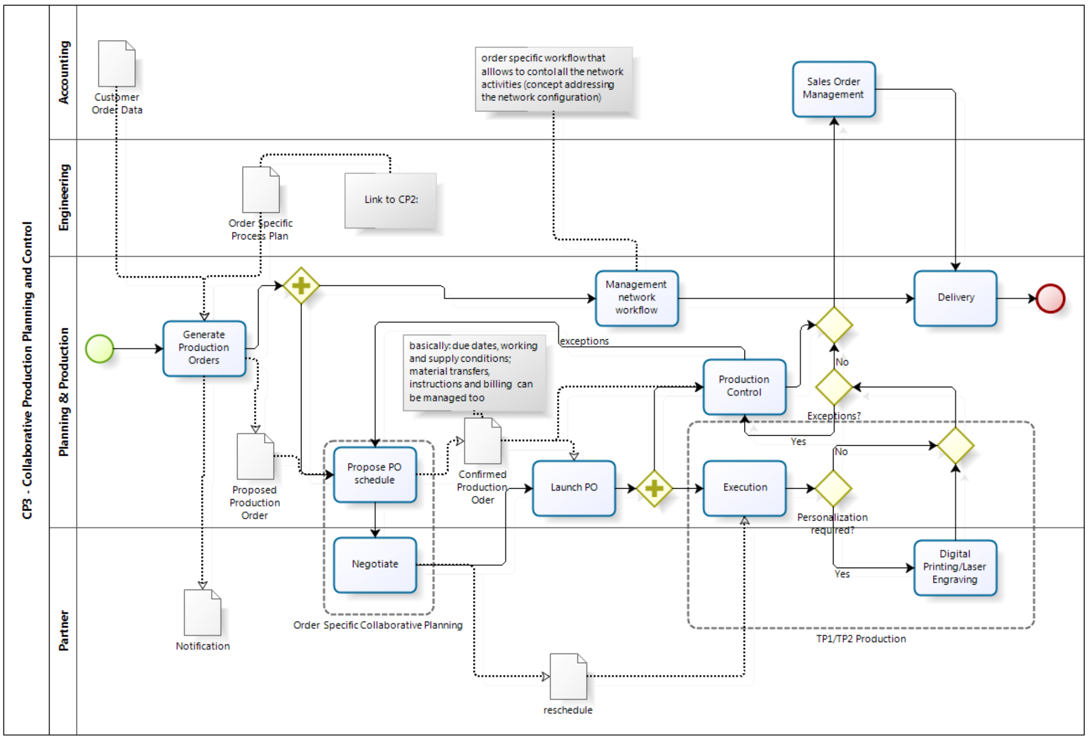


Figure 41 - Collaborative Production Planning Business Process Model

4.6. Summary and Conclusions

Starting from the competitive challenges that companies are facing, this chapter tries to identify the supply chain management strategies and best practices that company managers have implemented to attend the differentiated forms of market demand (*Research Question 1*).

In order to identify the primary supply chain management strategies tailored for responsiveness and efficient use of knowledge on customized manufacturing environments namely customer-focused supply chains followed a twofold approach.

First, a literature review on supply chain research, made it possible to distinguish a set of known networked business processes strategies and operational practices that were useful in the preparation of a subsequent multiple case study analysis.

Secondly, it was performed a cross-case sectorial qualitative analysis to investigate "how" and "why" networked companies interact with their supply chains. This sectorial multiple case analysis focused on two perspectives. The first perspective concentrated in an “as-is” description of the current business processes, supply chain strategies, and operational practices. The second perspective focused on the “to-be” analysis of the business processes required for the qualification and selection of potential partners, the network formation, operation, and the necessary ICT tools and functionalities to support customer-focused supply chains.

For the multiple case study, a research protocol was designed to assist the guidance of the interviews and the brainstorming sessions. The protocol considered four dimensions of analysis (Knowledge, ICT, Organizational and Sustainability) for the present and future scenarios.

Subsequently, the “To-Be” analysis identified nine business processes required to support the customer-focused supply chains. The collaborative business processes were: market analysis, the definition of collection, specific product design and modeling, collaborative process planning, partner search, customer order processing, product-specific collaborative process planning, collaborative production planning, and production control and monitoring.

From the description and analysis of these nine collaborative business processes, it was possible to identify which present processes, practices, and tools need to be transformed or created in order to support future supply chains address the marketplace demand for innovative, fashionable and sustainable products.

This analysis demonstrated that especially there is a lack of support methods and tools in three areas. The first area is related to market knowledge. Manufacturers need to capture and anticipate market trends in order to design and develop suitable products. This need opens a field of research in the areas of data mining and business intelligence.

The second area addresses the need for collaborative design tools in distributed environments. Particularly in collaborative networks and especially in the case of complex products, the objective to achieve a reduced time to market response in presents itself as a critical challenge. This challenge is a natural result of the distributed design environment and the dispersion of competencies among the various network partners. A related difficulty is a lack of supporting tools that capture and reuse the knowledge acquired during the experimentation and design of new products in distributed environments.

The third area arises from the fact that it is a challenge when facing the need to link and coordinate the manufacturing operations between independent companies belonging to the same supply chain. Present IT solutions are based on centralized approaches were a leading company assumes the role of dictating the plan to the other partners. However, a centralized approach might not be the best method to guarantee global coordination between independent companies in complex supply chains. Alternatively, a decentralized approach without coordination mechanisms between the partners might lead to non-optimal solutions, because it will only reflect local solutions. Therefore, the need for practical and functional IT solutions for collaborative production planning and control in decentralized supply chains.

The following chapter, departing from the present analysis results, presents a new framework aimed to support companies in defining and forming customer-focused supply chains for attending the demand of innovative, fashionable and sustainable products with short life-cycles, small batch production sizes, and high configurability and parameterization.

Chapter Five

SET-BASED CUSTOMER-FOCUSED FRAMEWORK

This chapter addresses the multidisciplinary complexity of customer-focused supply chains creation for innovative and fashionable goods, in particular, by tackling the main collaborative business processes tailored for responsiveness and efficient use of knowledge on customized manufacturing environments through a lean set-based framework proposal.

This innovative supply chain lean-based framework is intended to cope with the challenges posed by the omnipresent consumers demand of products with manufacturing of low volume, high variability and increasingly reduced time-to-market expectations. This framework proposal is based on a review of literature from various academic perspectives and extensive empirical data collected across a variety of industry sectors including a multiple case study of the fashion footwear industry sector. Network characteristics and different patterns of networking activities are identified for each type of supply network, namely in relation to their focus, performance, and sustainability.

5.1. Framework Conceptual Vision

As the previous chapters have shown, a more significant number of today's companies are asked to supply small series of innovative and fashionable goods of high quality, affordable price and eco-compatible in short time and with high service levels and create a particular type of supply chain. Indeed, the conventional functional style of organization design is under transformation by most enterprises in the world today due to factors such as the convergence of Internet as a communication medium, the globalization of markets and the emancipation of consumers with increasing demanding of high-customized, fashionable and/or innovative products.

This trend identified in the last decade in highly dynamic sectors such as clothing and footwear industries is forcing enterprises and enterprise supply chains to a new holistic view of how a company should operate and cooperate in order to address the new evolving and volatile markets. The underlying idea behind this trend in supply chain management is the need to incorporate customer focused behavior. This behavior empowers companies to respond quickly to sudden changes in supply or demand; to adapt and evolve accommodating technological advances and consumer trends; and to align the interests all network stakeholders, maximizing the networks' performance (Lee 2004).

These characteristics: agility, adaptability, and alignment emphasize the dynamism and focus involved and depict the concept of dynamic customer-focused supply chains (Wadhwa, Saxena, and Chan 2008) (Gattorna 2010) (Persson 2011) (Shamsuzzoha et al. 2013).

The overarching concept behind customer-focused supply chain is linked to the ability of production networks to operate and stay side by side with customers and consumers as they evolve and accomplish this with a diminishing "ramp up" time.

This chapter, taking into consideration the above assumptions, presents a new framework for customer focused supply chains intended to support enterprise managers in order to design, develop, produce and distribute the production of small series of high-customized complex products, and related components in a collaborative networking environment.

In the classical view, a supply chain is seen as a complex network of suppliers, manufacturers, and distributors delivering goods to end consumers. In this crude view, the problem of creating and managing a supply chain is a problem which can be mathematically modeled in more or less detail and where the minimization of the cost is the primary objective.

The reality has shown that today's supply chain management is a more complex and dynamic problem than expected. Textbooks examples demonstrate it. Take the example of Toyota's strategy, which leverages the efficient/lean supply chain management approach as a competitive advantage and vital contributor to excel its profitability. Alternatively, the example of Spanish company Zara, its agile/responsive strategy of fast fashion relies on its capability of designing more than 13.000 new styles every year with a design to store response time that can be as short as 15 days. Or the case of Apple, which can implement an efficient/lean make to stock approach and simultaneously develop high responsiveness supply chains at launching new products.

All of these cases have implemented an adequate operative strategy as a mean to reach the ultimate objective, to attend customer demand. Customers make purchasing decisions based on the benefits or the value they derive from the product or service relative to its price.

For example, Zara's core business distinguishes itself from competitors by providing timely fashion for the masses. In the case of Toyota, they provide high quality, reliable and low-cost products. On the other hand, Apple by investing in technology innovation can provide early adopters customers with high price and branded products.

According to Van Mieghem (2008) a company to execute its competitive strategy, must define a *financial strategy* specifying how capital will be raised and invested; a *marketing and sales strategy* specifying how market will be segmented and how the product will be positioned, priced, and promoted; and an *operations strategy* specifying three views, the processes, the resources, and competencies. The resource view focuses on the assets (tangible and intangible) used in operation. The processes view highlights the operation's activities. Moreover, the third view characterizes the competencies and knowledge required for the execution of the operations, i.e., what it can and cannot be done at the present stage of expertise.

Starting from Van Meighan' operations strategy work, this research work developed a vision of a framework supported in the same three vectors (processes, resources, and competencies) and aligned with the previously studied four environmental dimensions (organizational, knowledge, ICT and sustainability). Figure 42 presents de conceptual vision for the framework proposal.

The supply chain strategy present in this conceptual view aims to establish a profitable and sustainable position against the competitors by addressing the customers value proposition by delivering innovative and added-value products and services.

The three elements present in the operations strategies vision (processes, resources, and competencies), instantiated in the four dimensions (organizational, knowledge, ICT and sustainability) enable the execution of the business strategy in how to best deliver the value proposition for the customers.

In order to coordinate and perform their activities, supply chain networks need a wide variety of resources. These resources can be divided into two groups: tangible such as equipment, human resources, manufacturing plants; and intangible, for example, technology know-how, relationships with suppliers or partners, intellectual property.

The decisions associated to resources are related to the sizing (how much resource is required); the timing (when to use or adjust the use of the resource); the type (kind of resource required); and the location (where it should be placed).

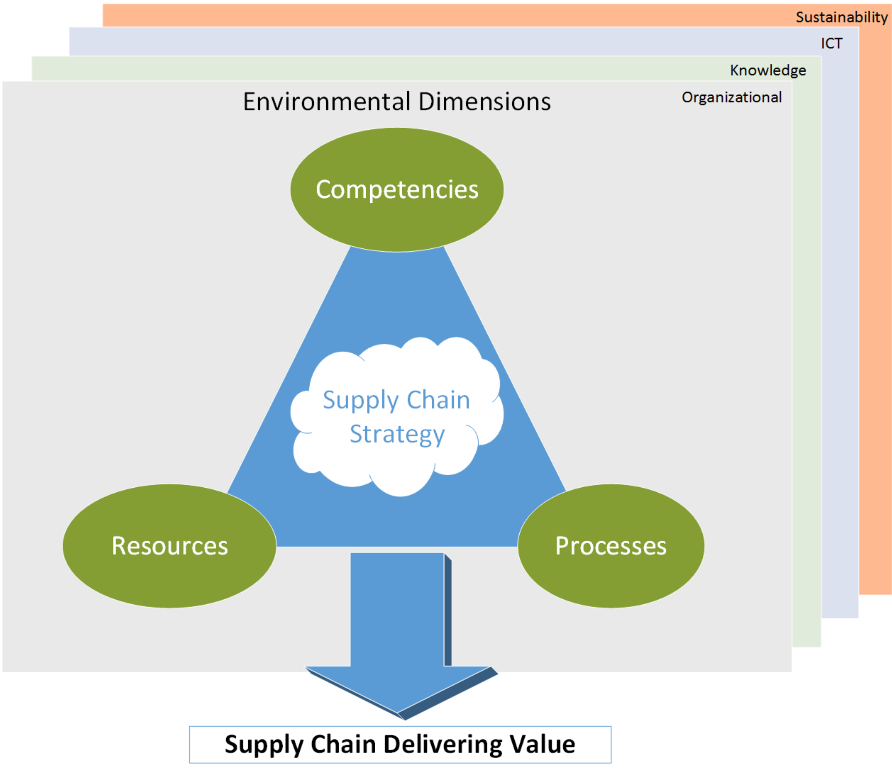


Figure 42 - Conceptual Vision for the Framework

On the other hand, in supply chain management, the process view explains how resources execute their activities and add-value. Explain how the business is conducted by detailing the relationships between activities and the actors who perform them. The business process view of the supply chain should be horizontal (discriminating the full set of inter-functional relationships among internal parties) and must be customer focused.

The decisions linked to the processes are related to the supply (when to outsource or to produce internally); the technology (which technologies are required); the demand (how to attend the demand); and the innovations (how and when to innovate).

The competences view of the supply chain management strategy characterizes the ability the organization has to align together the resources and the required processes to determine the set of outputs, products, and services provided to the customers. As Van Mieghem (2008) argued: "where competencies reside changes over time, they start in resources, gradually migrate to processes and eventually reside in values."

The competencies are related with the supply chain flexibility (how to address changes in products and volumes); quality (what is the quality level intended); time (what is the response time); and cost (how costly is the operation).

The present framework proposal, departing from this conceptual view, aims to enable companies to self-organize their networked resources, to design their business operations properly and provide the necessary competencies to tackle the target customers demand of innovative, fashionable and sustainable products.

5.1.1. Collaborative Networks Issues

In today's competitive environment, markets are becoming more dynamic, and customer focused, customers are increasingly demanding more variety, better quality, and service, with fast and reliable delivery. Combined with this reality, technological developments are happening at an incredible speed, resulting in innovative products and radical transformation of manufacturing processes. These changes have shifted how networked organizations conduct their businesses, and manufacturing operations (Ojha 2008, Vanteddu 2008, Fantazy, Kumar, and Kumar 2009).

During the 1990s, companies realize the need for looking beyond the borders of their firm to their suppliers and their customers to improve market value. This movement changed the company's focus from internal management of business and manufacturing processes to managing across the supply network (Chase, Aquilano, and Jacobs 2004).

Christopher and Peck (2012) commented that one of the most profound changes in the recent years was the recognition even from the most significant business organizations, such as corporations, that they have only relatively few competencies in which they can be said to have a real differentiation. This recognition has resulted in a focus upon core business and a trend to seek the other competencies from other partners. The growth of partnerships has placed increasing emphasis on managing relations between partners in the organizational network.

Nowadays competition within the innovative and fashionable goods sectors is among global networks, and one of the critical issues are on how to set and implement innovative managerial models and methods to support collaborative practices, especially among SMEs, which represents the majority of companies in Europe (Camarinha-Matos, Boucher, and Afsarmanesh 2010) (Dyer and Singh 1998).

The most recent research in the field of supply networks addressed different forms of business organizations that participate in value creation. They are distinguished for example, by the value chain orientation (horizontal, vertical, lateral), life span (long-term vs. short-term), the degree of virtualization or hierarchical structure (hierarchical vs. non-hierarchical networks) (Grefen et al. 2009).

Recent years have shown unprecedented growth in a large variety of collaborative networks and customer communities, mainly due to the advances in ICT technologies, namely the internet support and social networking. Customers are coming together in online communities, where they publish and share their products and services experiences, assessing the manufactures, vendors and service providers effectiveness (Romero and Molina 2011).

Increasingly, consumers are participating both in the front-end period with contributions to the idea generation and conceptualization, and the back-end period with involvement in the design and testing phases of new product development by enhancing the innovation process and thus co-creating value (Nambisan 2002, Frow et al. 2015).

Simultaneously, due to the business increasing emphasis on technological innovation and the improvements in ICT technologies, a growing number of designers and network stakeholders use knowledge management tools and integrated systems to support innovation in collaborative design (Romero, Molina, and Camarinha-Matos 2011, Leavy 2012).

The recent research shows that collaborative design of networks is a knowledge-based path, requiring not only experts with knowledge and experience on different multidisciplinary areas but also requiring the integration and coordination of the design and development phases of different actors. The challenge of providing reliable and fully operational collaborative design and knowledge management systems increasingly relies on integrated platforms but also practices and methods that promote and sustain the development co-ordinately (Chu and Tian; 2010).

Chase, Aquilano, and Jacobs (2004) summarized this new paradigm by pointing out that recent trends such as outsourcing and mass customization are forcing companies to find flexible ways to meet customer demand. This flexibility is forcing companies migrating from traditional forms of functional commitment with focal companies in a network to scenarios where the focus is in the optimization of core activities for each partner to maximize the speed of response to changes in customer expectations.

In accordance, customer focused supply chains are characterized by the speed at which the system can adjust its output within the available range of the external flexibility types: product, mix, volume, and delivery, in response to an external stimulus such as a customer order or a business opportunity.

Research in collaborative networks of innovative and fashionable products have identified six critical phases with the aim of organizations address a specific market opportunity until the final dispatch to the customer (see Figure 43). Research also has shown that each one of these phases presents significant challenges regarding their complexity, time constraints and resources consumption (Bastos et al. 2012).

Figure 43 – Market-oriented manufacturing network phases

In the face of these critical impact phases, the prevailing market environment asks for flexible and reactive organizational structures which rapidly adjust to new manufacturing challenges and revise the business requirements accordingly.

These new market characteristics are compelling manufacturing networks to embody shorter life-time existences and take advantage of new infrastructure technologies to support distributed decision making, information sharing and knowledge management (Zangiacomi et al. 2013).

In the face of these critical impact phases, the current market asks for flexible organizational structures, which quickly adapt to new business requirements and manufacturing challenges. These new demands are forcing business networks to have shorter lifetime existence and take advantage of new infrastructure technologies to support distributed decision making, information sharing, and knowledge management.

The paradigm of customer-focused value chains is emerging in literature as a collaborative approach answering to consumer's needs and expectations (de Treville, Shapiro, and Hameri 2004) (Lyons et al. 2012) (Hines 2014) (Bastos, Azevedo, and Ávila 2015).

This customer focus implies different approaches to market-based not only on traditional sales channels (as shops or retailers) but more and more on an Internet-mediated contact with consumers both for product co-design, product customization, and final sale.

Research provides evidence to practitioners that by increasing the firms' responsiveness, organizations can increase their capability to compete based on low price, high delivery dependability, high product innovation, and low time to market (Thatte 2007).

A direct outcome of firms and by extension collaborative networks responsiveness is the reduction of the time to market. The time to market is the lead time between a technical or market opportunity arising and satisfying the customer need with full-rate production or quality product. The time to market lead time is critical since all competitors eventually get access to new technical ideas and new market information at about the same time. The winner is the one which is consistently faster than the competition. As Li et al. state: "time to market is the ability of an organization to introduce new products faster than major competitors"(Li et al. 2006). There is a widespread acceptance of time to market as a source of competitive advantage (Holweg 2005a).

According to Ward (Ward and Sobek II 2014) the time to market can be decomposed into the sum of four periods: reaction time (period between the opportunity appearing and company decision to invest); exploration time (period which the development team explores alternative implementations); lock-in time (during which a final solution is detailed); and fix-up time (during which the company tries to deal with the problems aroused during the implementation of the solution) (see Figure 44).

Figure 44 - Time to Market periods (based in (Ward and Sobek II 2014)

Inversely to the concept of 'time to market' there is the concept of 'market miss.' In reality, markets are missed because the development team fails to understand the customer, or because it is not innovative enough and therefore missing the customer needs on time or generating cost and quality problems.

Customarily, the development value stream inside companies or collaborative networks, produces operational value streams. Operational value streams run from suppliers to manufacturers, into product features, and finally out to customers. Manufacturing units are the primary customers of the development value streams. Actuality, the development process only has value if it enables manufacturing operations to deliver better products to the final customer.

In conventional development processes, the approach followed is the "waterfall" or "V" methodology. In this approach, starting from the concept specification, first, it is designed the system, freezing the interfaces between the subsystems, then designed the subsystems, following a top-down method.

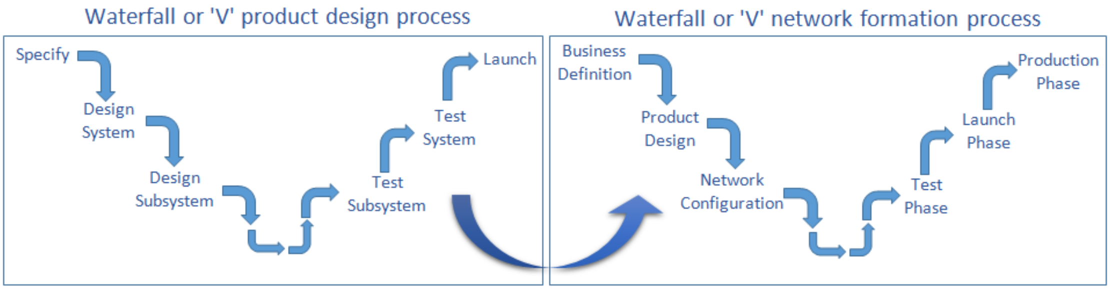


Figure 45 - Waterfall or traditional approach

A similar "waterfall" approach is followed in the development process of collaborative networks. The initial definition of the business opportunity leads to the collaborative design of the product and subsequently to the process planning and the network configuration definition. Figure 45 presents the similarities between the product design process and the collaborative network formation process using the conventional "waterfall" approach.

Although abundantly used this "waterfall" approach, it presents for several researchers significant drawbacks. The followed top-down approach means that critical systems decisions about module or subsystems interfaces are made by early insufficient data about what is possible. The resulting designs on products, processes or network configuration are usually distorted and inconsistent, leading to usually low levels of reutilization of parts, manufacturing systems or reconfiguration of networks (Ward et al. 1995) (Liker et al. 1996) (Inoue et al. 2013).

In reality, it is common for companies to select suppliers through a bid process usually based on cost. This approach requires the release of product specifications or drawings. In many cases, this practice blocks the opportunity to identify what suppliers and partners can do, and therefore which system design, module specification or network configuration makes sense. Also, since the selection of network members is based in many cases by quotation, which is in many cases, is more a "promise" than a commitment.

A significant consequence of the typical product development cycle based on the "waterfall" approach in supply networks is the occurrence of problems that are discovered late or in advanced phases of the design process. These problems force design loopbacks and network reconfiguration (see Figure 46) which often consumes 50 to 75% of engineering resources (Kennedy and Harmon 2008).

In summary, the traditional "waterfall" approach presents several drawbacks which include: inefficient use of resources due to the late problems discovery and the necessary loopbacks; the discard of knowledge due to the early product concept definition and design specifications which limits the network partners involvement and knowledge generation; and finally generates poor and unreliable solutions in terms of products and network configurations since it is based before the customer interests are understood.

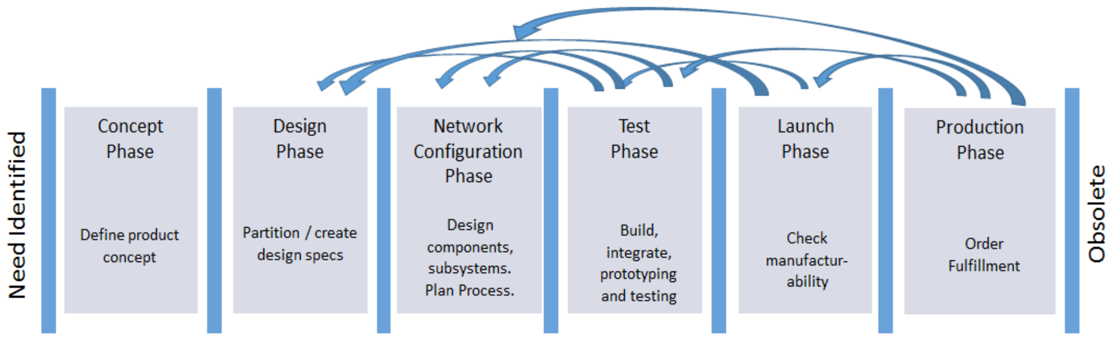


Figure 46 - Loopbacks in "waterfall" collaborative networks formation

5.2. The Set-Based approach in supply networks

In addition to Van Mieghem operational strategy proposal, a second conceptual contribution for the design of a framework proposal was the lean inspired Set-Based Concurrent Engineering (SBCE) design support tool.

The concept of set based thinking was initially conceived by researchers from MIT and the University of Michigan in the late ’90s. Starting from Toyota’s product development success practices, Allen Ward and his team developed what they later called SBCE (Set-Based Concurrent Engineering).

From the field analysis conducted by D. Sobek simultaneously at Toyota Motor Company and Chrysler, it was evident that Toyota's product development practices surpass its competitors. Toyota is an industry leader in product development lead time and new product launches while using fewer resources than its competitors. It has also shown consistent market share growth and profit per vehicle. Toyota never performs unplanned design loopbacks; had a systematic knowledge sharing across projects; achieve 80% engineering development value-added productivity (4 times the typical automobile manufacturer); and never misses its milestones dates (Sobek 1997, Kennedy and Ward 2003).

Sobek summarized the definition of SBCE as engineers and product designers “reasoning, developing, and communicating about sets of solutions in parallel and relatively independent” (Sobek, Ward, and Liker 1999).

In fact, according to the lean approach from Toyota, the most critical input to production is knowledge. Starting from this paradigm, Toyota does not think of product development as a series of steps that result in a product, but rather as an overall environment that produces a stream of products.

In order to acquire this 'knowledge breeding environment,' the set-based approach followed by Toyota seeks continuously to obtain usable knowledge from the following sources:

- **Integration knowledge** - includes learning about customers, suppliers, partners, designers, the manufacturing network, the market;
- **Innovation knowledge** - the conception of new ideas and solutions;

- **Feasibility knowledge -** allows comprehension of the manufacturing constraints and capabilities enabling better decisions among the possible solutions.

The effort to collect this knowledge starts immediately at the customer requirements early definition. Traditionally, using the "waterfall" approach, the customer requirements are frozen early, followed by a more detailed design and interface specification of the process. In contrast, in the set-based approach, Toyota builds a set of possibilities to satisfy their customer needs, and through a series of experimentation, combination and knowledge acquisition, they narrow the possibilities until arriving at a final solution (see Figure 47).

In order to the set-based development approach be successful, it relies on basic tools. As is usual in the lean philosophy, the tools should be simple and as possible rely on the visual sense. Understanding and documenting technical knowledge in the case of the set-based approach is achieved in the forms of trade-off curves, checklists and limit curves.

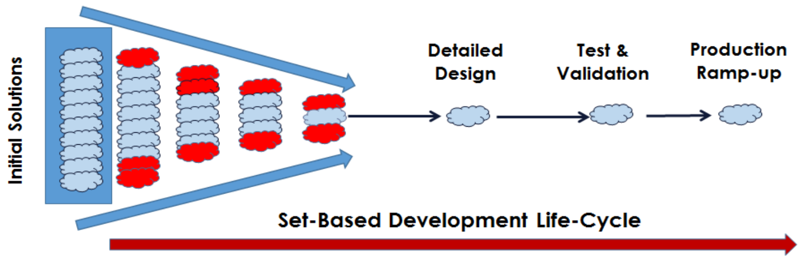


Figure 47 - Set-based development life-cycle

This form of representation naturally transforms tacit to explicit knowledge. Afterward the approach integrates the knowledge through causal mapping for problem-solving as depicted in Figure 48.

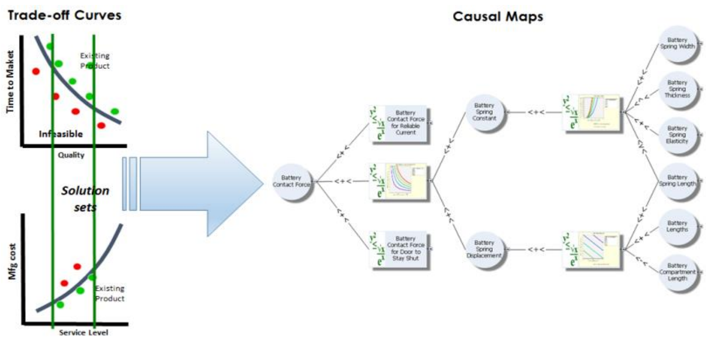


Figure 48 - Set-based development supporting tools

In summary, a set-based development approach enhances early and efficient learning so that enough information is attained before decision making. It requires collaborative learning and the involvement of many areas of expertise, but also the relevant stakeholders' commitment. Also, by allowing delayed decision-making, until enough knowledge is acquired, enables wise decisions and not guessing. It also supports collaborative, converging decision-making by assuring that decisions in one area will not impact decisions on other areas.

Collaborative networks due to their intrinsic characteristics have immensely to benefit from this comprehensive approach proposed by the set-based development theory. The following section details what are the main issues related to the collaborative network's environment.

5.3. Set-Based Framework Proposal

The set-based framework proposed, aims to support companies in defining and forming customer-focused supply chains for the demand of innovative, fashionable and sustainable products with short life-cycles, small batch production, and high configurability and parameterization. The framework is based on matching theoretical approaches from literature, namely the collaborative networks organizational paradigm and the lean approach of set-based design, but also, by matching practical requirements and constraints observed in the multiple case study of footwear sector and R&D industrial case projects namely on the TCFI (textile, clothing and footwear industry) sector.

The emerged needs from the analyzed business cases consider three different decision levels: strategic, tactical and operational. Figure 49 presents the overall conceptual view of this proposed framework mapping its decisional levels with the framework structural dimensions considered, namely organizational, knowledge, ICT and sustainability. All these levels are instantiated along with the dimensions and are embedded with the contributions from the collaborative networks paradigm and the lean set-based development system approach.

A critical element of the framework is related to the functional view of the value chain formation. Namely, the partner engagement and supply chain formation can occur in different phases of the network business scenarios:

- **Strategic level**: during the definition of the product portfolio when the manufacturer needs to define strategic partners which will support both the design and the manufacturing of the products.
- **Tactical level**: collaboratively participating in the detailed product design and the matching production process design.
- **Operational level**: once a customer order is collected it is necessary to choose among the partners those who will be activated for that specific order.

For all of these three levels of collaborative work, different criteria and partner search capabilities shall be used, in order to ensure a comprehensive knowledge-based networked development engineering process.

In the case of **the strategic level**, the partner selection should be based on criteria for the identification and selection of partners based on partner profiles which summarize the performance of the partner in the past regarding process and technology knowledge, product design skills, cooperation, and collaboration degree, sustainability commitment, etc.

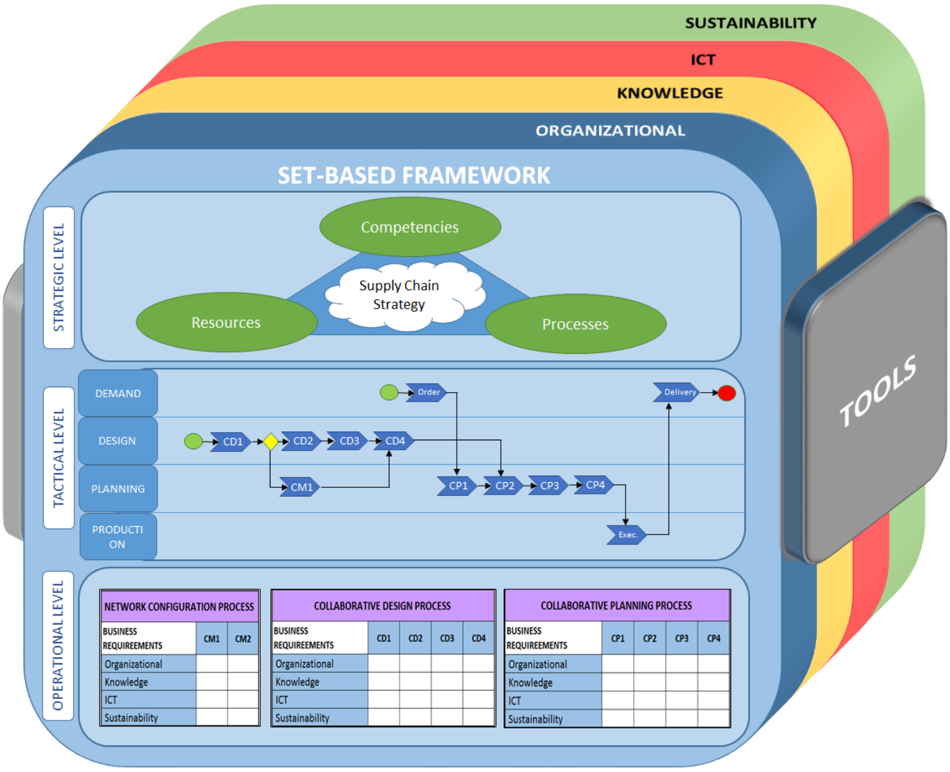


Figure 49 - Set-based framework conceptual view

Partner search and selection at a strategic level shall be useful to define formal framework agreements. With this kind of agreements, partners commit to reserving part of their production capacity available for the manufacturing of a particular product along the production period and participating in the early modular definition of products and respective interfaces.

The choice of partners is based not only on the type of product offered but also on the performance of the partner itself in terms of quality, time, price. In this context, other important indicators are flexibility and adaptability to requests coming from the supply chain managers, that is the ability to quickly reconfigure or set-up processes to support new products or the flexibility to adjust batches quantities.

Table 30 presents the set-based framework strategic focus regarding the resources, processes and competencies axis, matching with all of the four structural dimensions, organizational, knowledge, ICT and sustainability.

This strategic focus aims to go beyond old channel management based on a loose combination of business functions characteristic of a traditional supply chain management view, to a new approach based on integrative knowledge-intensive technologies and collaborative management models.

This new view intends to blur the boundaries that separate trading partners, transforming once isolated channel players into unified, "virtual" and "customer-focused" supply chain systems.

Table 30 - Framework strategic focus

		Organizational	Knowledge	ICT	Sustainability
RESOURCES	Type	- definition of the type of partners required for the collaborative network focused in scalable manufacturing and distribution functions	- knowledge-intensive partner search for the adequate members of the collaborative network	- identification of the IT support tools for the identification and formation of the network	- identification of the sustainability metrics and performance requirements to be assessed in the network
	Sizing	- outlining of resource capacity and type of resource per network partner	- how much resources (single task or multi-task) are committed to designing and experimenting with new products	- dimensioning of required ICT and leveraging the strengths of business partners	- definition of the optimum supply chain sizing configuration in terms of sustainability
	Timing	- definition of the availability of capacity per network partner and their timing for capacity adjustments	- knowledge integration of cross-channel correlative partners in order to create unique sources of value by synchronizing the resources, capabilities, and competencies of the entire network ecosystem	- enabling continuous alignment and operations synchronization of internal enterprise processes with the other complementary functions in supply chain partners	- analyzing and restructuring supply chain's organizational structure taking into account the sustainability focus by realigning resources, increasing end-to-end accountability, and leveraging specific leadership skills
	Location	- definition of partner's geographical locations and roles assignment	- identification and implementation of practices that support a supply chain model functional centered and strategic interoperability	- availability of a technical infrastructure that links computer systems and people integrating the processes in the different locations	- translate the sustainability metrics to measure results and process effectiveness across the different locations of the supply chain
PROCESSES	Supply	- collaborative decision making regarding the strategic sourcing processes by characterizing the interfaces and relationships with partners and suppliers	- foster knowledge integration by eliminating the barriers separating functions within or between a network organization business partners aiming to form a coordinated knowledge-intensive whole	- tool support for integrating supply processes by enabling physically remote pools of people, data, and processes to function together directed at the same performance goals	- broaden the responsibility of supply chain members in sustainable best practices by involving in the early stages of product development and product design all the stakeholders
	Technology	- implementing technological peer-to-peer networking in order to combine the capabilities, skills, and processes experience of each partner by integrating and directing their talents so they can work more efficiently and productively	- seek technological integration of processes by activating the creative thinking within and between organizations and then enabling them to work as a single knowledge-intensive virtual enterprise	- enable the opportunities offered by information technologies in modern organizations by pursuing client/server architectures and Internet web-based tools for processes communicating information horizontally in networks	- apply technological tools for best practices dissemination, emphasizing intra-organisational communication and enlarging the sphere of responsibility of supply chain managers

	Demand	- definition of interfaces and relationships with customers aiming an adaptive demand-driven supply chain supported in responsive processes	- create the mechanisms that sustain the market knowledge capture, assisting the products designers in understanding what constitutes the individual customer value proposition and improve knowledge of customer behavior that enables the delivery of customized products and service one customer at a time	- implement the tools that: enhance the experience of the individual customers, provide both technological and functional means of identifying, capturing, and retaining customers; and provide a unified view of the customer across the supply chain	- making customer aware of the long-term benefits of acquire eco-products and follow sustainable best practices into their products and services usage
	Innovation	- rapidly accelerating innovation life cycles through cyber-collaboration, enabling joint product innovation, networked designing of new products and operations management innovation and broader continuous improvement and learning throughout the network organization	- aiming at: product/process innovation; partnership management; Increasing core competencies and knowledge; and motivating workers with knowledge sharing skilling workers	´- implementing increasingly integrative technologies that connect all channel information, transactions, and decisions, whole channel systems will be able to continuously generate new sources of competitive advantage through innovation	- establish a culture of lifelong learning by this; innovation is fostered due to transferring know-how from one partner to another, passing sustainable best practices knowledge in driven fields of eco-processes and technologies
COMPETENCES	Flexibility	- aiming for supply chain flexibility by increasing the range of products and services offered, including the level of customization; expand the volume flexibility and robustness	- pursue knowledge sharing across supply chains companies by focusing on intense collaborative integration between partners and suppliers, with the goal of implementing mechanisms by which network partners can focus their unique competencies and knowledge on accelerating joint product development and manufacturing capabilities	- introduce ICT tools for operations excellence and fulfillment/ replenishment flexibility and promoting agility by endowing supply chains with nimbleness, simplicity, and speed to rapidly execute adjustments to demand and supply capabilities	- create a supply chain environmental management system (EMS) focused on implementing programs to monitor the principal environmental aspects affecting operations and implementing a design for environments (DfE) policies aiming for product development processes that allow flexibility
	Quality	- foster responsibility for the quality and integrity of processes across the supply chain network organization, pursuing the design-related dimensions such as performance and features, as well as process-related dimensions such as durability and reliability	- provide knowledge intensive initiatives aimed at monitoring and improving products and processes quality and reliability, and leverage final product quality by employing tools such as quality-by-design (QbD) and Six Sigma	- deploy total quality management (TQM) system integration across the supply chain by joining production systems from product engineering to shop floor manufacturing aiming for quality design, manufacture, and monitoring	- focusing on DfE procedures for developing a more sustainable supply chain, in particular by combining LCA techniques and by using the QFD multi-criteria matrices, an environmental supply chain compromise can be attained

	Time	- improve the organization's total response lead time by fostering responsiveness to customer requests as well by rapidly adjusting for changing environments	- foster knowledge gathering and usage to support strategic responsiveness and to capitalize on business opportunities by quickly adjusting business processes and channel network configurations to pursue new marketplaces, drive greater efficiencies and engaging emerging challenges	- with the application of web-based Internet tools in all of its various forms, enterprises were now poised to merge these inward-focused improvement tools with networking technologies capable of enabling unprecedented levels of productivity, market dominance, and customer responsiveness	- establish the objective to achieve environmental responsiveness in tandem with sound business management, by reducing the environmental impact of products beginning at the design stage as cross-functional product design teams work to have positive environmental results throughout the product's life cycle
	Cost	-effective cost management requires companies not only to design product/service offerings with focus toward continuous process improvement and cost reduction, but also to be able to reduce the time it takes from business opportunities to sales, and develop the capability to leverage knowledge from anywhere in the network to import needed competencies as well as reduce functional redundancies.	- sharing and creating knowledge by utilizing and integrating the competencies of network partners in the value proposition creation and/or value portfolio development, results in cost reduction and resources usage optimization	- effective supply chain integration requires systems that enable online collaboration networking and unified information access and low-cost technology tools to achieve the necessary level of collaboration intensity	- selection of low-impact materials, produce using minimum energy and materials, using eco-friendly energy production, reduce water usage and keep control of pollution sources are cost saving polities - using less energy is good for the environment, it is also good for business because it cuts companies' costs, and eventually avoids potential environmental liabilities

Concerning the framework **tactical level** in business processes definition of the supply chain, the collaboration is strengthened and widespread. Each partner makes drafts, simulate and conduct tests of solutions. The proponent of business opportunity expects that the network partners explore the trade-offs among different requirements, back decisions with test data and demonstrate designs by delivering fully functional prototypes early in the process. In some cases, partners are asked to execute several alternative prototypes and their trade-offs. While in traditional companies, a supplier for a particular component is picked at an early stage, using the set-based approach, network participants are asked to present alternatives solutions, demonstrate the feasibilities of the solutions, and develop sub-systems in parallel with the other supply chain companies' designers.

From the footwear industry supply chain multiple case study analysis, it was possible to identify nine business processes that compose the framework tactical level definition (cf. Table 31). These nine business processes have proven to be critical to the tactical implementation of a dynamic and customer-focused supply chain. Although the identification of these processes originally came from the footwear sector, however in a later analysis in the TCFI sector with different industrial cases, the results were very similar, which allowed a stronger validation.

Each one of the nine business processes is described next.

Table 31 - Tactical level business processes list

ID	Business Processes
CD1	**Market Analysis**
CD2	**Definition of Collection**
CD3	**Specific Product Design and Modelling**
CD4	**Collaborative Process Planning**
CM1	**Partner Search**
CP1	**Customer Order Processing**
CP2	**Product Specific Collaborative Process Planning**
CP3	**Collaborative Production Planning**
CP4	**Production Control and Monitoring**

Market Analysis

The current market reality shows that TCFI industry is strongly pulled by a highly unstable and rapidly changing demand, due to fashion-related and seasonal fluctuations, as well as emerging consumers' needs in terms of wellbeing, health, and sustainability.

More and more, firms need to pursue innovation strategies based on creativity, quality, and differentiation of products. In order to achieve this path of creativity, quality and innovation, companies and especially designers are increasingly dependent on knowledge. This knowledge enables companies to move toward the goal of understanding customers and using that understanding to make it easier for the company to provide products and services desired by customers.

For the business process definition of the market analysis it is necessary to define the means to obtain knowledge concerning the market and especially the customers. The knowledge must be extracted from a combination of structured and unstructured data describing different entities:

- Consumers (aesthetic, physical parameters, comfort and health requirements)
- Retailers (sales status and customer preferences)
- The interaction between designers and suppliers (sectorial requests and provisions).

The data representing the behavior and preferences of the customers obtained not only from transactional systems (e.g., orders) but possibly also from other sources where they express their opinions, including social networks (Facebook, Twitter, Pinterest etc.) and online communities of consumer target groups.

The market analysis business process is particularly useful for collaborative designers to obtain knowledge about:

- clustering, to identify subgroups of customers with homogeneous behavior (e.g., young urban, middle-class men and rich, middle-aged, highly educated women);
- association, to identify emerging trends (e.g., shirts with classic design typically also have single cuffs).

Figure 50 presents the Market Analysis business process diagram using BPMN.

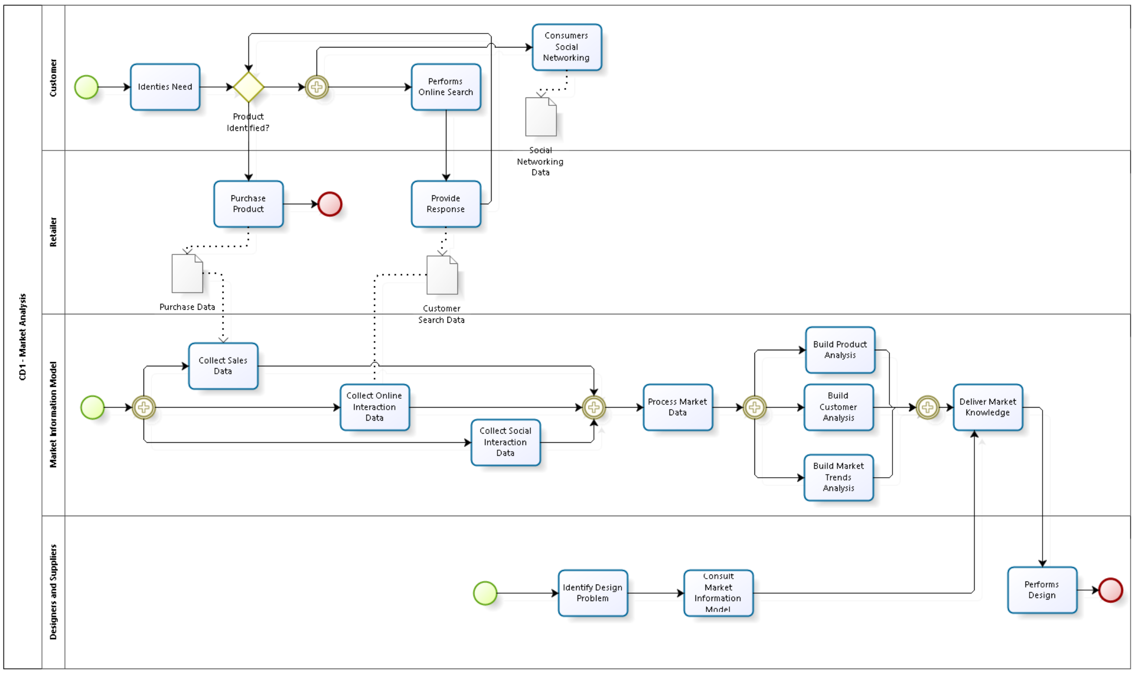


Figure 50 - Business Process for Market Analysis

These models can be used to improve production planning and supply chain management (e.g., anticipating trends in product consumptions and, consequently, in raw material needs), to design new products (e.g., anticipating what product features may be most successful in the near future) and sales and marketing (e.g., customizing catalogues and websites for different customer profiles).

Definition of Collection

A collection describes the set of products, to be designed, developed and launched to the market according to seasonality. Usually, in the case of the TCFI sector, there are two to four collections per year, and they are also linked to essential sector fairs and exhibitions.

A collection is composed of a set of coherent and complementary model types, each with a range of configuration options or variants. The collection plan defines (or at least proposes) also the business objectives, as well as promotional and marketing strategies and the distribution and retail goals, in order to enable and ensure the successful realization of the collection plan.

The collection plan is of strategic relevance for the company, and therefore the creation of a new collection of products, in particular for specific target groups, involves the company management. It implies to have a collaborative environment where different types of users (manufacturers and designers) with different roles (and IT skills) contribute to creating a collection of suitable configurable and customizable products for the target consumer groups.

In the case of fashion and innovative companies willing to enter into new niche markets, it is vital that collection for target groups is conceptualized within a clear business strategy. Figure 51 presents the business process diagram for the collection definition.

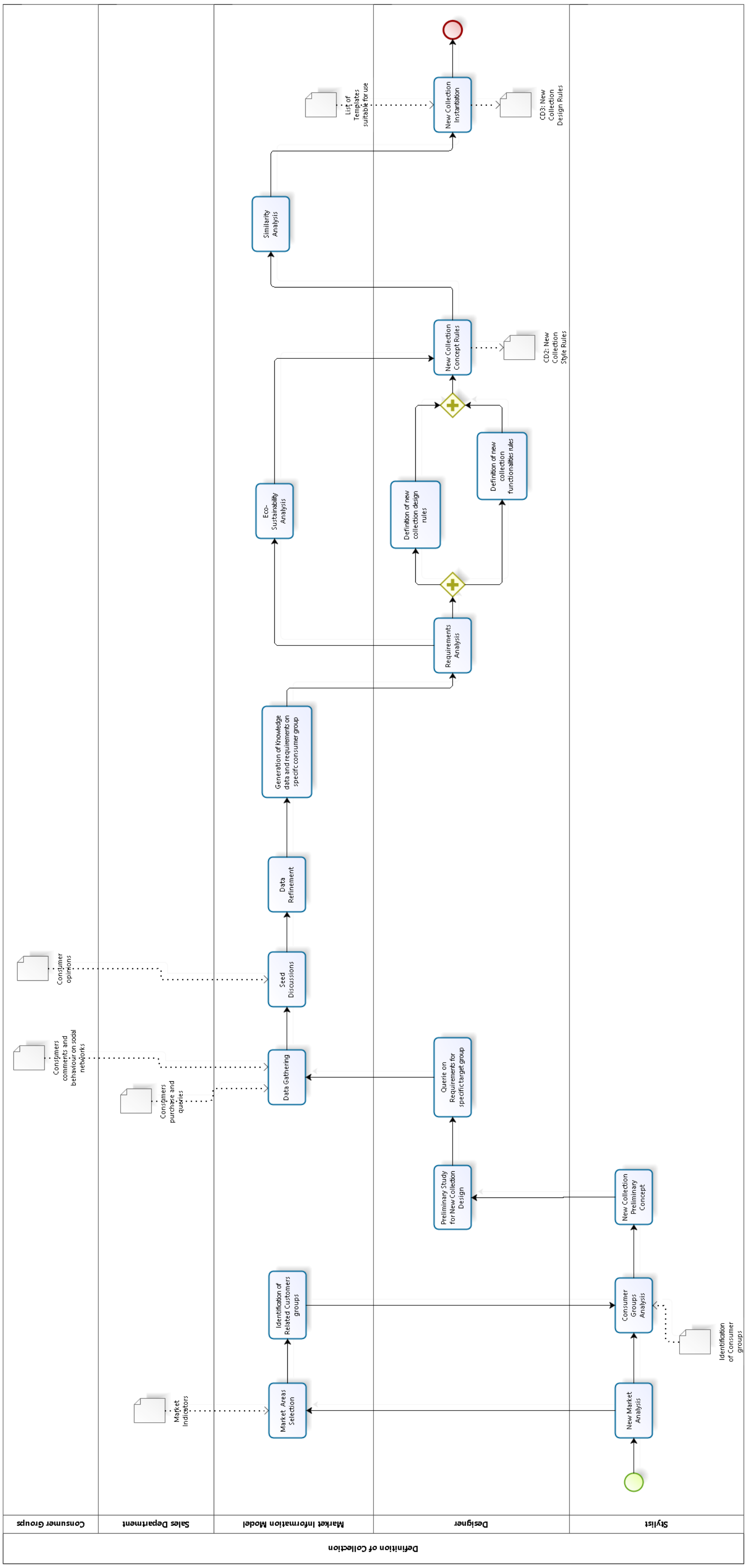


Figure 51 - Business Process Definition of Collection

Specific Product Design and Modelling

This business process is carried out by the designer teams (of products and suppliers of materials and components) and delivers the technical product specifications (CAD technical model of the product and Bill of the Material list). Because the product is designed collaboratively, the availability and the ability of the different partners to support a specific product concept is a critical factor. Figure 52 presents the business process diagram for the specific product design process.

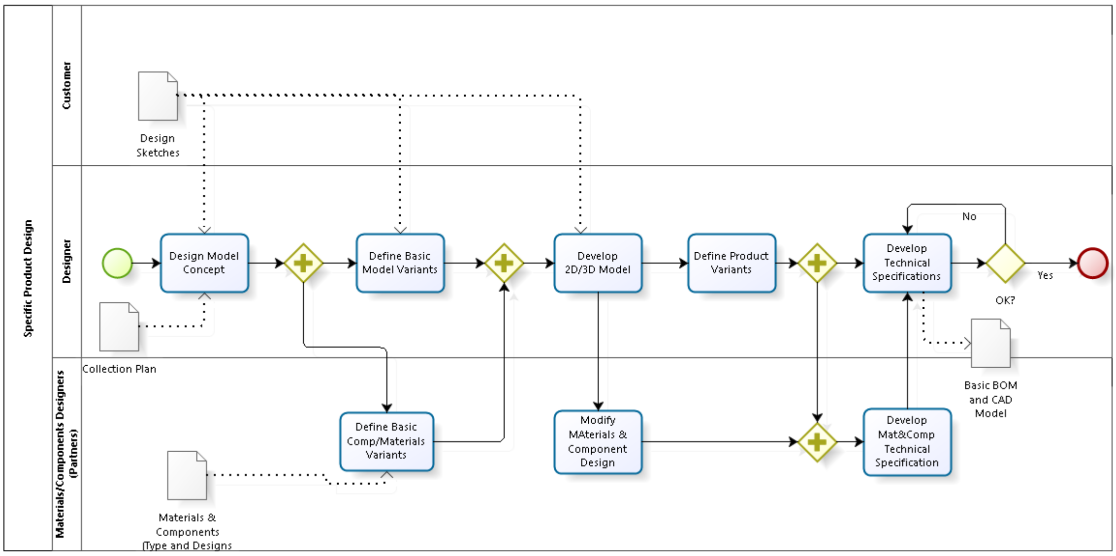


Figure 52 - Business Process Diagram for Specific Product Design

Collaborative Process Planning

Collaborative process planning is carried out in two phases: the first one performed by the product designers (in each partner). They are responsible for identifying the internal and external components in order to establish the generic production process. The second phase is performed by the production engineers and they are responsible for detailing the process plan identifying the resources, process operations sequence, durations, and line balancing.

Taking into account cost considerations and the partner selection this activity is responsible for selecting which specific supplier partners will participate in the process and in which process step they will be involved. For this reason, in this process, the availability and the ability of suppliers to support a specific production is a significant factor.

The cost considerations, resource capacities, and supplier specific data are crucial elements in the definition of the most efficient process plan for the new product supply chain. However, in case of fashionable and innovative small series production, there is also the need to consider the agility and responsiveness of the different suppliers. For all these reasons it is essential to involve suppliers in the process planning design phase of the supply chain. Their collaborative contribution is fundamental in order to the production engineers accomplish efficient, balanced and resilient solutions.

Figure 53 presents the business process diagram for the specific product design process.

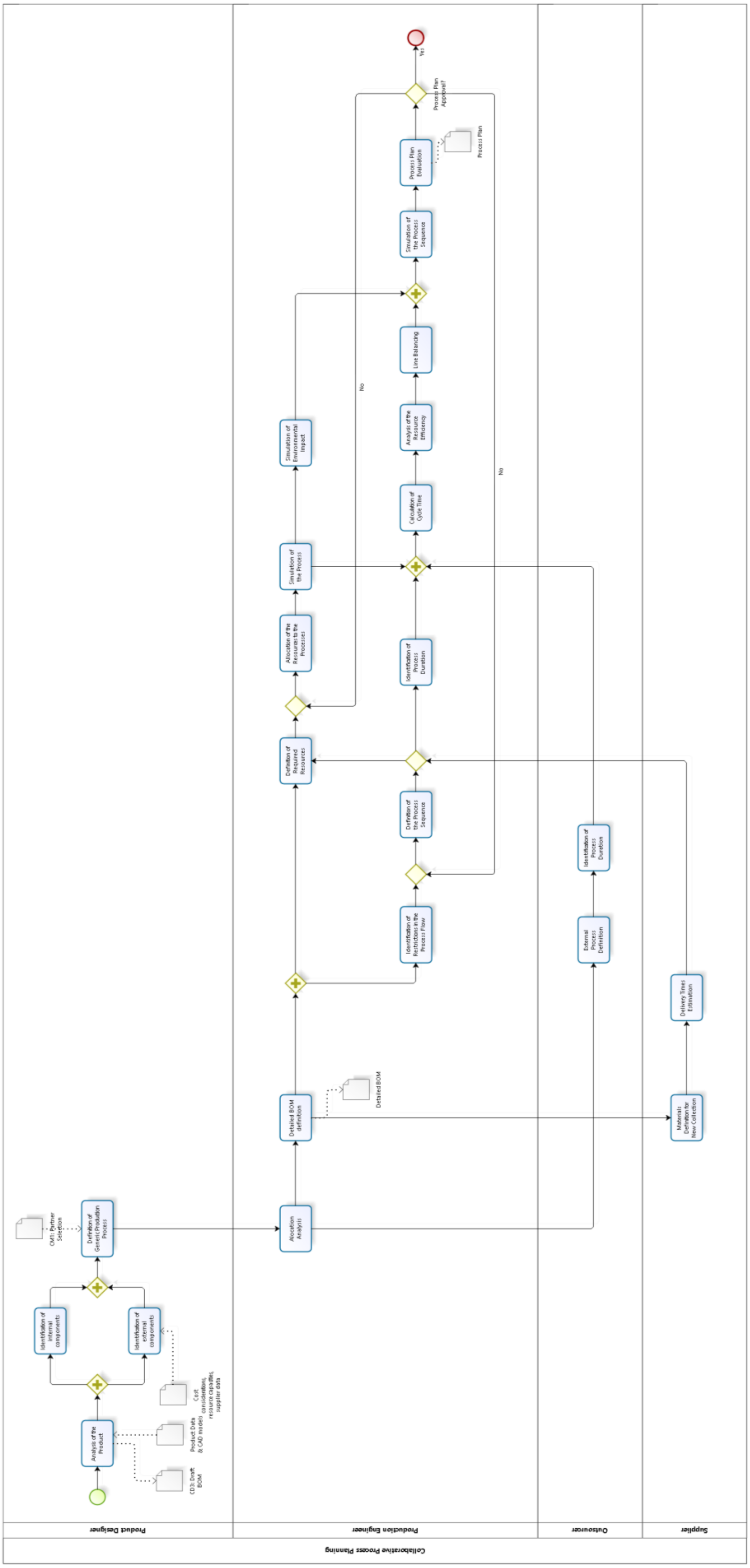


Figure 53 - Business Process Diagram for Collaborative Process Planning

Partner Selection

Identification and selection of Partners for outsourced operations; it may occur in different phases of the TCFI business scenarios and mostly at tactical level during definition of the product collection manufacturer needs to define partners. These partners will support both the design and the production of the collection itself. This occurs at the operational level once a customer order is received, and it is necessary to choose among the partners which ones will be activated for a specific order.

During the tactical identification of partners, it will be useful to define formal agreements. With this kind of agreements, partners commit to keeping part of their production capacity available for the manufacturer along with the product life-cycle.

Identification of partners should also be based on partners' qualification. In this process, the supply chain managers define for each partner category some minimal criteria which are necessary conditions to be a partner in this supply chain network. Sustainability criteria are also included in the tactical selection of partners. These criteria are based both on product quality and process monitoring.

The definition of partnerships means to define collaborative networks based on trust. For this reason potential partners should know that in this type of relationship they should be open to sharing information with the other partners. This is necessary because it is not only a pure buyer-seller relationship, but it is a more complex relationship which requires to share data not only on product quantity/quality but also on process and technology know-how.

Operational selection of partners for a specific customer order is done during the production stage of the product life-cycle and is performed among the partners already identified in the tactical selection. Selection is based mainly on capacity available for the lead time required by the customer, responsiveness, and costs. Partner selection is an essential and knowledge-intensive process and to support this selection, it is required a repository of potential partners' skills and knowledge.

Figure 54 presents de business process diagram of the partner selection.

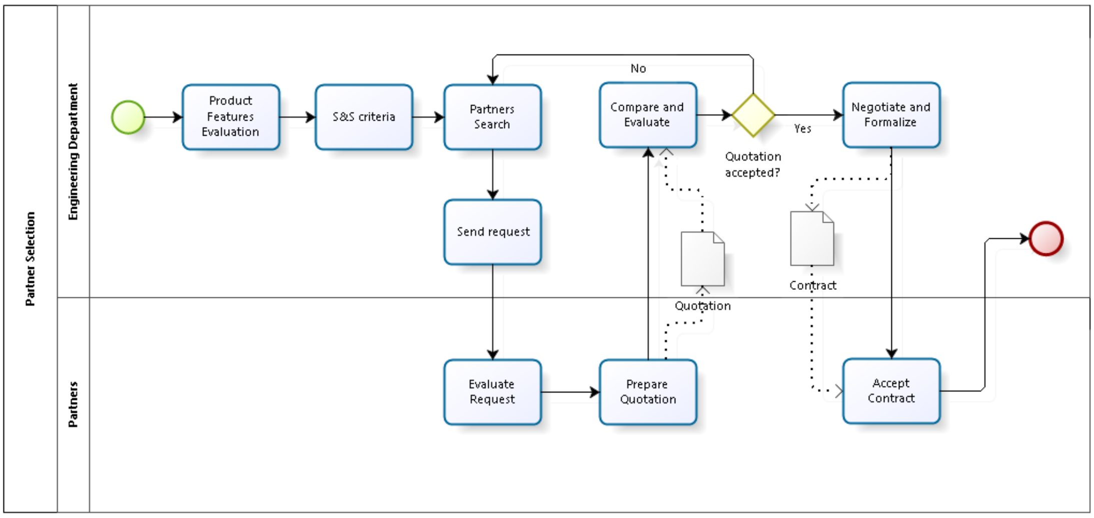


Figure 54 - Business Process Diagram for Partner Selection

Customer Order Processing

The customer order processing starts once the company receives customer order for a specified item (including configuration, customization features, delivery conditions as well as standard input as quantity, size, due date, etc.). Before generating the related Production Order, it is necessary to manage a workflow that includes a specific set of administrative and pre-production steps; workflows can be based on communications steps, exchange of documents, status monitoring, etc.

Figure 55 presents de business process diagram for the customer order processing.

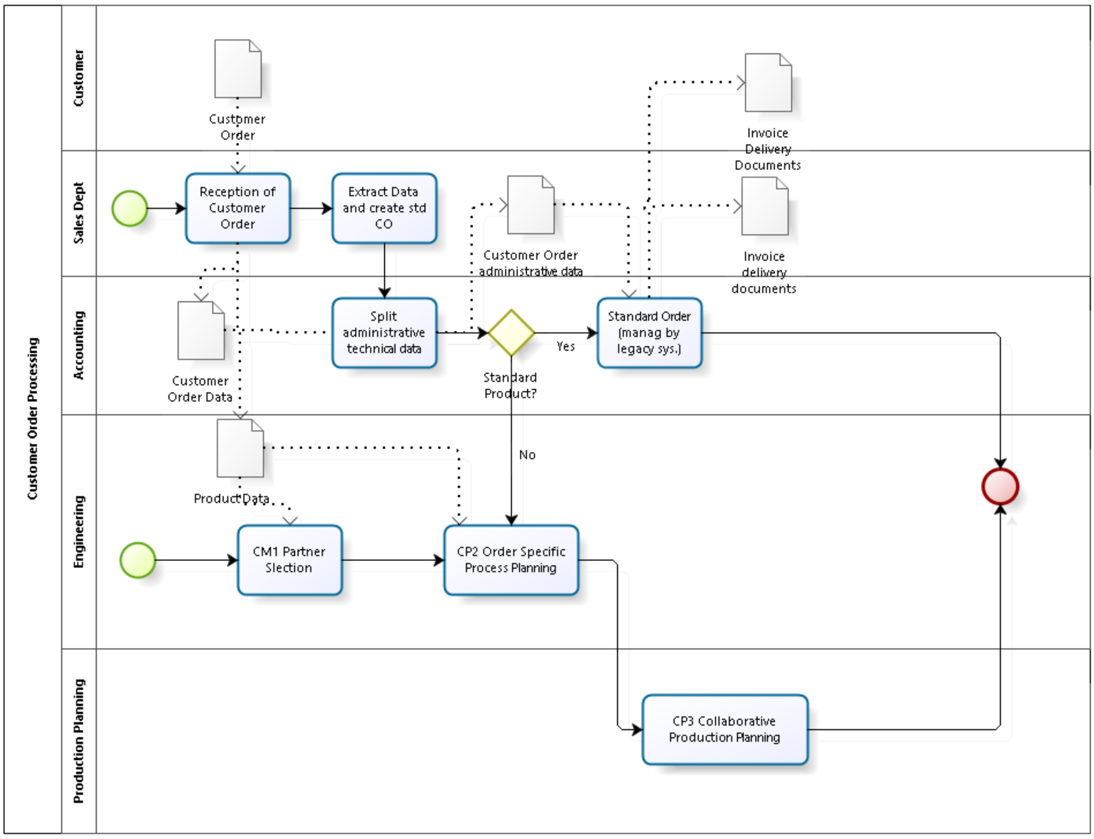


Figure 55 - Business Process diagram for Customer Order Processing

Before generating the production orders is necessary to take into consideration that different customer orders arrive at the same period and information on administrative issues (like customer name, payment, delivery) are split from the technical information on the product requested and sent to different departments.

Regarding the standard product customer order requests, the process follows the traditional legacy approach, using the previously define supply network and taking into consideration that in case of small series orders, production orders are the result of the aggregation of different customer orders.

In the case of a non-standard products customer order, it is necessary to perform a specific process planning with the collaborative involvement of selected partners using the partner search process. Subsequently, it is necessary to perform the collaborative planning process in order to achieve the networked manufacturing plan for that specific customer order.

Product Specific Collaborative Process Planning

Once the Customer Order for a specified item has been confirmed and managed at the administrative level, the related Production Orders can be generated. This process is based on fixed product and process data (i.e., inherited from the product model); other data are "customer order" specific (in general, no changes at Design Level are necessary while new Materials are allowed) and must be provided in order to allow internal and external manufacturing activities. This process also implies the final assignment of external activities to Partners. Figure 56 presents de business process diagram for the specific product process planning.

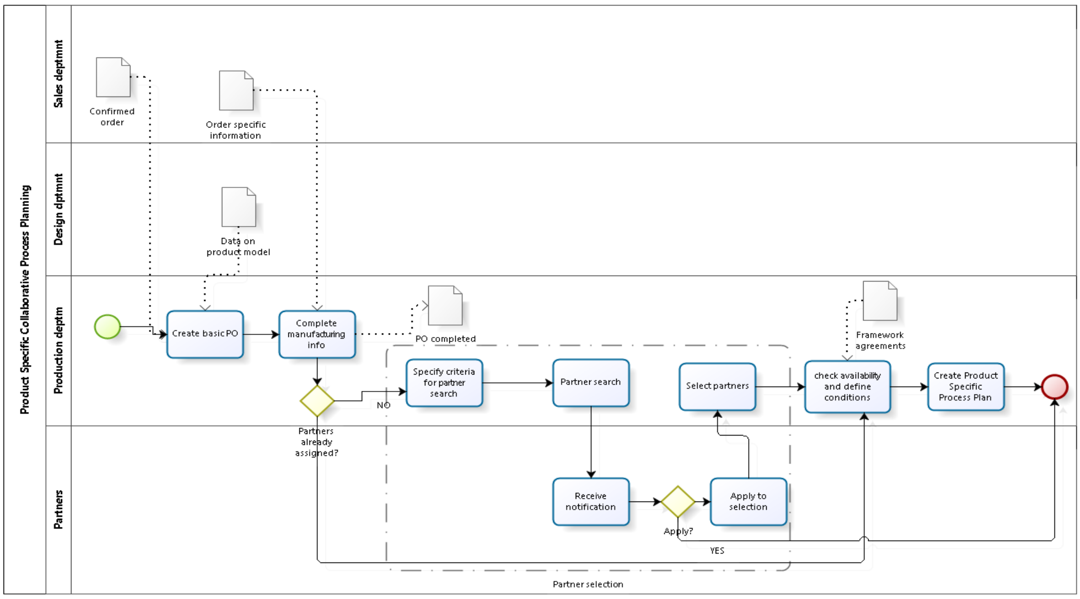


Figure 56 - Business Process Diagram for Product Specific Process Planning

By this additional process is the definition of the data necessary working cycles and BOM. One of the most relevant information added at this phase is related to the assignment of the external productive operations to the partner more fitting in terms of capability and skills. This external operations can happen at different levels according to specific conditions. In most cases partners, have been already identified and the operation assigned during the previous design process plan phase. In this case, it is necessary only to check for their availability to produce on time what is required in the PO according to the due date fixed with the customer.

For each specific outsourced phase, usually, the principal partner and some alternative options are defined. In this case, conditions for collaboration have been already discussed and also established during the Collaborative Process Planning and are usually detailed in the framework agreements that are signed at the beginning of the product life-cycle with the involved partners.

If partners have not been already chosen or if particular operations are implied by a specific personalization required in the customer order it may be necessary to start the partner search and selection process in order to find the best partner able to perform these operations. Collaboration with suppliers is a crucial point to define which phases of the manufacturing process need to be revised and changed for the customized order.

Collaborative Production Planning

Once the Production Orders related to a Customer Order have been processed (all data for product manufacturing have been provided) they need to be scheduled and launched for the actual production. Due dates and any other synchronization steps for the Production Orders assigned to external partners must be agreed and formalized (negotiation based throughout the entire supply chain network).

Collaborative planning means that partners accept to share their planning operations for achieving a coordinated plan. Usually, companies predominantly plan according to their own goals, but in cooperative relationships, they additionally need to provide means for the overall supply chain performance optimization.

Thus, collaborative planning includes aspects that enable partners to recognize how individual company plans should be adapted, according to which criteria the planning can be optimized, and which restrictions in the standard planning must be accepted. In short, collaborative planning describes how individuals can orient their plans towards each other to reach a joint optimization of the planning across company boundaries.

In the case of small series, demand forecasting is very difficult, and production is based on high flexibility not only of the manufacturing systems but also of collaborative schemes. Planning activities need to be held frequently according to the customer orders arriving. At this level, it is necessary to have a collaborative process tool supporting the Production Planning of external activities and workflow control for the whole customer/production orders.

The first tool could be part of the Production Planning process and tools and requires managing data related to partners, products and operations/resources. For these reasons, the integration with PDM and other Legacy Systems is required.

The requested knowledge related with the scheduling of orders usually tries to determine: which order at which machine in which sequence, in order to minimize costs and times (e.g., reduction of set-up times in case of sequence-dependent set-up procedures, or allocation of orders to machines according to capabilities and necessities). Also, the collaborative planning tries to assess the availability of partner resources and the possibility for quick adaptations which relies on partners' data.

Typical software solutions enabling the calculation of schedules use optimization algorithms or soft computing methods (genetic algorithms, fuzzy logic, constraint-based algorithms, etc.). Such methods, also including traditional elementary priority rules, typically provide schedules with some 80-95% of quality. However, knowledge for fine-tuning is required in order to managers find solutions for critical issues regarding distributed production planning between the participating organizations.

Knowledge is also needed for handling exceptions, e.g., in case of machine breakdown, or poor material quality, in particular from the partners, so that a quick re-schedule can be created and realized.

Figure 57 presents de business process diagram of collaborative production planning.

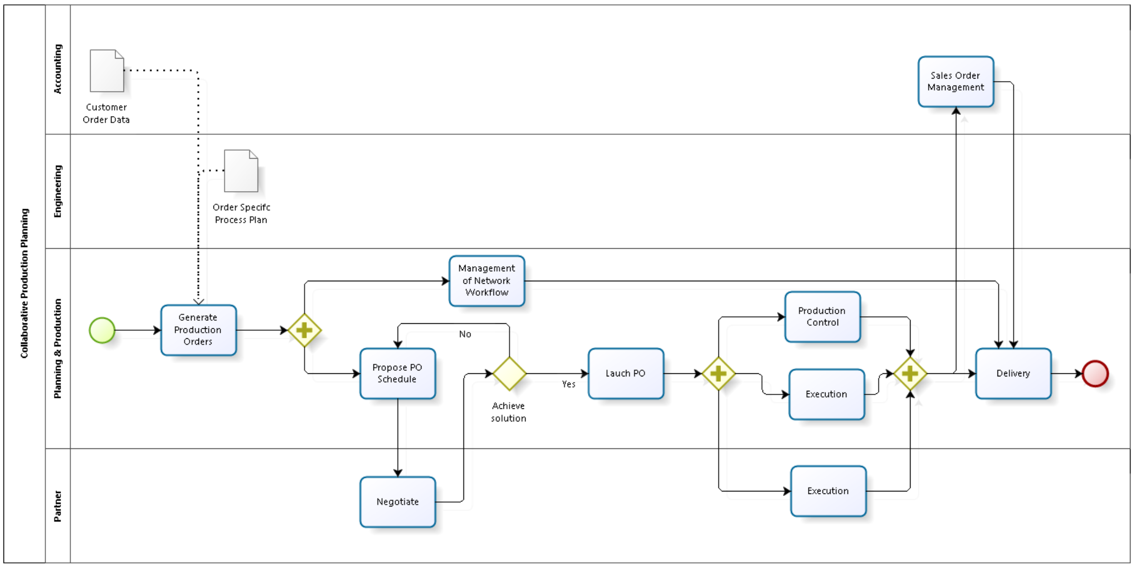


Figure 57 - Business Process Diagram for Collaborative Planning

Production Control and Monitoring

The production control and monitoring process are responsible for collecting from suppliers and outsourcers information about the sustainability of their manufacturing processes. From the manufacturer point of view the following aspects can be characterized:

- Monitoring for quality assurance of products and processes.
- Monitoring sustainability of suppliers (both from the production process point of view and the eco-compatibility of materials) and outsourcers activities.
- Monitoring sustainability of internal factors

Information on processes sustainability shall be collected periodically from suppliers and partners and shall be used as a parameter to evaluate their performance and to help to select the best partner for future supply chain networks.

Primarily, a set of proper KPIs referring to Eco and Quality aspects must be defined. This step is done by the production managers and can be based on inputs from customer groups targeted by the project and referred to their specific requirements and needs. Moreover, suppliers and partners can provide thresholds for process parameters used in the definition of KPIs and align them to reasonable targets. This process implies strategic collaboration with partners which should be available to share data concerning their processes within the network. This step is feasible only if stable relationships are established and a high level of trust has been consolidated.

Eco and quality monitoring run in parallel during the realization of each production order, collecting data and information useful to calculate the KPIs previously defined.

For what concerns quality check, a first step is performed when materials and components are purchased from suppliers. At this moment, specific tests (e.g. presence of toxic elements) are requested to suppliers or are executed to verify quality and eco characteristics of what delivered according to the quality policy of the network. The first set of information is derived and will be useful for product environment evaluation.

During the execution of the manufacturing operations for a specific PO, the production process is monitored by collecting data on the eco-compatibility of the process that will also be used for the LCA calculation. Similar monitoring is performed on the internal productive phases. A second quality check is done on the outsourced WIP when delivered and on the internal WIP in order to avoid defects.

Then a final quality check on the product is made. All these quality checks need to be planned within the network according to the availability of the quality control staff and according to the production plans. At this point, by data collected from suppliers and partners and of information on the quality of products, KPIs are calculated and are then compared with the targets established at the beginning.

Possible corrections are planned in the production process in order to be in line with targets foreseen or if targets are too optimistic, a revision of them has to be made, and more feasible objectives need to be defined. KPIs and other relevant information coming from this stage have to be correctly handled and stored in order to be made available to the network stakeholders previously identified.

Figure 58 presents the business process diagram of production control and monitoring.

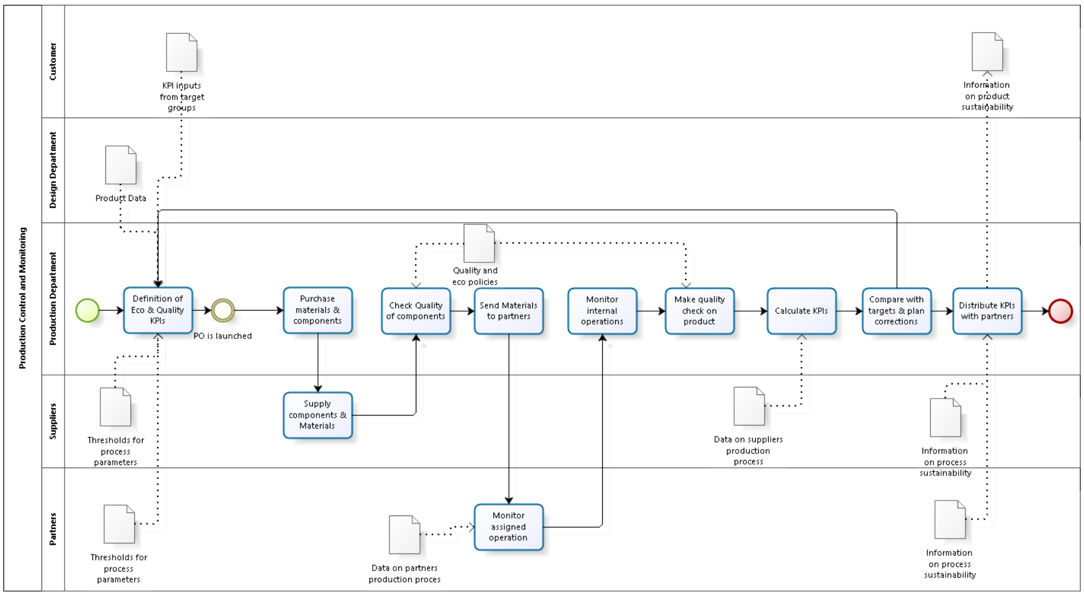


Figure 58 - Business Process Diagram of Production Control and Monitoring

Regarding the **operational level**, the framework fosters the practices and methods necessary for the implementation of the previously defined business process support in order to:

- Collect market knowledge regarding consumers' trends and expectations for innovative and fashionable products;
- Collaborative design of complex and innovative products in a network environment:
- Collaborative planning for dynamic and customer-focused supply chains.

The following sections detail how the framework set of web-based collaborative tools support the identified business processes.

5.3.1. Knowledge Management Tool

The current market reality shows that global SME companies are facing a highly unstable and rapidly changing demand, due to innovation challenges, fashion-related constraints, and seasonal fluctuations, as well as emerging consumers' needs in terms of satisfaction, health, and sustainability.

Another stressing factor relates to the profound restructuring of the distribution systems for mass consuming products. This transformation is shifting the influence of manufacturers, giving more bargaining power to distributors, putting pressure on prices. More and more, firms need to pursue innovation strategies based on creativity, quality, and differentiation of products.

In order to achieve this path of creativity, quality and innovation, companies and especially designers are increasingly dependent on knowledge. This knowledge enables companies to move toward the goal of understanding customers and using that understanding to make it easier for the company to provide products and services desired by customers.

The literature has established that three distinct yet highly complementary factors, market knowledge, cross-functional collaboration, and knowledge integration mechanisms enhances the performance in product innovation processes. Market knowledge is directly linked with the firm's knowledge about its customers, partners, suppliers, retailers and competitors. On the other hand, cross-functional collaboration represents the degree of cooperation and the extent of interaction between designers, suppliers, the research and development (R&D), and other functional units in the product innovation process. The third factor complementary to the previous is the knowledge integration mechanisms. These mechanisms refer to the formal processes and structures that ensure the capture, analysis, interpretation, and integration of market information and other types of knowledge among different functional units within the company or network (Luca and Atuahene-Gima 2007).

The market knowledge is captured from a combination of structured and unstructured data sources describing different entities:

- Consumers (aesthetic, physical parameters, comfort and health requirements, etc.)
- Retailers (sales status and customer preferences)
- The interaction between designers and suppliers (sectorial requests and provisions).

The data representing the behaviour and preferences of the customers can be obtained not only from transactional systems (e.g., orders) but possibly also from other sources where they express their opinions, including social networks (Facebook, MouthShut, Twitter, Pinterest, etc.) and online communities of consumer target groups (Being Girl – Procter and Gamble, Lugnet – Lego, My Starbucks Idea – Starbucks, etc.).

Specific tools are required to collect the data for the market information model. These tools must be able to integrate different types of information repositories and metadata characterization to achieve semantic interoperability.

For transactional databases, conventional technologies can be used, such as relational queries. Given that the databases are often stored in different systems (e.g., SQL Server, Oracle, MySQL, etc.), they are accessed using standard technology such as ODBC or JDBC.

For online communities, several internet technologies can be used, including crawlers, semantic web, and information extraction methods (Turmo, Ageno, and Català 2006).

Since the end of the eighties, the primary database paradigm is the relational model, i.e., the database is designed in order to eliminate redundancy and reduce the disk space occupied by the data. The disadvantage of the relational model is the cost (in terms of time) necessary to obtain data using SQL (Structured Query Language) queries. Moreover, it is necessary to know which queries the end user desires previously. However, in the nineties, disk space got much cheaper.

As a consequence, a new paradigm of databases designed to minimize querying response time appeared under the name of Data Warehouses. A Data Warehouse is "a subject oriented, integrated, non-volatile, and time variant collection of data in support of management's decisions" (Inmon 1996):

- Subject-oriented because it is designed to support a particular interest of the company (e.g., marketing, sales or operations);
- Integrated because it integrates information from different sources guaranteeing unique and consistent definitions;
- Non-volatile means that once data is inserted in the Data Warehouse, it cannot be updated or deleted
- Time-variant because the information is extended with time.

This definition of the Data Warehouse focuses on data storage. However, the data is cleaned, transformed, cataloged and made available for use by managers and other business professionals for data mining, online analytical processing, market research, and decision support. This means that Data Warehousing comprises not only the data repository (Data Warehouse) but also all the processes for its management, namely, tools to extract, transform and load data (ETL) into the repository, and tools to manage and retrieve metadata, as well as tools to extract information from the data (Figure 59).

A common approach to answering multi-dimensional analytical queries swiftly in databases is On-Line Analytical Processing (OLAP). OLAP is a tool that uses a multi-dimensional structure for fast query analysis. The main difference between OLAP tools and traditional SQL querying tools is that OLAP tools previously organize the data in cube structures in order to speed up queries. Moreover, the queries can be executed using friendly front-end tools, without been necessary knowledge on SQL.

The design of the DW and its tools, particularly the ETL, must be done in close collaboration with the design of the data gathering mechanisms.

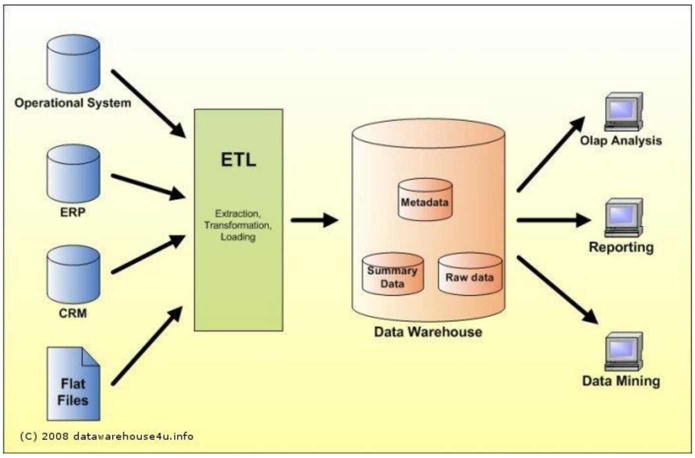


Figure 59 - Overview of Data Warehousing (from datawarehouse4u.info)

Data Mining (DM) is used mainly to extract knowledge from large volumes of data (Han, Kamber, and Pei 2006). DM is located at the intersection of well-established scientific areas such as Statistics, Databases and Artificial Intelligence. It uses techniques and methodologies from these areas in addition to having its own.

Two tasks that are commonly addressed with DM techniques are clustering and association rules mining. A DM project to be successful should follow a methodology.

The first DM technique clustering is the organization of a set of observations into subsets, where each subset contains observations that are similar to each other and not similar to observations in the other subsets (Jain, Murty, and Flynn 1999). Figure 60 presents an illustrative example. As an example, observations can be customers that are characterized by their preferences regarding clothes and shoes.

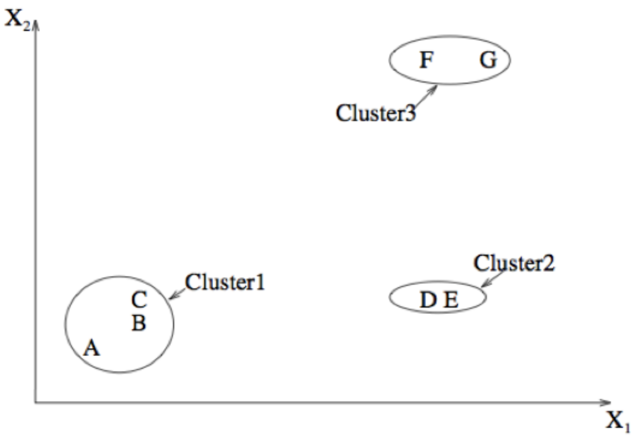


Figure 60- Clustering Example (source (Jain, Murty, and Flynn 1999))

Although a more thorough classification can be applied, clustering techniques are useful in segment and aggregate data in classes or sets. Clustering algorithms are commonly divided into partitioning and hierarchical methods. Partitioning methods are characterized by starting with an arbitrarily defined set of clusters and then improving the clustering by moving observations between clusters until achives a given stopping criterion. Hierarchical methods start either by placing all observations in a single clustering (divisive) or each observation in an individual clustering (agglomerative) (Jain, Murty, and Flynn 1999).

In the former case, the partitioning method start with an initial cluster that is subsquently divided into two clusters that optimize a given criterion. The process is repeated until each observation is in an individual cluster. The agglomerative approach works inversely, by joining pairs of clusters, until all observations are in a single cluster. An important application area of clustering is customer segmentation and profiling.

A second technique used in data mining is the association rules mining. The automatic recommendation is about selecting items to a user or predicting which item a user will like. Items must be potentially relevant for that particular user. One well-known example is the "customers who bought this also bought" of Amazon.com. In this case, given the books a user is interested in, Amazon's site automatically recommends other books of potential interest. There are different approaches to automatic recommendation. New items can be recommended to a user because they are similar, in content, to what the user likes (this is the content-based approach) or they can be suggested by the likes of users who have similar tastes (this is the usage-based or collaborative filtering approach).

The goal of the business is to understand the problem from the customer. Identify the business objectives and requirements and then translate them into DM problems and draw a project plan.

The development of the Market Information Model requires the combined use of several tools, namely for data gathering, business intelligence/data mining and data and knowledge sharing. Many alternatives exist for those purposes, with very different features and characteristics.

The Market Information Model aims to provide a new model of market information. This model enables designers to monitor the behavior of their customers continuously and, thus, be able to respond quickly to changes in the demand. This response is possible with Business Intelligence tools (Lo, Hong, and Jeng 2008). Figure 61 presents an overview of the market information model proposed tool.

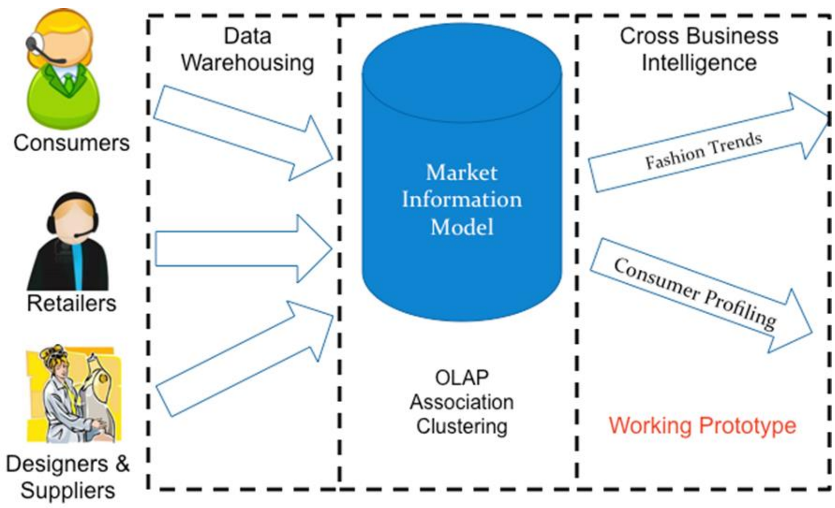


Figure 61 - Overview of the Market Information Model

The Market Information Model operates on a combination of structured and unstructured data describing different entities:

- Consumers (aesthetic, physical parameters, comfort and health requirements)
- Retailers (sales status and customer preferences)
- Interaction between designers and suppliers (sectorial requests and provisions).

The collected data is afterwards stored in a Data Warehouse (DW). To extract useful information from the DW, the designer is provided with OLAP tools, dashboards as well as Data Mining techniques. The following DM methods are particularly useful for designers:

- **Clustering** - to identify subgroups of customers with homogeneous behavior (e.g., young urban, middle-class men and rich, middle-aged, highly educated women);
- **Association** - to identify emerging trends (e.g., recently, shirts with classic design typically also have single cuffs).

These models can be used to improve production planning and supply chain management (e.g., anticipating trends in product consumptions and, consequently, in raw material needs), to design new products (e.g., anticipating what product features may be most successful in the coming seasons) and sales and marketing (e.g., customizing catalogues and websites for different customer profiles).

Figure 62 presents the proposed architecture of the Knowledge Market Tool (KMT). The KMT Fashion Intelligence service is represented by the BI module, the Fashion Profiler is the Customer profiling module, and the Trend Analyst services is the Trend mining module. In the prototype, the Business Intelligence (BI) and Fashion Profiler modules not only perform its knowledge extraction on transactional data but it also those structured data with comments (unstructured data) from social networks.

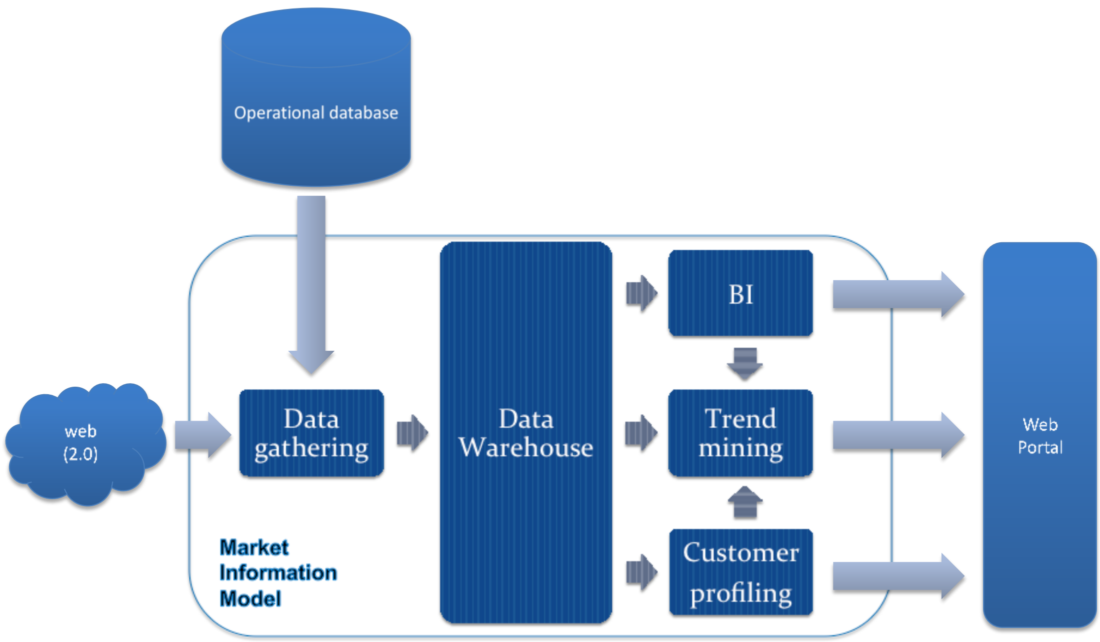


Figure 62 - Architecture of the KMT tool

The software tools used to implement the Market Information Model were Pentaho[8] and Rapid Miner[9]. The Pentaho suite combines several BI tools, including Kettle for ETL (Extraction, Transformation, and Loading), MySQL for data storage, Mondrian for multidimensional modeling and Saiku for OLAP (OnLine Analytical Processing).

Rapid Miner is a tool with an extensive set of operators for all the steps involved in a data mining project (data preparation, modeling, evaluation, and deployment).

The Web Portal was implemented using Liferay[10]. All of these components of KMT are integrated using web services.

Table 32 lists the KMT components features.

Table 32 - KMT components features list

Component	Features
Social Fashion Intelligence (FI)	• Data mart with transactional data organized for reporting and exploratory data analysis; • Data mart with data collected from comments made in social networks (Pinterest, in particular) about the products and part of the transactional data. These data are integrated and organized for reporting and exploratory data analysis; • Demand characteristics and social network comments exploration using OLAP; • Demand characteristics and social network comments reporting using reports and dashboards.
KMT Fashion Profiler (FP)	• Automatic segmentation customer demand using clustering algorithms; • Visualization of customer demand profiles;
KMT Social Trends Analyst (TA)	• Automatic identification of demand and social network comment trends using association rules mining algorithms; • Visualization of demand and social network comment trends;

The development of the KMT prototype as "proof of concept" was made to meet the overall functional specifications defined in the requirements analysis and specifications of the specific customer-focused supply chain framework.

It consists primarily of the configuration of the software packages Pentaho, Rapid Miner and Liferay, the configuration of the Pinterest to collect comments concerning products of the

[8] http://www.pentaho.com
[9] http://rapid-i.com
[10] http://www.liferay.com/

industrial partners and the import of those comments as well as transactional data into Pentaho.

Figure 63 presents an illustrative example of KMT user interface.

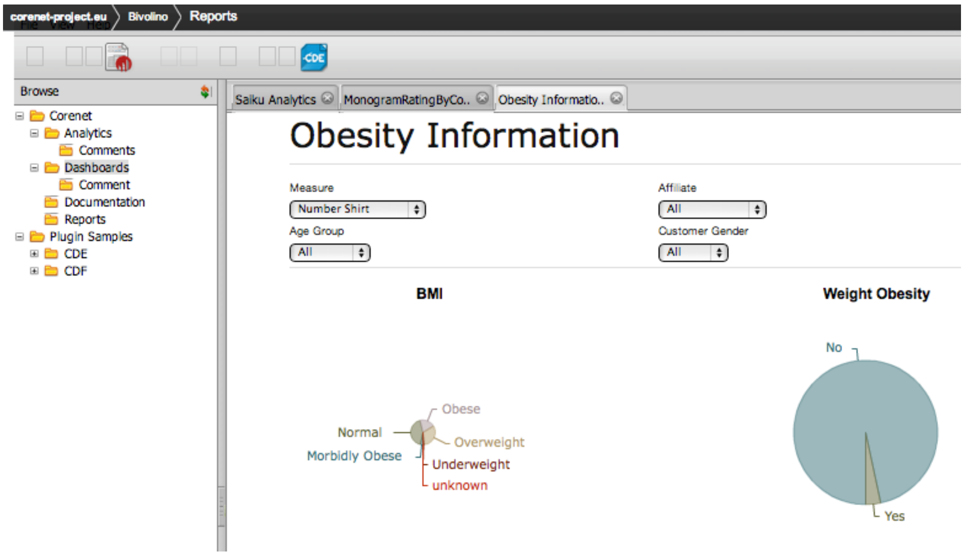


Figure 63- KMT user interface

The prototypes developed were two and are under tests with the collaboration of the end users for textile/clothing case scenario and footwear use case scenario. It is expected that this testing will lead to several improvements to the prototypes, including bug fixes and refinements in the analyses provided. In particular, the current mechanism for integration of KMT with social networks is expected to raise a significant number of issues, due to their complexity.

5.3.2. Set-Based Product Design Tool in Collaborative Networks

Regarding the operational level, the second addressed topic in the framework was related to the support for the collaborative design of complex and innovative products in a network environment. This section tackles this topic.

5.3.2.1. Problem Framing

The global manufacturing industry landscape has changed in the last decade due to the increase in global competition in product quality and production costs. Simultaneously, the demand has shifted towards innovative and complex products with increasingly shorter life-cycles. Consumer needs and expectations are arising as challenging opportunities for worldwide manufacturing companies which are required to put more emphasis on the service levels they provide, by reducing response times and by tackling customers' specific demand needs of innovative/complex high-quality products, in shorter periods.

In order to companies' managers succeed in addressing this new market demand through customer-driven value chains, they have to address the full set of product life-cycle stages efficiently. These stages encompass the conception, design, development, manufacturing, and supply of such products.

Alongside, managers are grasping the reality that market competition is shifting from company centered scenarios to supply chain networks with complex inter-organizational structures and intricated networked manufacturing processes. As a consequence, it is emerging at the manufacturing level the repositioning of strategies where companies are focusing on their core competencies and complement their needs through the adoption of collaborative strategies.

Additionally, with the continuous empowerment of the consumer and the rise of his role in the market landscape, the product design focus has been transferring from a traditional designer-centered approach to a more distributed and holistic scenario where the roles of the designer, the manufacturer and the 'customer' have been more well-balanced and interconnected. The implications of this trend in traditional manufacturing operations are remarkable at several levels. The current trend is pushing companies to be faster, more flexible and increasingly efficient in the way they design new products (especially innovative and complex products) and tackle business opportunities.

In the face of this new reality, business managers are now facing first-hand challenges related to the lack of tools and methods to assist the conception and design phase of new product development life-cycle. In reality, the traditional tools poorly address the required functionalities to support the collaborative design of innovative/complex products.

The present research work proposes a multidisciplinary approach to support the collaborative design of innovative and complex products in a networked environment. Aimed to assist product designers, customers, and manufacturers, it tackles the main collaborative business processes tailored for responsiveness and efficient use of knowledge on customized manufacturing environments through a lean-based collaborative approach.

The proposed framework expands to a collaborative networked environment the traditional lean product development principles named Set-Based Concurrent Engineering (SBCE) developed by the Toyota Motor Corporation (Sobek, Ward, and Liker 1999).

As research, has shown, in traditional business scenarios, SMEs have a minimal number of possibilities to be competitive, to differentiate and add value. Traditionally, SME's were competitive through specialization, proximity to the markets, flexibility and technical heterogeneity. However, these unique capacities and capabilities are no longer sufficient to allow them to compete with larger companies and lower cost countries (Hoyer 2008) (Shamsuzzoha et al. 2013).

Facing these increasingly competitive scenarios, SMEs companies, need to collaborate in order to embrace new business scenarios models that enable them to supply differentiated products, faster time-to-market responses, and competitive prices and quality levels. A promising approach presented to SMEs companies overcome the present limitations is the establishment of dynamic and non-hierarchical collaborative networks (CN). These collaborative networks allow SMEs to join and control the knowledge, capabilities, resources and critical mass required to offer unique solutions to complex requirements presented in present day business opportunities (Carneiro et al. 2014).

Additionally, in many industrial sectors, an ever-growing number of new products are introduced within increasingly shorter time intervals. Simultaneously, as products grow in complexity and functionalities, the product life-cycles have been cut to one third or even one fourth over the past decades. In summary, today's business landscape is characterized by small batches, short to micro product life-cycles, fast-passed new product releases designed to attend increasingly knowledgeable, well informed, and demanding customers (Bastos, Azevedo, and Ávila 2015).

Concurrently, the present need for greater product complexity in shorter periods necessitates the support of tools that effectively allow the use of distributed resources and the management of the derived knowledge and information. These collaborative tools need to consider the constraints and the requirements from the different product development cycles in the early development phases and fully support the concept of design-for-manufacturability.

All these issues create a challenge for companies' managers: how to address these present-day consumers demand personalized complex products in terms of high-quality levels, innovative functionalities and responsiveness? How to create and support a distributed environment that efficiently enables the design and conception of new complex products in non-hierarchical collaborative networks?

5.3.2.2. Network Formation in Collaborative Networks

Research in collaborative networks of innovative and complex products has shown that in order to a particular organization respond to a specific business opportunity, it has to perform the following six steps (see Figure 43) (Bastos, Azevedo, and Almeida 2012):

- **Business Definition** – identification of the business opportunity, selection of partners, definition of the general operating rules, non-disclosure agreements and contractual agreements;
- **Product Co-design** – collaborative design of the product involving designers, manufacturers, and consumers;
- **Product Process Design** – based on the previous product design, the involved partners, collaboratively detail the distributed engineering process plan;
- **Collaborative Planning** – development of a negotiated collaborative production plan among the manufacturing partners;
- **Execution –** after the definition of the detailed operation, subsequently, the planned operations are executed;
- **Dispatch –** after the completion of the manufacturing operations the product is delivered to the customer.

Each one, these critical phases, requires flexible and reactive organizational structures which rapidly adjust to new manufacturing challenges and review the customer requirements and the partner's capabilities accordingly. These new manufacturing networks embody shorter life-time existences and take advantage of new infrastructure technologies to support distributed decision making, information sharing and knowledge management (Zangiacomi et al. 2013).

Experimental work provided support to researchers that responsiveness is intrinsically related to competitiveness. Namely, networked organizations can increase their ability to compete based on product innovation, low time to market, low price and high delivery dependability by increasing the firms' responsiveness (Thatte 2007).

A significant aspect that dictates the success of these new forms of networked organizations is related to the responsiveness. The time to market lead time is a critical variable that measures the organization responsiveness. As Li et al. defend: "time to market is the ability of an organization to introduce new products faster than major competitors"(Li et al. 2006).

Particularly in collaborative networks and especially in the case of complex products, the objective to achieve a reduced time to market response in CNs presents itself as a critical challenge. This need is a natural result of the distributed design environment and the dispersion of competencies among the various network partners.

Furthermore, as explained before, in conventional development processes the approach usually followed is the "waterfall" or "V" methodology. In this approach, starting from the concept specification, first, it is designed the system, freezing the interfaces between the subsystems, then designed the subsystems, following a top-down method.

Figure 45 presents the resemblances between the traditional product design process and the collaborative network formation process using the conventional "waterfall" approach.

A significant consequence of the classic product development cycle based on the "waterfall" approach in distributed product design networks is the appearance of problems that are detected too late or in advanced stages of the product design process.

In conclusion, the traditional "waterfall" approach results in several disadvantages which limit the network partners' involvement and knowledge and ultimately point to the implementation of a set-based design approach.

5.3.2.3. Method description

Traditionally, the business opportunity that triggers the collaborative set-based design process for a new product arises when a customer asks for a new product by defining the respective requirements, expectations, and additional information about the expected delivery date. Figure 64 represents the process flowchart.

Subsequently, the company that acts as front-office or broker for the CN receives the product request, analyses the presented requirements and performs a first validation about the viability of the business opportunity.

Then, a partner search procedure is performed to select the partners to be invited to participate in the collaborative development of the new product. This procedure is a crucial activity since the broker must take into account the required skills and capabilities of each potential partner for the success of the overall project. At this stage, the consortium also negotiates how the project revenues are divided among the different partners of the network.

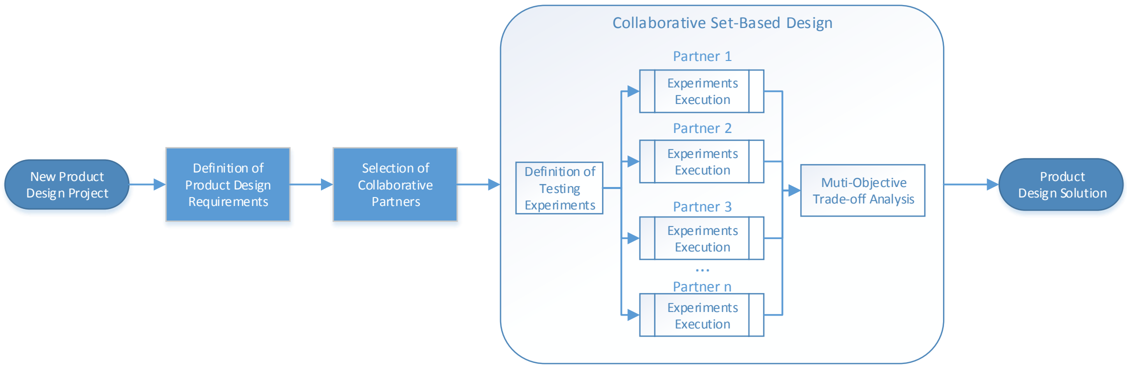


Figure 64 - Collaborative Set-based Design Flowchart

After the selection and commitment of all the members of the collaborative networks, it is deployed the collaborative set-based design process, first through the definition of the testing experiments required and respective assignment to the different partners. A designated project leader usually is assigned to perform this task.

After the execution of different experiments by the partners, the multi-objective trade-off analysis tool combined the knowledge. The tool allows the integration of the different experiments results and helps the project manager identify if it is required further experimentation, or if the process achieved an adequate product design solution that complies with the customer requirements. The final output of the collaborative set-based design process is the new product design solution.

Since in most of the cases, the engineering product development process involves experimentation and analysis of several key technical parameters, usually, this results in decision-making where optimal decisions have to be taken in the presence of trade-offs between two or more conflicting objectives. For a typical engineering product development multi-objective optimization problem, no unique solution exists that simultaneously optimizes each one of the objectives.

The objective functions are conflicting, and therefore more than one Pareto optimal solutions are present. Each one of the Pareto solutions is called a non-dominated optimal. Therefore, none of the objective functions is possible to improve without lowering some of the other objective values, and all solutions are considered equally good (Miettinen 2012).

The set-based design approach supports the goal to find the representative set of Pareto optimal solutions, by quantifying the trade-offs present in a specific product design problem. By identifying the significant set of optimal solutions that satisfy the different objectives present in the customer requirements, the approach assists the human decision maker in their effort of collecting knowledge and efficient use of resources. Figure 65 presents a simplified representation of the implemented set-based design algorithm.

The set-based design tool implementation also assists the collaborative design team identifying the most exciting solutions. This approach is particularly attractive if the number of objectives is large and consequently the number of Pareto-optimal solutions could be enormous, and it may be challenging to select a single “best” solution out of this large set of alternatives. Literature suggests that the most interesting solutions of the Pareto-optimal front are solutions where a small improvement in one objective would result in a large decline in at least one other objective. These solutions are usually called "knees" (Branke et al. 2004).

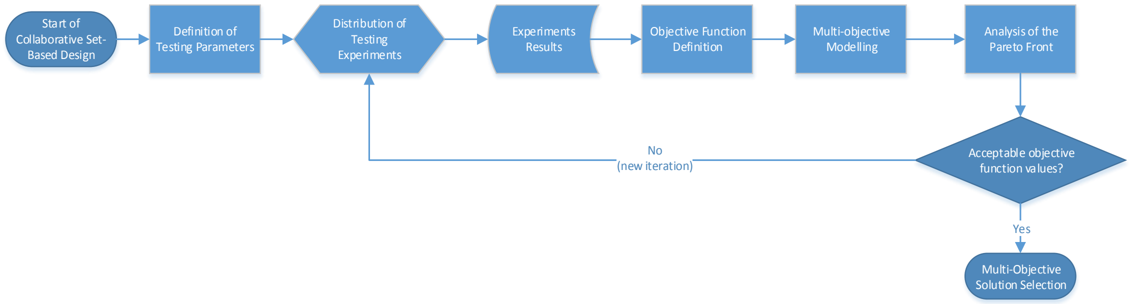


Figure 65 - Collaborative Set-based Design Algorithm

The following section presents a simplified footwear industry case example intended to explain and demonstrate the tool implementation of the collaborative set-based design approach.

5.3.2.4. Explanatory example

The case example presented is related to the selection of the sole material for a specific woman fashion shoe. The collaborative network involves four partners/suppliers, and the objective was to investigate the characteristics and behavior of four sole candidate materials. The selected materials are *Platazote, Dynafoam, Ortho Felt* and *Spenco.* The parameters considered relevant for the study are the *Thickness (4mm – 12mm)* and *Density (36 – 85 Kg/m^3.* The collaborative network has performed a set of pressure and utilization tests for the following characteristics:

- Hardness (ISO 2439 – ILD) for the values 25%; 40% and 60%;
- Stability Control (measured by the angle under load);
- Quality Conformance (visible damage)

Each partner performed the tests using one of the selected materials. The suppliers certify all of the materials used on tests.

Figure 66 presents the graphical representation of the tests results for the objective functions of hardness (H), Control Stability (CS) and quality conformance (QC).

In order to identify the objective function, the tool performed a regression analysis using the test results obtained from the experiments.

Figure 67(a) and Figure 67(b) represent the objective function graphical representation of the surface of the H (hardness) and CS (control stability) from the *PLASTAZOTE* tests.

Afterward, the tool performs a multi-objective optimization using an epsilon-constraint method (Mavrotas 2009) and identifies the Pareto front represented in Figure 67(c).

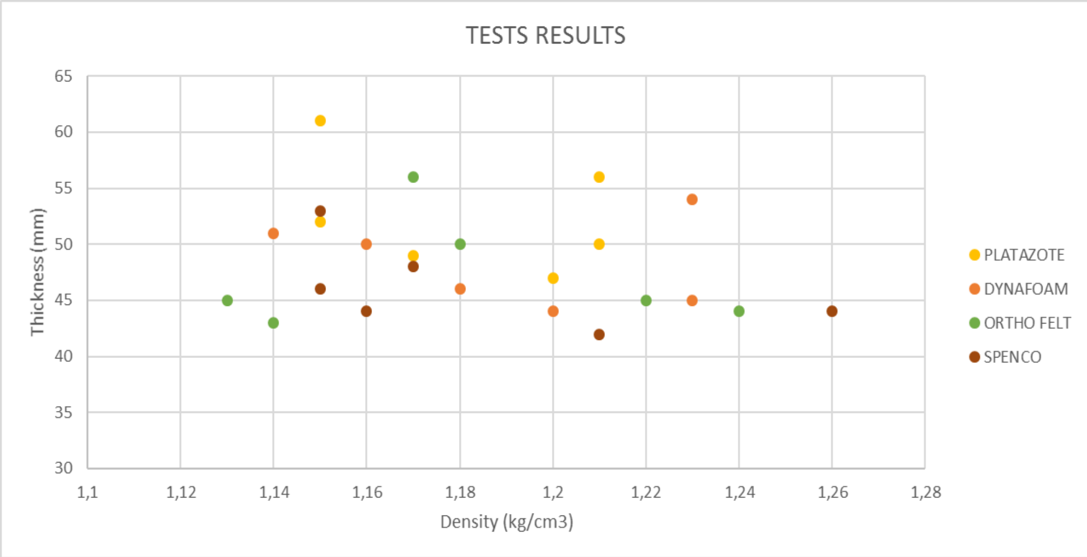


Figure 66 - Graphical representation of the tests results

This front presents the set of optimal solutions that satisfy the different objectives included in the customer requirements, namely the minimization of the function's variables: hardness and control in(stability) for compliant products.

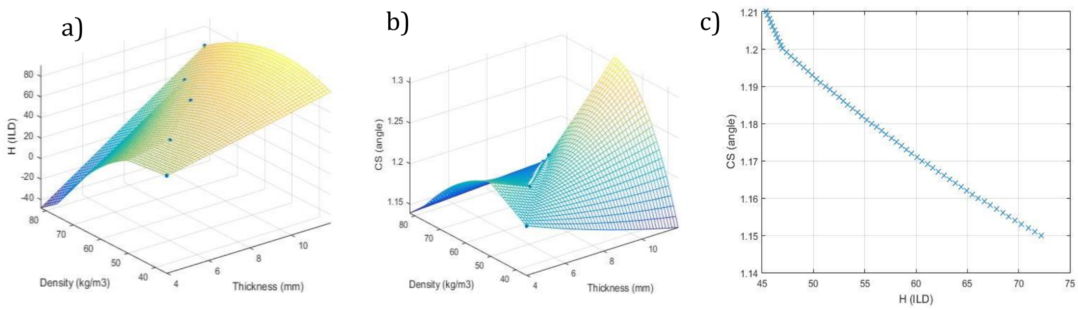


Figure 67 - PLASTAZOTE Graphical representation of the H (a) and CS (b) objective functions and Pareto front (c)

Subsequently, the tool suggests that the most interesting solution of the Pareto-optimal front is the called "knee" point of the *Dynafoam* material with 6 mm of thickness and density of 56 kg/m³ for the variables H=46 ILD and CS=1.18º. In Annex D is it included the code implemented for the present application case.

5.3.3. Collaborative Planning

In the set-based framework operational level, the third topic addresses the support of collaborative production planning in a network environment. This section presents this topic.

5.3.3.1. Background in Collaborative Planning

Collaborative networks present itself as a promising paradigm in a knowledge-driven world. A large variety of collaborative networks have emerged during the last years as a response to the growing challenges faced by business players in a global market. These highly integrated and customer-focused supply chains are extending the frontiers of traditional supply chains and contributing to the formation of virtual enterprises, virtual organizations, and professional virtual communities. The following sections present the technical background present in the literature related to these innovative organizational forms.

A significant challenge for networked organizations to deliver the products and services arises from the complexity of planning the individual tasks for the different operational processes. According to Dudek and Stadtler (2005), networked planning decisions include order releasing for procured material (procurement); lot-sizing; production planning and scheduling; manufacturing execution control; and detailed definition of distribution flows, routes and transport loads (distribution). Each network node performs several instances of activities in different locations along the supply chain. This reality means that each planning system must be aligned with the remaining systems in the network in order to deliver feasible plans. Traditionally, the only possible way to manage such a supply chain planning integration was assuming a centralized planning approach that integrates all participating units. This approach relied traditionally on information's systems called Supply Chain Management (SCM) systems.

The SCM systems were designed to handle data on incoming raw materials from outside suppliers, deliver data on distribution flows for customers, and synchronize the internal work processes with the outward flows. In practice, this system is suitable for companies belonging to the same group or with a strong commitment to a supply chain "owner." On the other hand, SCM systems cannot be applied to external companies that compete in the same market and are independent (Stadtler 2008).

A significant challenge arises when there is a need to link and coordinate the manufacturing operations between independent companies belonging to the same supply chain. Several authors argued in favor of a negotiated approach to achieve synchronization between production plans from each one of the companies participating in the supply chain (Holweg et al. 2005, Dudek and Stadtler 2005, Brand and Gaffikin 2007).

In line with the negotiation concept, Stadler (2009) proposed a negotiated coordination scheme, in which two or more decision-making units build aligned production plans. This decentralized approach allows all network members to adapt their manufacturing plans to achieve an overall plan that is acceptable by all supply chain members and avoids any centralized planning approach that does not consider an active contribution of all partners. This proposal aims at providing through a negotiated coordination an overall optimized solution for a business opportunity that arises in the context of the supply chain.

Kilger and Reuter (2005) presented a consensual definition of Collaborative Planning (CP). The authors defined Collaborative Planning as a linking of different local planning processes and domains that through collaboration achieve a joint and mutually agreed network plan. To accomplish an overall collaborative plan, the partners share pertinent information, allowing synchronous and accurate update of the planning results.

The main reason behind an integrated supply chain management solution for non-hierarchical and decentralized networks arises from the competitivity challenge. Through the Collaborative Planning approach, it is possible for these networked organizations to address issues such as:

- How to efficiently tackle each one of the business opportunities posed by the market with the joint competencies present in the network members;
- Provide a transparent environment with problem-solving mechanisms between the supply chain members;
- Efficiently use the available capacity across the manufacturing stages along the supply chain;
- Achieve efficient global solutions through the elimination of non-optimized activities.

This level of integration and coordination is only possible through the implementation of a collaborative approach between the different stakeholders along the supply chain, being jointly responsible for the network activities such as planning, flow management and manufacturing, and performance management. Collaborative relationships radically transform how information is shared between the different partners and drives business processes to new challenges (Camarinha-Matos and Afsarmanesh 2008a).

Research has shown that collaborative planning involves activities through which individuals coordinate their planning processes with external partners planning processes. Traditionally, individual companies primarily plan accordingly to their own goals, but in cooperative relationships, they also try to take into consideration different scenarios which enable the optimization of other players planning goals. Thus, collaborative planning processes usually consider views which enable individual managers to recognize that their plans should be adjusted, not by their selfish local criteria, but by optimized global planning goals. In short, collaborative planning enables individual companies to redirect their plans towards a common goal to reach a joint optimization of the planning across enterprise boundaries (Windischer et al. 2009).

The path to a collaborative planning approach has revealed several challenges to individual organizations. The most significant challenge is the concept of centralized planning. Usually, local production managers transpose their reality and sustain that a centralized planning approach must be followed in order to guarantee the overall success of the network planning function.

Breiter, Hegmanns et al. (2009) present some questions about the adequacy of a centralized planning approach. The authors present the following significant obstacles:

- Collaborative network partners' engagement in several supply chains - companies participate in several networks, which could generate interferences on their planning activities. A centralized approach, to successfully manage these multi-supply chain scenarios, requires to include in its planning scope all the networks involved.
- The balance between local and global plans objectives - each company manages its internal production plans to achieve the best performance. If these objectives must be relaxed, all the needed changes to obtain the global plan objectives must be negotiated and not imposed. This easing is especially true when the network is composed of independent companies;
- Reluctance to share information – to implement a centralized decision making, relevant and strategic information is needed from partners, concerning their resources and capabilities. Companies usually classify this information as confidential and are unavailable to share it along with their partners;

- Lack of acceptance of central authority models. The enforcement of central plans requires the capitulation of local autonomy, which is not welcome on the current business market.
- Following these significant obstacles, the conclusion points out that a centralized approach might not be the best approach to guarantee global coordination between independent companies in complex supply chains. Alternatively, a decentralized approach without coordination mechanisms between the partners might lead to non-optimal solutions, because it will only reflect local solutions.
- A reliable decentralized coordination mechanism based on negotiation might be the solution because it aims to ensure information confidentiality, decision autonomy and trust enrichment among supply chain partners.
- When working with dynamic and complex business scenarios like the textile and footwear sectors, the centralized approach presents several constraints, like the loss of local autonomy, which is not accepted by the most companies due to their segmentation, competition, and rivalry.

5.3.3.2. Coordination and collaboration through negotiation

Several authors sustain that a decentralized planning approach with coordination between independent partners requires negotiation mechanisms (Chai, Sakaguchi, and Shirase 2010, Dudek 2009, Wang, Liu, and Li 2009).

Breiter, Hegmanns et al. (2009) proposed an approach where they applied automated negotiations with companies or decision-making units represented as software agents as the mechanism to establish coordination in the supply chain. In this case, the negotiation is the process by which a group of agents communicates with one another to try and come to a mutually acceptable agreement on some matter.

Stadler (2009) also presented a multi-agent system as a solution to deal with the negotiation process for collaborative planning. According to the author, an agent is an autonomous, goal-oriented software process that operates asynchronously, communicating and coordinating with other agents as needed. A coordinated state is reached when the agents find a jointly acceptable point in the agreement space.

Both models tackled the collaborative network coordination problem through the decomposition of the global production planning model by a set of agents that represent each one of the partner entities participating in the network. The procedure for the exchange of the local planning results relies on an iterative coordination scheme, and these local planning results are integrated as restrictions into the global solving processes of the local planning models.

Although innovative in the way the authors deal with the problem of decentralized negotiation, these multi-agent approaches continue to face a significant obstacle, the partners' unwillingness to share confidential information critical to their business processes. Therefore, a more practical approach is required to address the problem of decentralized production planning negotiation among independent networked companies.

5.3.3.3. Collaborative Planning Tool

Traditionally for industrial companies, one of the most critical business processes is the production planning. In networked organizations, the production planning function attains new levels of complexity and have a massive impact on the overall performance of the supply chain.

When considering practical and complex networked production planning scenarios for innovative and fashionable products (like the textile or footwear sectors, for instance), local autonomy of each entity, unwillingness to subordinate to a central authority, confidentiality of business information and transparency among the negotiation processes are essential issues.

Starting with the issues and the requirements explained earlier regarding the decentralized collaborative problem, the present work proposes an Intelligent Collaborative Planning Framework. The preliminary research work that resulted in the present proposal was initially based on the European funded project "Customer-oriented and eco-friendly networks for healthy fashionable goods (CoReNet)" that aimed to provide industrial companies with the tools and methods to face the challenge of working in demand-driven and customer oriented collaborative networks namely for innovative and fashionable product supply chains. The proposed framework considered four main stages in the supply networks lifecycle (see Figure 68):

- Process Planning: product designing with the identification of the internal and external components to establish the generic production process;
- Partner Search: the creation of a supply network, including the formalization of the contract with partners;
- Operation: collaborative planning, manufacturing, and delivery by the supply network;
- Dissolution: closure of the supply network.

Figure 68 - Supply networks lifecycle

Both the Partner Search and Operation stages require planning procedures since a consistent and real quotation is needed to present to the customer, not only considering prices and materials but also providing a delivery date or a production lead time. The related supply network planning operation needs to allow straight cooperation and collaboration between the involved partners.

The main features presented in this Partner Search tool are:

- Search partners on two different domains: internal (among already known suppliers) and external (internet).
- Use syntactic and semantic engines to refine and filter search.
- Use user-defined criteria to perform a search.

- Use mash-up services to filter results.
- Save results in different areas: staging area for results to be evaluated and partners area for to-be-used results.

The proposed approach focuses on the operation phase of the supply networks life-cycle, and considers four main phases for the supply chain planning sequence:

- Partner Search: the creation of a supply network, including the formalization of the contract with partners and suppliers and overall process plan;
- Aggregate Planning: rough production plan for customer quotation;
- Detailed Planning: detailed production plan definition with optimization of costs;
- Dispatch: definition and dispatching of production orders for the entire supply network.

Both the Aggregate and Detailed planning phases require decentralized collaborative planning procedures (see Figure 69) since a consistent and real quotation is needed to be presented to the customer, not only considering prices and materials but also providing a delivery date or a production lead time. The related supply network planning procedure needs to allow straight cooperation between the involved partners.

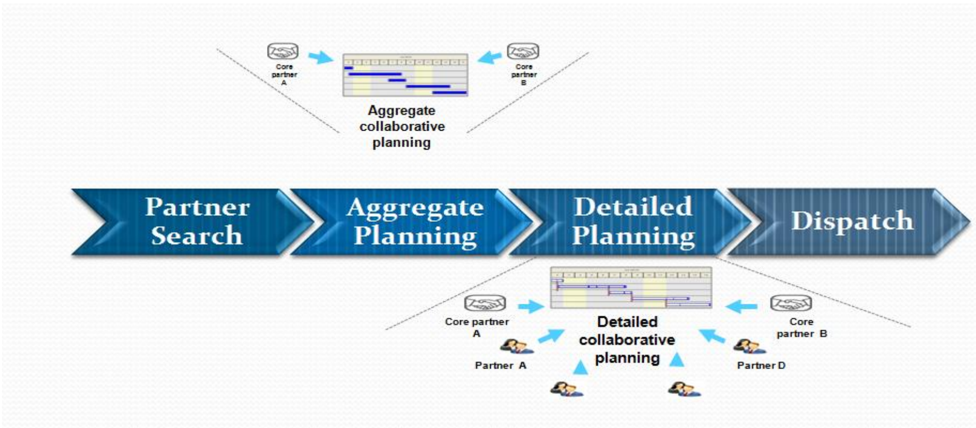


Figure 69 - Planning activities during the supply network lifecycle

The Partner Search tool developed in the project is based on the definition of Partner Profiles including both data provided by the supplier itself (e.g. administrative data, description of competences, provided material or process, etc.), as well as data derived from the analysis of the suppliers' past behaviour based on performance indicators like the following ones:

- Collaboration degree: indicating how the supplier behaved in previous collaborations (e.g., number of collaborations held in the previous period, number of successful negotiations, etc.).
- Products quality: reflecting the quality of the provided products (e.g., number of defective products, etc.).
- Flexibility: describing the partner's ability to react rapidly and adapt to changes in the order or at production time.

Subsequently, the collaborative planning process manages the activities to support companies' plans towards each other to reach a joint optimization of the planning across departmental boundaries.

When working with actual and complex business scenarios like the textile or footwear sectors, local autonomy of each entity is an important issue.

For this reason, based on the requirements analysis retrieved from the industrial project partners, an innovative collaborative planning concept is proposed in the present framework for supporting intelligent decision making in supply network planning. This framework focus on satisfying the networked manufacturing requirements for innovative and complex products. This new approach is based on decentralized and cooperative actions and offers user-friendly interface, that connects the supply network stakeholders and supports complex negotiation practices on a web-based platform. Furthermore, through the use of a multi-criteria analysis, it is possible to define assessment mechanisms in order to optimize the overall supply network planning process

The proposed approach relies on a decentralized negotiation model, which allows partners to propose new delivery dates and costs, represented graphically in Figure 70.

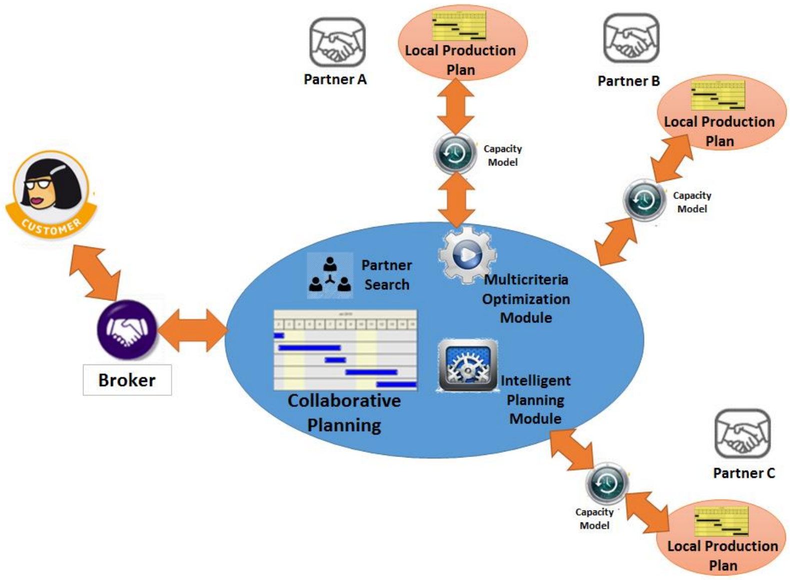


Figure 70 - Decentralized collaborative planning approach

With the present approach, a business front-office acts as a broker and tackles every business opportunity proposed by a customer, interfacing with the collaborative network. The broker starts by accessing the partner search module, which allows him to identify the list of potential partners that satisfy the business and technical requirements to participate in the collaborative network.

After the elicitation of the significant requirements on the required custom-made product, the product concept/design is defined by the Broker and by the new partners that are invited to join the supply network, based on their specific competencies and availability.

For the building of the collaborative plan, there are two steps: the quotation and the order promising. The first step aims to help the prospective partners to collaboratively define a realistic quotation and price sharing through a decentralized negotiation process which takes into consideration the dependencies and time overlap between the required operations.

Major problems to tackle in this planning phase are the priority rules (Who allocates? Who manages?) and the availability of partners. The planning objective is to minimize/maximize specific criteria such as the overall cost of the supply network solution, partner' historical behavior regarding the collaboration degree, the manufacturing flexibility, products quality, and simultaneously meet the required delivery date.

To assure transparency on the following negotiation process, the broker and the selected partners collaboratively define the criteria that will support subsequent decisions in the process, namely the multicriteria assessment of the plan proposals. For the selected list of criteria items, it is possible to define a degree of importance, using a percentage score as a weighting factor. This score translates the importance that the partners assign to each one of the criteria items and allows them to express it through a ranking system.

The framework by allowing a collaborative definition of the criteria selection accomplishes two goals: enhances the transparency of the negotiation process by clarifying the way the best solution achieved and valued; and boosts the probability of criteria items inclusion which maximize the probability of gain of the customer's proposal and also the internal efficiency of the network. This collaborative agreement is an important step to assure the requirement of transparency in non-hierarchical networks.

At the same, it is agreed between the networked partners the negotiation conclusion conditions, namely the end date for the negotiation and the maximum number of iterations during the collaborative planning negotiation. Afterward, the broker, based on the product specification operations list, details an operation frame interval (with starting and finishing dates) for each production stage, generating an initial solution ("rough" plan).

Each partner receives the first "rough" plan (stage time frames) and a set of requests for quotations, one for each operation stage allocated to him. Each partner proceeds then to a local analysis of their local production capacity to evaluate if it is possible to accept the proposed dates and lead time for the indicated quantity. A quotation is then formulated, accepting or not the proposed plan and proposing one or more alternatives for the request.

Based on these quotation responses, the negotiation process continues through the identification of the possible best solutions and evaluating them accordingly to the agreed criteria. Afterward, based on the previous responses, the framework performs another iteration by intelligently redefining the proposal framing (stage time frames) based on the assessment of the available information and sends a new set of requests for quotations, one for each operation stage allocated to each partner.

The negotiation process continues until it reaches one of the end conditions. Usually, the negotiation ends when attains a maximum number of iterations, or deplete the available negotiation time. Subsequently, the consortium selects the best-evaluated solution accordingly to the agreed criteria and sends the corresponding response to the customer.

5.3.3.4. Intelligent Collaborative Planning Approach

The proposed Intelligent Collaborative Planning Tool is intended to help companies support the demand of short life-cycle products such as innovative and fashionable products. It is a result of a literature and sector case analysis and focuses on developing a practical operational alignment for the supply chain configuration, and the operations planning at an aggregated level.

Figure 71 presents the overall view of the Intelligent Collaborative Planning Tool proposal presenting its main elements. The collaborative planning approach integrates the actors or roles definition; the methods and functionalities; and a set of tools.

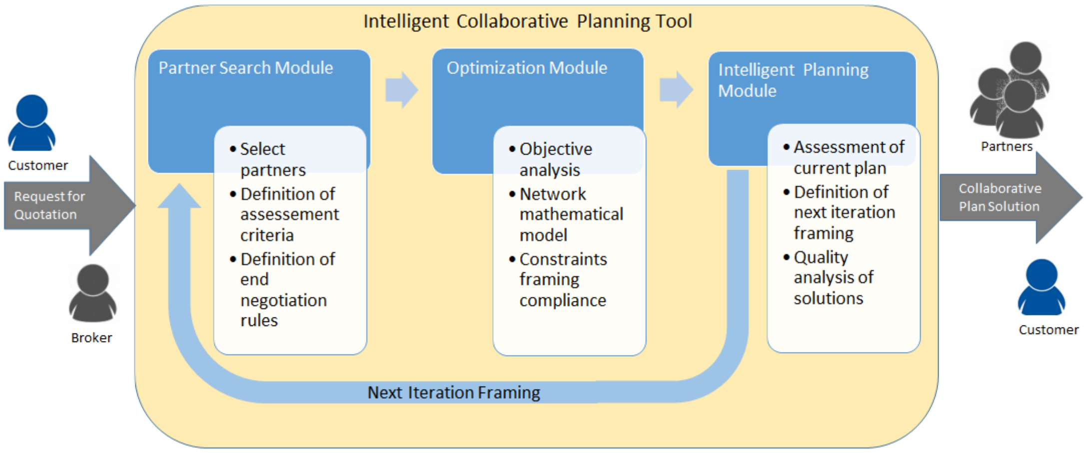


Figure 71 - Intelligent Collaborative Planning Framework

The framework integrates the following elements:

- Actors – identifies and characterizes the entities that participate in the collaborative negotiation process and their role;
- Methods – comprises the procedures, techniques, and approaches required to implement the intended functionalities;
- Toolset – the set of software tools and modules that provide the required functionalities.

Regarding the **Actors**, the framework identifies the following roles:

- Customer – an entity that generates the business opportunity by creating a quotation request for the collaborative network, and/or the specification of the product or service requirements;
- Broker – an entity that acts as front-office support with the customer and coordinates in a decentralized way the collaborative negotiation process;
- Partner – an entity involved initially in the negotiation for the formation of the supply chain and subsequently with the participation in the networked manufacturing process.

Concerning the **Methods** definition, the framework includes the following procedures:

- Partner selection – a mechanism that supports partner profiling and searching capabilities to support the set-up of supply chains;
- Definition of assessment criteria – a method that collaboratively establishes the criteria for the evaluation of the possible solutions;
- Definition of end negotiation rules – a mechanism that allows the closing of the negotiation process when reaches the agreed conditions;

- Objective analysis – provides an adequate evaluation of the possible planning solutions based on several agreed criteria;
- Network mathematical model – a multi-stage process mathematical model supports the identification of optimal solutions for the selected assessment criteria;
- Constraints framing compliance – given that production planning in collaborative networks involves multi-stage manufacturing operations, it is necessary to ensure that each stage operations do not overlap and considers transit intervals;
- Assessment of the current plan – since the collaborative negotiation process relies on trust, the procedure assessment of each possible planning solutions is performed transparently using the defined criteria;
- Definition of next iteration framing – since the collaborative planning negotiation process occurs iteratively, and the objective is to minimize the number of iterations (with the consequent request-for-quotation and response from each partner), this procedure aims to define an intelligent definition of next iteration multi-stage framing dates for each partner request-for-quotation.
- Quality analysis of solutions – using the objective analysis and the relevant data collected during the negotiation, this procedure allows the quality evaluation of the solutions obtained and the subsequent update of the relevant indicators for each partner.

Concerning the **Toolset**, the Intelligent Collaborative Planning Tool includes:

- Partner Search module – tool responsible for the searching, negotiation and selecting of the potential partners for each stage of the manufacturing process of the customer requested product;
- Multi-criteria Optimization module – tool responsible for multi-criteria analysis of the multi-stage partners' proposals using an optimization approach to identify the best solutions;
- Intelligent Planning module – tool responsible for evaluating the multi-criteria optimization solutions and propose new time frames proposals in the iterative negotiation process.

In the following sections, it is explained in detail the Optimization module and the Intelligent Planning module.

5.3.3.5. Optimization Module

This module aims to seek optimal solutions in each phase of the negotiation, taking into account multiple assessment criteria such as cost, due dates compliance, partner KPI's, etc. In each phase, each combination of partners' proposals corresponds to an alternative plan.

The assessment of the alternative plans solutions takes into account multiple conflicting criteria and corresponds to an optimization problem. Considering as an explanatory example the negotiation scenario in which the partners agreed to establish as evaluation criteria the cost, the collaboration degree and, the ISO 9001 quality certification, the objective mathematical formulation of the partner's selection problem is[11]:

$$\min f_1(x) = \sum_{i=1}^{n}\sum_{j=1}^{m}\sum_{k=1}^{l} c_{ijk}\, x_{ijk} \qquad (COST)$$

$$\max f_2(x) = \sum_{i=1}^{n}\sum_{j=1}^{m} f_{ij} \sum_{k=1}^{l} x_{ijk} \qquad (COLLABORATION\ DEGREE)$$

$$\max f_3(x) = \sum_{i=1}^{n}\sum_{j=1}^{m} q_{ij} \sum_{k=1}^{l} x_{ijk} \qquad (QUALITY\ CERTIFICATION)$$

where n is the number of partners, m is the number of phases, and l is the number of proposals of each partner in the stage. There are three objectives to optimize: minimization of the cost ($f_1(x)$), maximization of the collaboration degree ($f_2(x)$) and maximization of the quality certification ($f_3(x)$). In this model, c_{ijk} are the costs of the proposal k in the phase$j$ and partner i; f_{ij} and $q_{ij}$are, respectively, the collaboration degree and quality certification of the partner i in the phase$j$. The binary decision variables are x_{ijk} and indicate if proposal k in the phase$j$ and partner i is selected. The constraints of the model are:

- to impose that just one proposal is selected for each phase

$$\sum_{i=1}^{n}\sum_{k=1}^{l} x_{ijk} = 1\,, \qquad \forall j \in \{1, \dots, m\}$$

- to guarantee that the proposal selected in each phase do not overlap in time with the selected proposal of the next phase (precedence constraint)

$$\sum_{i=1}^{n}\sum_{k=1}^{l} \left(t_{ijk} + d_{ijk}\right) x_{ijk} \le \sum_{i=1}^{n}\sum_{k=1}^{l} t_{ij+1k}\, x_{ij+1k}\,, \qquad \forall j \in \{1, \dots, m-1\}$$

  where t_{ijk} and d_{ijk} are, respectively, the initial date and duration of the proposal k in the phase j and partner i

- to guarantee that the due date of the project (T) is satisfied

$$\sum_{i=1}^{n}\sum_{k=1}^{l} (t_{imk} + d_{imk})\, x_{imk} \le T$$

- to define the decision variables as binary values where 1 means that the proposal is selected and 0 that the proposal is not selected

$$x_{ijk} \in \{0,1\} \quad \forall i = 1, \dots, n \;\; \forall j = 1, \dots, m \;\; \forall k = 1, \dots, l$$

[11] During the project, more than a hundred assessment indicators have been identified and selected by the industrial project partners. To simplify the explanation of the collaborative planning approach, it was chosen only to use three assessment criteria (cost, level of collaboration, and certification of the company with ISO 9001).

This problem has a combinatorial nature, and the aim is to identify from the set of all feasible alternative plans, the optimal one. Also, due to the existence of several objectives simultaneously, it is necessary to formulate a single objective function using scalarization methods.

The single objective optimization problem is obtained by the application of the weighted sum method to the normalized objective function corresponding to the minimization of the aggregated function $f_{\mathrm{a}}(x)$:

$$\min f_{\mathrm{a}}(x) = w_1 F_1(x) - w_2 F_2(x) - w_3 F_3(x)$$

where w_1, w_2 and w_3 are the normalized weights $(w_1 + w_2 + w_3 = 1)$. The maximization objectives were converted into minimization ones by negating the corresponding objective function.

This approach takes into consideration the assessment criteria and the negotiation rules previously established between the partners.

5.3.3.6. Intelligent Planning Module

The Intelligent Planning module was designed to allow that the decentralized collaborative planning negotiation process could improve as fast as possible on each iteration by improving the quality of the framing dates proposals and as a result, achieve better and faster solutions for the overall collaborative plan.

During the negotiation, the main constraints to the solution improvement are the partner low willingness to disclose his capacity model information to the network partners, and the reduced availability for lengthy negotiations with a large number of responses to the brokers' requests for quotations. This last constraint means that each partner is only available to participate in a small number of requests for quotation, and when it exceeds the number, the partner loses interest in the negotiation process.

The information collected from interviews on the industrial partners involved in the research project indicates that on average each partner would only be available to respond to a maximum of 5 quotation requests for each business opportunity.

Considering that a fundamental requirement for a set of partners to operate in a collaborative network relies on the ability to construct collaborative plans with efficient solutions, the proposed planning tool needs to present intelligent mechanisms that allow, in a small number of iterations, to improve the collaborative plan solutions in accordance to the criteria chosen by the partners.

Align with this view, for the intelligent planning module different strategies were designed and evaluated using the limited information available on each iteration. Through this intelligent approach, it is possible to make the process of defining new time framings for each production stage more efficient when comparing with the traditional random approach. Table 33 presents a list of the implemented strategies for the intelligent planning module.

Table 33 - Intelligent Planning Module Strategies

Strategy	Next frame proposal based in
Average	Average values of previous replies
Weighted average	Weighted average values of previous replies
Best proposal	Previous best proposal
Genetic approach	Cross-over of previous best proposals

Each one of the implemented strategies takes into consideration specific aspects that potentially could generate a path of improvements in the collaborative planning solutions. The aspects that backed up the development of proposed strategies were:

- **Average** – In the studied industrial sectors, a large number of partners present similar seasonal load patterns. Therefore, the average value of the partners' quotation replies tends to converge to periods of the lower load in the capacity models and as a consequence of lower cost;
- **Weighted average** – this strategy substantiation is similar to the average strategy but in order to value the lower cost of responses, takes into account the weighted average of the inverse of the cost on each previous iteration response;
- **Best proposal** – this strategy assumes that the best previous iteration response is a good suggestion for the next framing iteration;
- **Genetic approach** – this strategy is inspired by the Genetic algorithm (GA) metaheuristic approach. This strategy approach uses bio-inspired selection and crossover operators. It starts by selecting the best previous iteration solutions and then performs a crossing over the operation, mixing these best solutions in hope to obtain better solutions in the next iteration.

The developed strategies in the intelligent planning module resulted mainly from the empirical experience of the planning managers of the studied collaborative networks. This module integrated into the Collaborative Planning Tool was designed as a decision support system and allows the application of a set of strategies to define the stage intervals accordingly to the choice of the broker process manager.

5.3.3.7. Collaborative Planning Service

The Collaborative Planning Service is a web-based tool deployed under the Liferay portlet container platform. It is a portlet that offers different web-based views accessible for each one of the specific user groups/roles to support user interaction through the collaborative planning tool as depicted in Figure 72.

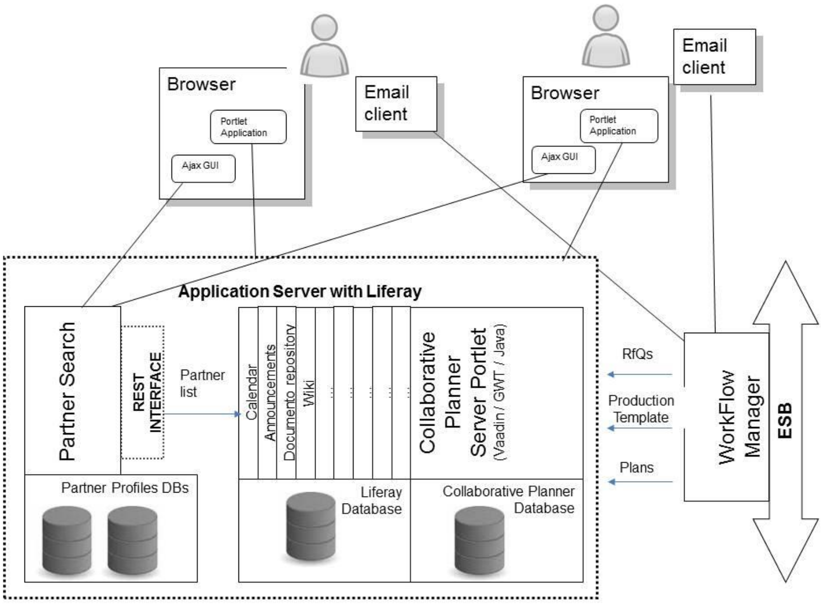


Figure 72 - Supply Chain Architecture Diagram

The diagram presents the technical choices performed for integrating the tools developed to support the Collaborative Planning network design and set-up. The application was made available to the end users through a unique access point, based on the Liferay portal that enriches these services with social networking functionalities and advanced communication services for commenting, ranking, reporting bugs and asking for assistance. The proposed approach provides several benefits for manufacturers and suppliers of the textile and footwear sectors that are looking for agile solutions for the order management and the collaborative production plan processes supporting the production of small series of innovative and fashionable products. Indeed, the solution:

- is easily accessible and straightforward to use, as the tools provide advanced GUI and are available within a unique portal (thus no installation is required);
- supports the exchange and the automatic check of business information through well-known channels, like the emails (hiding technical details about the internal format of the exchanged documents);
- helps the selection of partners leveraging on information already owned by the manufacturer and provides an open and collaborative environment where planning with the selected ones an agreed production plan.

The Collaborative Planning framework allows each partner to directly propose new delivery dates, lead times and costs, via a web-based planning graphical tool which is available and shared by all supply network partners. Every time a partner proposes a change on a given operation, it is (actually) asking the affected partner to accept this change (and declare its cost) or to make a counter-proposal. Each negotiation round corresponds to a pre-defined period available to discuss/negotiate delivery times and costs, allowing partners to present quotations for each request-for-quotation (RfQ) performed by other partners.

Each proposed change (which "triggers" RfQs to all involved partners), actually asks the partners to present quotations, which might totally or partially meet, the asked RfQ or even suggest new changes. When a proposal has 100% agreement of all partners (i.e., "no pending notifications"), it is considered a plan; although it might be changed by any supply network partner, as long as the negotiation period is not expired.

For each negotiation iteration, the intelligent planning module suggests a new stage framing which in turn generate responses that assessed by the optimization module providing improved solutions for the collaborative planning process.

Based on the set of criteria defined in advance by the broker and the partners, the optimization module serializes the feasible collaborative plans according to the set criteria.

For each of these criteria, it is possible to define a degree of importance, using a percentage score as a final weighting factor, which will be used to calculate the best partner proposal. In this way, each criterion has not got the same importance, but each one has got importance expressed by a ranking system.

5.3.3.8. Application Case – Analysis and Results

In order to test and validate the Intelligent Collaborative Planning Framework proposal, it was constructed an application case based on the footwear sector industry. This application case scenario considered a three-stage production process. For each one of the production stages, the Partner Search module identified four potential partners with the relevant KPIs presented in

Table 34. Afterward, the broker and the selected partners collaboratively define the criteria that will support subsequent decisions in the process, namely the multi-criteria assessment of the plan proposals.

Table 34 - General case information

Information About Partners			
	Collaboration Degree	Quality Certification	Location (kms)
Partner 1	90	1	100
Partner 2	100	1	120
Partner 3	95	0	50
Partner 4	85	0	15
Partner 5	75	1	25
Partner 6	82	1	35
Partner 7	85	0	60
Partner 8	90	0	48
Partner 9	100	1	50
Partner 10	95	1	150
Partner 11	90	0	120
Partner 12	85	0	30

Table 35 presents the selected criteria and the corresponding weight.

Table 35 - Selection of evaluation criteria

Evaluation Criteria				
Parameter		Weight	Option Selected	Formula
Date			Cost -> Vector normalization	(1/value)/(1/minimum)
Cost		0,7	Cost -> Vector normalization	(1/value)/(1/minimum)
Partner	Certified	0,1	Benefit -> Linear Normalization	value/maximum
	Collaboratio	0,2	Benefit -> Linear Normalization	value/maximum
	Location		Cost -> Vector normalization	(1/value)/(1/minimum)

The selection of the efficient solution relies on the evaluation of all alternative collaborative plans assessed through a criteria analysis. Since the different criteria have different scales, it is necessary to use a normalization operation in the serialization of the criteria. For the present case, was selected a linear normalization according to the following cost $C(x)$ and benefit $B(x)$ transformations, respectively, for minimization and maximization criteria:

$$C(x) = \frac{\frac{1}{x}}{\frac{1}{m_{\text{ND}}}} = \frac{m_{\text{ND}}}{x}$$

$$B(x) = \frac{x}{M_{\text{ND}}}$$

where m_{ND} and M_{ND} are the minimum and maximum objective function values of the solutions found in the optimization process.

A weighted value function $V(x)$ is computed to score all solutions found:

$$V(x) = W_1 C\big(f_1(x)\big) + W_2 B\big(f_2(x)\big) + W_3 B(f_3(x))$$

where W_1, W_2 and W_3 are the weights established with the partners. The assessment of solutions according to the value function results in values between 0% and 100%, which represents the score of the alternative collaborative plan. The closest to 100%, the better the collaborative plan.

Table 36 presents an evaluation of five alternative plans, considering the agreed criteria items, which consider the cost, Collaboration degree, Quality certification.

Table 36 - Evaluation criteria for alternative plans

Normalized Decision Matrix					
	Cost	Collaboration	Quality	Partners	Plan Score
Alternative Plan 1	0,983333333	0,862068966	0,666666667	1; 5; 10	92,741%
Alternative Plan 2	1,000000000	0,879310345	0,333333333	3; 5; 11	90,920%
Alternative Plan 3	0,973009447	0,862068966	0,666666667	3; 5; 10	92,019%
Alternative Plan 4	0,990070922	0,862068966	0,666666667	1; 6; 11	93,213%
Alternative Plan 5	0,993226899	0,862068966	0,666666667	1; 5; 12	93,434%

5.3.3.8.1. Capacity Models

In order to allow the adequate testing of the intelligent collaborative planning framework in the application case scenario, it was necessary the implementation of capacity models that could reflect each partner behavior during the negotiation. Since this capacity model information was considered confidential by the industrial partners in the project, in the project was necessary to develop a static capacity model for each one of the involved partners.

Using the experimental approach presented by Witte (1996) work, each one of the capacity models followed the behavior presented in the load chart represented in Figure 73. The author sustained that static capacity modeling can simplify the data collection and the validation effort necessary to respond to the market demand.

In reality, the concept is very straightforward. In the time horizon considered, it is possible to establish a relationship between the demand load with the cost reply for quotations. By analyzing the planning time horizon, it is possible to identify three areas. The first area on the right side of the load diagram corresponds to the short-term period where the production capacity of the partner is fully committed and the cost of producing in this period is higher. In the second area, the medium-term period, the load usually decreases over time, and the corresponding cost for the quotations reply from the partner follow the same trend. On the other hand, the third zone corresponds to a long-term period in the future where the capacity load is minimal, and the cost reaches its structural minimum.

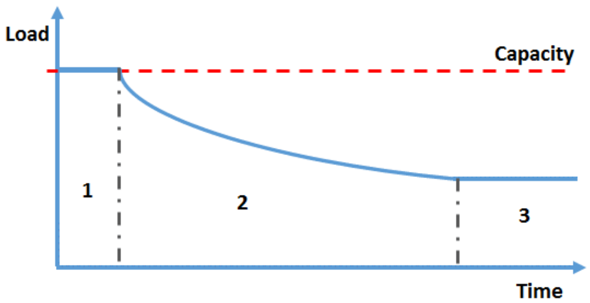


Figure 73 - Static Capacity Model for Partners

Based on the described approach, and using data provided by the industrial project partners, it was possible to define the necessary capacity models used in the application case.

5.3.3.8.2. Optimization Module

The optimization module was implemented in MatLab version R2015a [MatLab]. The optimization problem was coded in MatLab language and solved using the intlinprog function provided in the Optimization Toolbox version 7.2. This function implements the Branch-and-Bound algorithm for linear integer programming problems.

The solutions found during the optimization process correspond to the optimal ones according to the objectives in each iteration. Each one is an alternative plan that is assessed. The criteria analysis allows selecting one of these solutions by the computation of value function according to the weights established with partners. For illustration purposes, in Figure 74, the solutions obtained on the 5th iteration of the negotiation are plotted in terms of cost, collaboration level, and quality certification.

It is necessary to refer that the partners' selection problem has a combinatorial nature and there is a large number of different feasible solutions. The optimization process provides the means to find the optimal solution. In cases where there is a tie, the decision-making process offers a trade-off analysis between tied optimal solutions to support the choice of the final solution.

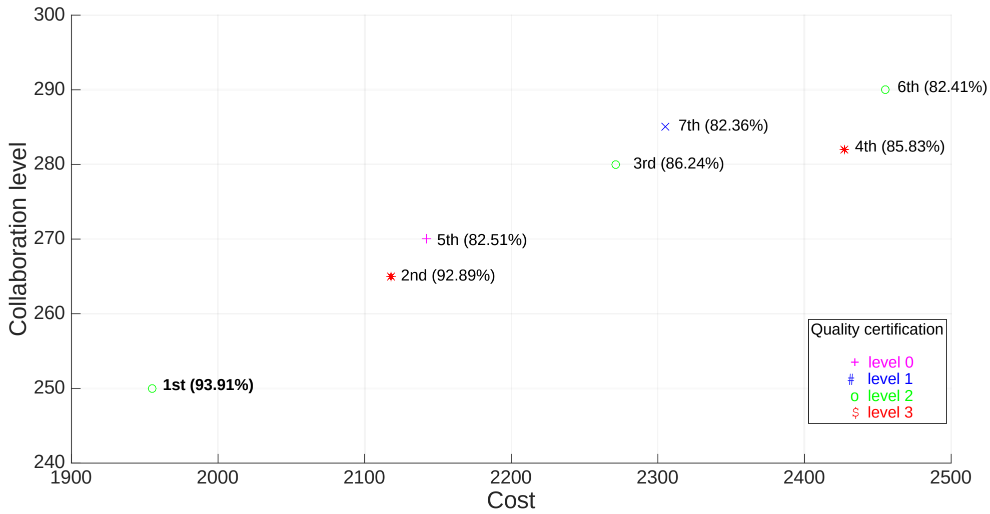


Figure 74 – Example of solutions assessment according to the evaluation criteria

5.3.3.8.3. Intelligent Planning Approaches

As presented in the Intelligent Collaborative Planning Framework description, the Intelligent Planning module is a facilitator in the iterative search for better collaborative planning solutions. This module works as feedback mechanism where the optimized outputted solutions of the optimization module are analyzed, transformed and routed back as inputs to the circuit of the collaborative planning negotiation in the next iteration as part of a cause-and-effect loop.

Using the four implemented strategies for the intelligent planning module (see Table 37) it was possible to assess the rate of improvement of the multi-criteria evaluation of the optimized alternative collaborative plans on each iteration. Annex E presents the sample code implemented for the present example.

Table 37 presents the intelligent planning module results comparison for each strategy on all the iterations using a linear normalization procedure.

The assessment of each one of the strategy approach, show that all four strategies implemented for the Intelligent Planning module present a significant improvement of results during the negotiation process. In the 5th iteration, the results show that the maximum deviation between the worst and the best result is less than 5.4%.

Table 37 - Intelligent Planning Strategy Results Comparison

Intelligent Planning Strategy	Average	Weight Average	Best Proposal	Genetic Approach
Iteration 1	0,7984971	0,7984971	0,7984971	0,7984971
Iteration 2	0,8219750	0,8559725	0,8457682	0,8371205
Iteration 3	0,8430391	0,8651374	0,8799396	0,8753838
Iteration 4	0,8738795	0,8774835	0,9137538	0,9014386
Iteration 5	0,8886209	0,9038363	0,9390805	0,9258324

According to Table 37 the best strategy approaches were the "Best Proposal" and "Genetic Approach," and the results differences were less than 1.5% in the criteria evaluation score.

5.3.3.8.4. Overall Results

The preliminary analysis of the results in the application case showed that the proposed framework achieved interesting results. Coincidently, the feedback from the project's industrial partners' assessment of the framework was very positive.

The analysis of Table 38 shows that depending on the number of iterations in the negotiation of the collaborative plan, the different strategies generate different outcomes. In the present application case for two iterations, the "Weight Average" strategy presented the best results. For a higher number of iterations, the best performing strategy turned out to be the "Best Proposal." Nevertheless, all four of the empirical strategy proposals presented promising results.

Table 38 - Iteration Improvement of Collaborative Planning Evaluation

Intelligent Planning Strategy	Average	Weight Average	Best Proposal	Genetic Approach
Iteration 2	3,25%	7,28%	5,86%	4,80%
Iteration 3	5,69%	8,11%	10,14%	9,62%
Iteration 4	9,63%	9,68%	14,37%	12,90%
Iteration 5	11,51%	13,04%	17,54%	15,97%

The final analysis of the results shows that although the complexity of the multi-site planning task of a collaborative network was very high, the present proposal has advantages compared to the traditional centralized and multi-hierarchical negotiation approach.

Also, it was obvious during the study that the use of the feedback loop enabled the system to learn from previous responses, adding knowledge to the negotiation process, which at the end generated better results.

5.4. Summary and Conclusions

The TCFI field analysis has shown that the generic scenario of SME independent companies' in collaborative networks, traditionally requires the consideration of cross-sector interactions across the network. This reality occurs since some activities like customers' requirements analysis, product and process design, production planning and product delivery need to be synchronized and collaboratively integrated into complex scenarios.

The present Intelligent Collaborative Planning Tool proposal aims to offer a practical and integrated set of methods, tools and web-based technologies to assist SME independent companies to integrate and engage fully operational and heterogeneous collaborative networks.

The already concluded European project called "Customer-oriented and eco-friendly networks for healthy fashionable goods (CoReNet)" provided the initial momentum and valuable knowledge for the development of this Collaborative Planning Tool.

One of the significant outcomes of the CoReNet project was the development of a web-based platform where the actors involved in the collaborative network activities could find information, interact, obtain support and easy access to the tools developed and configured within the collaborative community.

The collaborative platform evolved with further development work and subsequently included the designed methods and tools proposed in the Intelligent Collaborative Planning Tool. The current demonstration prototype of the web-based collaborative platform is now able to support the set of collaborative services comprised in the overall Customer-Focused Supply Chain Framework.

The novelty of the present approach derives from the implementation of the tools and methods required in the non-hierarchical decentralized collaborative planning model. This model links a mathematical optimization algorithm with an intelligent planning module which feeds the optimal solution search engine with a feedback loop enabling the system to learn from previous responses, minimizing the number of negotiation iterations.

The preliminary collaborative planning results have been very promising for the tested application cases, and the industry partners that integrated the project recognized the merits of this approach.

As further developments, the development team intends to additionally evaluate the current software prototype of the Intelligent Collaborative Planning Tool with more application cases based on other industrial sectors.

Another research path includes the research and development of other intelligent planning strategies aimed to make the tool approach more flexible and effective.

In summary, the set-based development approach, enhances early and efficient learning and knowledge acquisition, so that enough information is available before decision making. It assists the project manager in redefining the search areas for the most relevant parameters experimentation. Through visual representation of the data collected, it disseminates and integrates the knowledge to all the different members of the product development team. The approach supports collaborative learning and the involvement of many areas of expertise among the collaborative network, but also the relevant stakeholders' commitment to address business opportunities responsively. Also, by allowing delayed decision-making until enough knowledge is acquired, enables wise decisions and not guessing. It also supports collaborative, converging in decision-making by assuring that decisions in one area will not impact decisions on other areas.

Through a parallel development of a collaborative portal, this new set-based design approach integrates a web-based toolset, which supports the necessary mechanisms for network formation, the networked design of complex products and the intensive gathering and reutilization of knowledge in networked environments.

As future developments, we intend to improve the proposed approach based on the contributions and comments of the industrial users. Simultaneously, we plan to foster the ongoing development of more efficient and reliable knowledge-based tools embed on the lean approach of set-based design for networked collaborative environments.

In order to test and validate the concepts presented in this new holistic framework, a specific set of methods, tools and technologies were defined with the purpose to support the formation and the operation of collaborative networks for production of innovative and fashionable products enabling synchronized product design, production and delivery of functional answers to consumer needs. A key element in order to deploy these services for the supply networks stakeholders is the Collaborative Portal (see Figure 72).

In conclusion, the Collaborative Portal as a "proof-of-concept" prototype is a web-based tool designed to help managers in the face of business opportunities to:

1) configure and form collaborative networks;
2) allow the manufacturers to manage knowledge about its suppliers and partners;
3) support the creation and updating network knowledge using a set-based approach;
4) foster the assessment of network members' performance through the visualizing of selected key performance indicators.

Chapter Six

CONCLUSIONS AND FUTURE RESEARCH WORK

Presented the set-based customer-focused framework proposed in this research project, as well as the different application tools designed and implemented as a proof-of-concept, chapter six is strictly related with the overview and discussion of the project results and its generalization. Hence, this chapter not only includs some considerations related with the current state and trends of the supply chain management discipline and body of knowledge but also summarizes the work done to answer the research questions presented in chapter one. Moreover, it includes a description of the main outcomes of this research project, both from scientific and industrial perspectives, as well as the directions to be followed in future research.

6.1. Main Conclusions

The objective of this research work was to increase the understanding of the supply chain management discipline, namely by addressing the main challenges that managers and the different supply chain stakeholders are facing in the present turbulent marketplace.

Over the last decade, a broad spectrum of manufacturing companies has come to perceive the concept and practice of supply chain management as their most important strategic discipline for competitive advantage. It is widely recognized that adequate management practices supported by suitable technology toolsets possess immense transformational power and empowers companies' ability to innovate the very foundations of today's business structures.

Supply chain management has gain an increasing importance, because companies have realized that their capacity to continuously reinvent competitive advantage depends less on internal capabilities and more on their ability to look externally. Company managers are increasingly looking for their networks of business partners in search for the right set of resources that helps them conceive and implement the adequate set of processes in order to attain the competencies that will enhance their organizations, core product, and process strategies.

Simultaneously, companies' managers are increasingly challenged to reduce the time to market response (lead time between technical or market opportunity arising and the fulfillment of the customer need with full-rate production) of demanded products or services. The time to market on the case of innovative and fashionable goods is a critical factor which dictates the success of the company, since all competitors gain access to new technical ideas and new market information at about the same time, and the ones who succeed are the first to reach the market with their products.

At the same time, it is observed continuous empowerment of the customer role in the definition of the company's products portfolio. This trend has altered the way companies design and manufacture products. At the design level, it has compelled companies to evolve from a designer-centered approach to a co-designing attitude in which the roles of the designer, the researcher and the 'customer' are interconnected. Moreover, at the manufacturing level, this momentum has resulted in a profound impact in the product set of configurations and features, product volumes and response lead time. Due to the mass customization requirements imposed by this customer empowerment, it has been observed a dramatic increase in products variety and complexity as well as decreasing products life cycles. This reality has been directly affecting the manufacturing systems management, due to the increase of both static and dynamic complexities.

While the static complexity is directly linked with the system's structure and configuration, the number and the variety of the products, the system's variety of components (e.g. labours, machines, buffers, transportation mechanisms), as well as their interconnections and interdependencies in the supply chain. On the other hand, the dynamic complexity is related to the uncertainty of the system's behavior for a specific time period, the demand uncertainty, the behavior of the competitors and the occurrence of unpredicted events that disrupt the supply chains. This increase in complexity is demanding for collaborative and customer-focused solutions that support companies in addressing the challenges posed by the current and upcoming global marketplace.

Nowadays, no corporate leader believes that organizations can survive and compete isolated from their networks of suppliers and partners, and particularly disconnected from their customers. Indeed, the definitive core competency an enterprise may possess is not found in a temporary advantage it may hold in a product or process, but instead in the ability to continuously enable and implement market-winning competencies arising from collaborative alliances with their supply chain partners.

Unquestionably, companies' managers have always recognized that relying on the capabilities of business partners could compensate for their operational deficiencies, thereby enabling them to expand their competencies and reaching the marketplace with increased competitiveness. Nevertheless, till recently there were limits to how strong these relationships could be due to companies' natural resistance to share market, process, and product knowledge, to difficulties in communicating and integrating their ICT systems, and the incapacity to identify, form and integrate collaborative networks of independent companies that are suitable to constitute their business channels.

Our research demonstrated that three significant changes are enabling companies to profit from the power of supply chains to a degree unattainable in the past. The first, the present generation of ICT technologies are now enabling the integration of SCM and ERP systems with specifically designed networking toolsets capable of connecting all partners into a single supply chain community. Second, new collaborative network management concepts and practices have materialized in recent years which foster the development of new technologies and their practical application in the supply chain universe. Finally, the third change, due to the transformation of the global market, a company operating in every business environment is now required to work in and with supply chains. Undeniably, the companies that can master networked-enabled technologies are the ones that are gaining in today's highly competitive global marketplace.

As a result of the growing need for network integration, organizations are becoming increasingly dependent on the support of the adequate set of management tools based on state-of-the-art ICT technologies. These technologies are required to assist the collaborative design of new products and services, the products life cycle management and in particular at the operational level the network production planning and flow management processes. In order to companies pursue the objective to become a networked-enabled organization, it is require it is required that they endorse new practices and methods but also a supportive infrastructure that assures them control over the business processes they establish with other companies and simultaneously enables them to be agile, adaptive and flexible in order to react proactively to the market demands.

The supply chain growing focus of today's enterprise came in response to several critical business requirements that have conditioned the way companies do business and define strategies. With this in mind, the present research project aimed to study the supply chain management subject and analyze which are the critical business requirements that support the creation and operation of the future supply chains.

At the beginning of this project research, after the analysis of the state-of-the-art literature, it was identified the need for a comprehensive classification schema of supply chains and networked organizations. In order to fill this gap, the present work proposed a **classification schema for supply chains** that take into account the present literature achievements on this subject but also included relevant field data from specific industrial cases in different sectors and scenarios. The proposed classification model lays on a three-dimensional axis: demand & sourcing; product & process; and infrastructure. This classification model is intended to assist supply chain managers in defining the adequate manufacturing strategy for the overall supply chain network.

A second research axis focused in the transient behavior of the market and the impact it has on supply chain decision-making. Changing market conditions can influence demand patterns and effectively change for instance functional products into different types of products such as innovative that are bought in different ways. Companies' managers, facing a competitive market, are constantly challenged to reduce the lead time between technical or market opportunites arising and satisfying the customer needs. Notably, the time to market in the case of innovative and fashionable goods is a critical factor to achieve competitiveness.

Simultaneously with the increasing empowerment of the customer role, the design focus has been shifting from a designer-centered approach to a co-designing attitude in which the voice of the final customer is crucial. All of these factors have a profound impact on supply chains' products design processes, production planning, and manufacturing operations. Therefore, the present research proposed a customer-focused supply chain framework, composed of tailored business processes, practices, and tools, aimed to support the different supply chain stakeholders in better understanding the complexity of the future supply chains, and cope with the foreseen competitive factors.

Thus, the primary outcome of this research work is the **Set-Based Customer-Focused Framework** build to enable companies to self-organize their networked resources, to design their business operations properly and provide the necessary competencies to tackle the target customers demand of innovative, fashionable and sustainable products. The framework comprises three elements in its conceptual view: *resources; processes* and *competencies* in accordance to the previous objectives and lays upon the lean inspired set-based thinking in order to continuously collect and share useful knowledge from the different stakeholders of the collaborative network. The framework was instantiated in a Collaborative Portal that offered a set of the three collaborative tools: *Knowledge Management Tool; Set-Based Product Design Tool* and *Collaborative Planning Tool*.

In summary, it is the author's belief that the results of the present research work contribute to the body of knowledge of the supply chain management discipline.

6.2. Explanation of the Research Questions

The present research project aimed in bringing further knowledge and insights for the transformation that present-day supply chains management practices and approaches are currently undergoing. Namely, by bringing further awareness on how supply chain managers can collaborate in addressing consumers unpredictable demand for customized, value-added and sustainable products not only in terms of quality but also in terms of innovative functionalities and responsiveness.

In line with this focus, this research work seeks to answer the two research questions initially proposed, which guided this entire project.

RQ1. How to describe and characterize the current supply chain instances?

The literature and the field study undergo during this research project have shown that the ultimate goal of supply chain managers is to continuously reach the markets faster than the competition with the right products, have the capacity to meet the differentiated forms of customers demand with increasingly faster delivery times, and to ensure that the supply chains are synchronized in order to efficiently and effectively meet the marketplace demand.

As a preliminary effort to seek an answer to this first research question, the state-of-the-art research identified three main operational supply chain management strategies. The first, identified as efficient/lean, where the focus is to efficiently supply a predictable demand at the lowest cost for their functional products. The second strategy called responsive/agile where the primary purpose is to respond as quickly as possible and as flexible as possible to unpredictable demand in order to reduce obsolete inventory and stocks run out. Moreover, a third approach, called hybrid/leagile where there is a combination of both previous production paradigms separated by a decoupling point. This decoupling point is the point that separates the segment of the supply chain oriented toward customer orders (agility part) focused in the responsiveness, from the segment of the supply chain (leanness part) which is based on planning a smooth and standard production flow with the aim of minimizing costs.

During the field study, it was possible to identify each one of these three-operational supply chain management strategy depending on the characteristics of the products and the market conditions the companies were strategically addressing.

Complementarily, to bring a more in-depth understanding regarding the supply chain body of knowledge, the present research addressed the study and classification of networked organizations in its diversified heterogeneous dimensions. Aiming to achieve this goal, during the research project it was proposed a comprehensive classification schema of networked organizations mapping the resources, competencies, organizational context, regulatory aspects, and market approach dimensions. This supply chain classification proposal is intended to clarify the distinction between the different network infrastructures, value proposition offers and market approaches observed in the contemporary supply chains. The classification schema comprises three main dimensions: product; demand & sourcing; and infrastructure and include a set of decision support guidelines for the definition of the "most suitable" operational strategy for each of the classification dimensions. The classification model also included a trade-off curve analysis, where the decision maker is helped in understanding which compromises or trade-offs are required in the strategic repositioning of the supply chain in the classification dimensions.

Aiming with the objective of identifying and clarifying the supply chain management strategies and best practices that company managers have implemented to attend the various forms of market demand implicit in the Research Question 1, the present research project performed a sectorial case analysis. The industrial sector selected due to its characteristics and importance for the European economy was the fashion footwear industry sector.

At the first stage of the sectorial multiple case analysis, the focus was in the "as-is" description of the current business processes, identifying its main actors, production processes, available ICT tools and systems, organizational strategic and operational decisions, and sustainability policies and processes.

The "as-is" analysis has shown that the competitive situation of companies in the footwear sector is characterized by a firm orientation towards product individualization, especially in the case of specific customer segment groups. Simultaneously, the study has revealed an increase of the customer power, which has driven companies to differentiate their products from those of competitors by providing personalized and innovative solutions in an increasingly reduced period.

From the case study analysis, it was possible to identify and describe the current relevant business processes through scenarios description collected on site. These scenarios were directly linked with the major stakeholders' activities related to the footwear companies supply chain. This business process analysis described the different types of business partners, and their respective activities, the material flow along the supply chain, and information and knowledge flow between all involved partners in the form of information objects and messages.

The study has shown that the conventional supply chain strategies and practices followed by most companies are under transformation due to factors such as the convergence of Internet as a communication medium, the emancipation of consumers which increasingly demand high-customized, fashionable and innovative products. This change is challenging the way traditionally the companies design their business processes and interact with each other in the supply chain.

As reported in the case analysis interviews, managers are now seeking to adapt their business processes to a new view where a company is required to operate and cooperate in a more integrated networked environment in order to address the new evolving and volatile markets and incorporating a customer-driven behavior.

RQ2. Which business processes, methods, practices, and tools are required for customer-focused supply chains address the marketplace challenges?

During the "To-Be" phase analysis of the multiple case analysis, nine business processes were identified and detailed. They were: market analysis, the definition of collection, specific product design and modeling, collaborative process planning, partner search, customer order processing, product-specific collaborative process planning, collaborative production planning, and production control and monitoring.

From the description and analysis of these nine business processes, it was possible to identify which present processes, practices, and tools need to be transformed or created in order to customer-focused supply chains address the marketplace demand for innovative, fashionable and sustainable products.

As significant conclusion, the analysis identified three critical requirements which the customer-focused supply chains must address. The first is related to the customers and market knowledge. Companies require means to fully comprehend market trends in advance and identify specific consumer groups in order to design and develop the appropriated products and services. The second requirement is linked design capabilities that companies must have in order to offer differentiated products with shorter time-to-market responses and competitive prices and quality levels. This need requests the support of tools and methods that effectively allow the use of distributed resources, competencies and the management of the derived knowledge and information in a collaborative product design approach. The third requirement for customer-focused supply chains is associated with the need for collaborative planning support of tools and methods that allow the coordination of manufacturing operations between independent companies belonging to the same supply chain.

In line with the previous case analysis results, this research project proposed and developed an innovative customer-focused supply chain lean-based framework. This framework defines at the strategic level three vectors (processes, resources, and competencies) that support the creation of the necessary collaborative business processes. These strategic vectors are aligned with four environmental dimensions (organizational, knowledge, ICT and sustainability) in the definition of the strategic vision and policies for the high-level management decisions of the collaborative network. At this level, the framework seeks to support the selection of the strategic partners which will support both the design and the manufacturing of the supply chain products.

Concerning the framework tactical level, the supply chain relevant business processes were identified and detailed. These business processes were tailored with a focus in supporting the collaboration mechanisms among the supply chain. The selected business processes included in the framework range from knowledge-intensive market analysis to collaborative production control and monitoring and include collaborative process planning, partner search mechanisms, and collaborative product design and production planning.

At the operational level, the framework fosters the practices, methods, and tools necessary for the implementation of the previously defined business processes. Therefore, three prototype web-based tools were developed and included in the framework "proof-of-concept."

The first tool called ***Knowledge Management Tool*** was conceived to support designers to identify market trends and monitor the behavior of their customers and, thus, be able to respond quickly to changes to the market demand. The proposed approach is based on a combination of structured and unstructured data sources and is intended to describe the different entities behavior ranging from customers, retailers, and other designers.

The second prototype tool was named ***Set-based Product Design Tool***. This tool inspired on the lean approach of Set-Based Concurrent Engineering aimed to support a knowledge-intensive collaborative design networked environment of complex and innovative products.

The third and last tool, called ***Collaborative Planning Tool*** was developed with the objective to supportt collaborative production planning in a network environment. Following a decentralized negotiation model, in a non-hierarchical network of independent companies, delivers optimized collaborative plans for the entire supply chain.

As a "proof-of-concept" and as a mean for industrial users and academic researchers test and validate the proposed set-based customer-focused framework concepts and tools a web-based Collaborative Portal was designed and implemented. This Collaborative Portal provides several benefits for manufacturers and suppliers integrating collaborative networks that are looking for agile solutions for the order management and the production plan processes supporting the production of small series of innovative and fashionable products. Indeed, the solution:

- is easily accessible and easy to use, as the tools provided advanced GUI and are available within a unique portal (thus no installation is required);
- supports the exchange and the automatic check of business information through well-known channels, hiding technical details about the internal format of the exchanged documents;
- helps the selection of partners leveraging on information already owned by the companies and provides an open, collaborative environment where planning with the selected ones an agreed production plan.

6.3. Main Contributions and Achievements

The present research work started with the objective of providing a better understanding of the supply chains management approaches that are going to subsist and emerge in the near future of a globalized marketplace. Aligned with this objective, the research effort was directed in pursuing a better understanding of which organizational forms supply chains are urged to adopt. These organizational new forms companies need to adopt are required in order to respond to the challenges that are meeting in a worldwide marketplace, the critical business processes that they need to endorse and sustain, and the supporting technologies and ICT tools that they need to acquire and develop.

In line with this research guidelines, it was identified a set of present, and future challenges in the way companies do business, and in the way, they design the supply chains to reach the marketplace for their products and services. This analysis helped to characterize the supply chain management area of study, in terms of current industrial company's needs, as well as the trends and innovative solutions that were developed with the aim to overcome these challenges.

The following section will describe shortly the primary outcomes of the present research project, envisioning the enhancement of knowledge in the supply chain management discipline.

I. Classification Schema for Supply Chains

Aiming to provide a better understanding of the different types of supply networks in the way they are characterized and classified, this research project presents a classification schema proposal for supply networks. This classification schema is intended to assist managers and decision-makers in better understanding the characteristics of the supply chain networks they integrate, and its positioning concerning other networks in the business market. The model helps to clarify the different network structures, value proposition offers, and market approaches observed in the contemporary supply chains.

The analysis schema is based on three main dimensions: product; demand & sourcing; and infrastructure. With the integration of these three dimensions in a single multidimensional building, it is provided for the company decision-makers a comprehensive classification model to assist them in defining the adequate operational strategy for a supply chain based on the previous model dimensions.

Departing from the premise that operational competencies are ruled by trade-offs defined by the operational system of resources and processes, the classification model guides managers in identifying which are the relevant trade-offs that must take into account in their business model.

Since organizations have finite resources, this means that the selected operational strategy must shape and conform to the adequate trade-offs balance by constraining the adequate resource settings and network profile and activities. The adequate operational strategy must be aligned with the overall supply chain strategy, and through the trade-off curves analysis, it is possible to assess it quantitatively (by NPV increase or cost reduction) or qualitatively (by evaluating if supply network competencies are aligned with the customer value proposition).

The present supply chain classification model, by considering an operational trade-off approach assists the supply chain managers inside a specific network organization to better understand their positioning regarding other competing organizations in the market and perceive which compromises or trade-offs we must undertake in the strategic repositioning of the supply chain for the relevant classification dimensions.

Hence, using this conceptual view, it is possible for a specific network manager when defining its competitive strategy use the ability to shape the trade-offs and choose an appropriate competency positioning point for their network.

II. Set-Based Customer-Focused Framework

The framework aims to support companies in the definition and creation of customer-focused supply chains for the demand of innovative, fashionable and sustainable products. The proposed framework offers a conceptual and functional view of the value chain formation and operation in a collaborative environment.

Simultaneously the framework offers a practical and integrated set of methods, tools and web-based technologies to assist non-hierarchical independent companies to integrate and engage effective, efficient and responsive value chains in a collaborative networked environment.

The current implementation of this framework included the development of three tools. The first, **KMT** (Knowledge Management Tool) aimed to collect market knowledge regarding consumers' trends and expectations for innovative and fashionable products. The second tool, **Set-BasePD** (Set-Based Product Design Tool) targeted to support the collaborative design of complex and innovative products in a network environment. Moreover, the last, **CPlan** (Collaborative Planning Tool), a tool designed to assist and support negotiated collaborative planning in customer-focused supply chains of independent and non-hierarchical networks of companies. These tools were embedded in web-based a Collaborative Portal.

The Collaborative Portal was designed to assist supply managers in addressing and identify business opportunities of innovative and fashionable products; in configuring and forming collaborative networks; in creating and gathering product design knowledge using a set-based approach; and collaboratively plan and manufacture products in network environments.

It is our view, that this framework proposal enables a vision of a technology-enabled supply chain, which requires companies to embrace management practices that are more flexible, responsive, and networked through increased interconnection, intelligence, and collaboration. The present proposal, aligned with the current transformational trend found in collaborative networking, includes a set of tools and technological supported methods that enables companies in addressing the growing demand of innovative and fashionable products efficiently and responsively through the application of supply chain information technologies.

As a final retrospective, the results of the present research project include contributions above, the Collaborative Portal prototype (including the described set of tools) and twenty research papers submitted to peer-reviewed international conferences and international journal (cf. Annex F).

6.4. Research Limitations

Even though the present research project followed sound and well established methodological approach in the way the research was conduct, the author recognizes the following limitations and weaknesses related to the results and research outcomes:

Use of the research results – due to the complex nature of the studied entities (supply chains), the research itself was not intended to collect data and measure the quantitative behavior of a specific variable, but to analyze the different structures and knowledge that people place upon their business activities in a supply chain environment. Since this kind of study, aims to understand the subjectivity of social complex phenomena, namely collecting requirements, it required a qualitative approach and specifically Design Science Research methodology. Qualitative research is designed to explore the deep structure of the phenomenon using compact descriptions that explore the multiple dimensions and properties of the phenomenon. In this case, the research methodology followed a grounded theory and a rigorous approach. Therefore, a multiple case analysis was carried out during the research project specifically restricted to the fashion footwear industry sector. This sample selection was intentional due to the innovative and fashionable characteristics observed in the products demand of this industrial sector. Nevertheless, this choice created obvious difficulties in the effort to generalize the results to other industry sectors. Despite these limitations, the results obtained from this study were later applied and tested in other industrial sectors such as Textile and Clothing with significative results and positive comments.

Supply Chain Classification Schema validation – the classification proposal for supply networks presented in this work was built from supply chain state-of-the-art literature and relevant field data retrieved from specific industrial case analysis in the TCFI industry sector. The model established correspondences between classification dimensions and operational strategies. These correspondences are retrieved from literature frameworks and integrated into a single analysis model. During the project period, it was possible to perform particular tests to the classification model applicability and results. Nevertheless, these tests were limited and insufficient to fully and independently validate the supply chain classification model.

Set-Based Supply Chain Collaborative Tools applicability in hierarchical environments – the need for increased flexibility is forcing companies migrating from traditional forms of functional commitment with focal companies in classical forms of supply chains into innovative scenarios where the focus is in the optimization of core activities for each partner in collaborative networked environments. Usually, these environments are composed of independent non-hierarchical companies. This reality was the pre-condition for the design of the set-based customer-focused framework and the correspondent development of the supporting toolset. Nevertheless, the current and possibly the future supply chain landscape will include traditional focal companies which operate in hierarchical environments. In this case, the present framework is not adequate, and traditional SCM systems are presently the best approach for the supply chain management of this kind of supply chains.

6.5. Future Research Directions

As a roadmap for future research initiatives, a series of investigation directions have already been defined in order to enhance the research work here presented. The first primary objective as future developments for the research team is to continue testing the current Collaborative Portal prototype through the contributions of the industrial users. Simultaneously seeking to add to the current set of tools other methods and tools that contribute to the ongoing effort to deliver a more efficient and reliable knowledge-based framework designed to assist companies operating in collaborative networked environments.

A second objective is to proceed with the development of the Supply Chain Classification Model. This development integrates two phases. The first phase aims to fully validate de classification model through a larger sample, testing it in companies from various industrial sectors. The second phase includes the development of a integrated trade-off analysis decision support tools intended to assist network managers defining its competitive strategy by shaping the trade-offs approach that best fits their competency positioning in the supply chain.

A third future research objective is to pursue the development of collaborative planning solutions in non-hierarchical networks of independent companies. The present collaborative planning approaches are still focused on delivering order promising capacity validate responses through aggregated planning mechanisms. Nevertheless, to fully explore the competencies and intrinsic potential of the different partners in a collaborative network, it is necessary to introduce collaborative production scheduling mechanisms that fully integrate the entire supply chain and provide cost effective and responsive solutions.

REFERENCES

References

(CSCMP), Council of Supply Chain Management Professionals. 2013. "Supply Chain Management Definitions." accessed 08-05-2013. http://cscmp.org/about-us/supply-chain-management-definitions.

Agarwal, A., R. Shankar, and M. K. Tiwari. 2006. "Modeling the metrics of lean, agile and leagile supply chain: An ANP-based approach." *European Journal of Operational Research* 173 (1):211-225.

Aitken, J., P. Childerhouse, and D. Towill. 2003. "The impact of product life cycle on supply chain strategy." *International Journal of Production Economics* 85:127-140. doi: 10.1016/s0925-5273(03)00105-1.

Akkucuk, Ulas. 2016. "SCOR model and the green supply chain." In *Handbook of research on waste management techniques for sustainability*, 108-124. IGI Global.

Almeida, António, Roberto da Piedade Francisco, João Bastos, Américo Azevedo, and Paulo Ávila. 2011. "Performance and Risk Assessement Framework for Sustainable Networks." Business Sustainability II, Póvoa Varzim - Portugal.

Anderson, Carl R, and Carl P Zeithaml. 1984. "Stage of the product life cycle, business strategy, and business performance." *Academy of Management journal* 27 (1):5-24.

Anderson, John C, Gary Cleveland, and Roger G Schroeder. 1989. "Operations strategy: a literature review." *Journal of Operations Management* 8 (2):133-158.

APICS. 2008. APICS Dictionary. In *The standard for excellence in the operations management profession*, edited by John H. Blackstone Jr.: APICS The Association for Operations Management.

Ávila, Paulo, Alzira Mota, Lino Costa, Goran Putnik, João Bastos, and Manuel Lopes. 2014. "Two approaches for the resolution of a resources system selection problem for Distributed/Agile/Virtual Enterprises–A contribution to the Broker performance." *Procedia Technology* 16:906-912.

Azevedo, A. L., C. Toscano, J. P. Sousa, and A. L. Soares. 2004. "An advanced agent-based order planning system for dynamic networked enterprises." *Production Planning & Control* 15 (2):133-144.

Azevedo, Américo. 1999. "Apoio à decisão na negociação de encomendas em redes de empresas." Phd Investigation, Departamento de Engenharia Electrotecnica e Computadores, Faculdade de Engenharia da Universidade do Porto.

Bakir, Ali, and Vian Bakir. 2006. "Unpacking complexity, pinning down the “elusiveness” of strategy: A grounded theory study in leisure and cultural organisations." *Qualitative Research in Organizations and Management: An International Journal* 1 (3):152-172.

Bastos, João, Américo Azevedo, and Rafael Almeida. 2012. "Collaborative Planning in Customer-Oriented Supplier Networks-The CoReNet Approach." Engineering, Technology and Innovation (ICE), 2012 18th International ICE Conference on.

Bastos, João, Américo Azevedo, and Paulo Ávila. 2015. "Towards a Customer-Driven Value Chain Framework–A Set-Based Oriented Approach." In *Risks and Resilience of Collaborative Networks*, 209-222. Springer.

Bastos, João, Valentina Franchini, Américo Azevedo, and Rosanna Fornasiero. 2012. "Collaborative Networks Model for Clothing and Footwear Business Sector." In *Collaborative Networks in the Internet of Services*, 349-359. Springer.

Bayus, Barry L. 1997. "Speed-to-market and new product performance trade-offs." *Journal of Product Innovation Management* 14 (6):485-497.

Berk, Jonathan B, and Peter M DeMarzo. 2007. *Corporate finance*: Pearson Education.

Bin, Liu, Chen Jian, Liu Sifeng, and Zhang Rong. 2006. "Supply-chain coordination with combined contract for a short-life-cycle product." *Systems, Man and Cybernetics, Part A: Systems and Humans, IEEE Transactions on* 36 (1):53-61.

Bonnefoi, Tatiana. 2005. "Demand Forecast for Short Life Cycle Products: Zara case study." Msc, ITESM, Massachusetts Institute of Technology.

Bowen, Frances E, Paul D Cousins, Richard C Lamming, and Adam C Farukt. 2001. "The role of supply management capabilities in green supply." *Production and operations management* 10 (2):174-189.

Bowersox, Donald J, David J Closs, and M Bixby Cooper. 2002. *Supply chain logistics management*. Vol. 2: McGraw-Hill New York.

Braese, Niklas. 2005a. "The dynamics of supply chains in the automotive industry." Massachusetts Institute of Technology.

Braese, Niklas. 2005b. "The dynamics of supply chains in the automotive industry." Msc, Massachusetts Institute of Technology. Engineering Systems Division, Massachusetts Institute of Technology.

Brand, Ralf, and Frank Gaffikin. 2007. "Collaborative Planning in an Uncollaborative World." *Planning Theory* 6 (3):282-313.

Branke, Jürgen, Kalyanmoy Deb, Henning Dierolf, and Matthias Osswald. 2004. "Finding knees in multi-objective optimization." PPSN.

Breiter, Andreas, Tobias Hegmanns, Bernd Hellingrath, and Stefan Spinler. 2009. "Coordination in Supply Chain Management - Review and Identification of Directions for Future Research - Logistik Management." In, edited by Stefan Voß, Julia Pahl and Silvia Schwarze, 1-35. Physica-Verlag HD.

Brintrup, Alexandra, Tomomi Kito, Felix Reed-Tsochas, and Steve New. 2011. "Mapping the Toyota Supply Network: Implications for Resilience."

Bruce, M., L. Daly, and N. Towers. 2004. "Lean or agile - A solution for supply chain management in the textiles and clothing industry?" *International Journal of Operations & Production Management* 24 (1-2):151-170. doi: Doi 10.1108/01443570410514867.

Buchanan, Stewart 2008. "IT Procurement Best Practice: Leverage Spend Analysis and Supply Chain Management to Develop a Global Vendor Relationship." *Gartner* G00157080:1-18.

Buono, Anthony F. 1997. "Enhancing strategic partnerships: Intervening in network organizations." *Journal of Organizational Change Management* 10 (3):251-266.

Bush, Ashley A, Amrit Tiwana, and Arun Rai. 2010. "Complementarities between product design modularity and IT infrastructure flexibility in IT-enabled supply chains." *Engineering Management, IEEE Transactions on* 57 (2):240-254.

Camarinha-Matos, L, and H Afsarmanesh. 2008a. "Enhancing Performance in Industrial Collaborative Networks." *International Journal of Production Research* 46 (5):1203 - 1205.

Camarinha-Matos, Luis M, and Hamideh Afsarmanesh. 2006. "Collaborative networks: Value creation in a knowledge society." *Knowledge enterprise, IFIP* 207:26-40.

Camarinha-Matos, Luis M, and Hamideh Afsarmanesh. 2008b. *Collaborative Networks: Reference Modeling: Reference Modeling*: Springer Science & Business Media.

Camarinha-Matos, Luis M, Xavier Boucher, and Hamideh Afsarmanesh. 2010. "Collaborative networks for a sustainable world."

Camarinha-Matos, Luis M, Ivan Silveri, Hamideh Afsarmanesh, and Ana Ines Oliveira. 2005. "Towards a framework for creation of dynamic virtual organizations." In *Collaborative networks and their breeding environments*, 69-80. Springer.

Camarinha-Matos, Luis M., and Hamideh Afsarmanesh. 2008c. "On reference models for collaborative networked organizations." *International Journal of Production Research* 46 (9):2453 - 2469.

Carbonell, Pilar, and Ana Isabel Rodriguez. 2006. "The impact of market characteristics and innovation speed on perceptions of positional advantage and new product performance." *International journal of research in marketing* 23 (1):1-12.

Carneiro, Luis, AHM Shamsuzzoha, Ricardo Almeida, Americo Azevedo, Rosanna Fornasiero, and Pedro Sena Ferreira. 2014. "Reference model for collaborative manufacturing of customised products: applications in the fashion industry." *Production Planning & Control* 25 (13-14):1135-1155.

Carter, Craig R, and P Liane Easton. 2011. "Sustainable supply chain management: evolution and future directions." *International Journal of Physical Distribution & Logistics Management* 41 (1):46-62.

Carter, Craig R., and Dale S. Rogers. 2008. "A framework of sustainable supply chain management: moving toward new theory." *International Journal of Physical Distribution & Logistics Management* 38 (5).

Carter, JR, and R Narasimhan. 1995. "Purchasing and supply management: future trends and directions." *Center for Advanced Purchasing Studies, Tempe, AZ*.

Catalan, Michael, and Herbert Kotzab. 2003. "Assessing the responsiveness in the Danish mobile phone supply chain." *International Journal of Physical Distribution & Logistics Management* 33 (8):668-685.

Chai, J. Y., T. Sakaguchi, and K. Shirase. 2010. "A Framework of Multi Objectives Negotiation for Dynamic Supply Chain Model." *Journal of Advanced Mechanical Design Systems and Manufacturing* 4 (2):457-468. doi: Doi 10.1299/Jamdsm.4.457.

Chang, H. L., C. H. Chen, and C. H. Su. 2008. "Developing Supply Chain Dynamic Capability to Realize the Value of Inter-Organizational Systems." *12th Pacific Asia Conference on Information Systems (Pacis 2008)*:674-685 -1563.

Chase, Richard B, Nicholas J Aquilano, and F Robert Jacobs. 2004. *Operations Management for Competitive Advantage*. Boston: McGraw-Hill.

Chatfield, Dean C., Jeon G. Kim, Terry P. Harrison, and Jack C. Hayya. 2004. "The Bullwhip Effect-Impact of Stochastic Lead Time, Information Quality, and Information Sharing: A Simulation Study." *Production & Operations Management* 13 (4):340-353.

Childerhouse, Paul, James Aitken, and Denis R. Towill. 2002. "Analysis and design of focused demand chains." *Journal of Operations Management* 20 (6):675-689. doi: Doi: 10.1016/s0272-6963(02)00034-7.

Chiles, Colby Ronald, and Marguarette Thi Dau. 2005. "An Analysis of Current Supply Chain Best Practices in the Retail Industry with Case Studies of Wal-Mart and Amazon.com." MsC, Georgia Institute of Technology, MIT.

Chrisman, James J., Charles W. Hofer, and William B. Boulton. 1988. "Toward a System for Classifying Business Strategies." *Academy of Management Review* 13 (3):413-428.

Christopher, Martin. 1998a. *Logistics and supply chain management strategies for reducing cost and improving service*.

Christopher, Martin. 1998b. *Relationships and alliances: embracing the era of network competition*: Gower Press, Hampshire, England.

Christopher, Martin. 2000. "The Agile Supply Chain: Competing in Volatile Markets." *Industrial Marketing Management* 29 (1):37-44.

Christopher, Martin. 2005. *Logistics and Supply Chain Management: Creating Value-Adding Networks*: FT Prentice Hall.

Christopher, Martin. 2010. *Logistics and supply chain management*: Financial Times/Prentice Hall.

Christopher, Martin. 2016. *Logistics & supply chain management*: Pearson UK.

Christopher, Martin, and Matthias Holweg. 2011. "“Supply Chain 2.0”: managing supply chains in the era of turbulence." *International Journal of Physical Distribution & Logistics Management* 41 (1):63-82.

Christopher, Martin, and Uta Juttner. 2000. "Developing strategic partnerships in the supply chain: a practitioner perspective." *European Journal of Purchasing & Supply Management* 6 (2):117-127.

Christopher, Martin, and Hau Lee. 2004. "Mitigating supply chain risk through improved confidence." *International Journal of Physical Distribution & Logistics Management* 34 (5):388-396.

Christopher, Martin, and Helen Peck. 2012. *Marketing Logistics*: Routledge.

Christopher, Martin, and Denis R. Towill. 2000. "Supply chain migration from lean and functional to agile and customised." *Supply Chain Management: An International Journal* 5 (4):206-213.

Christopher, Martin, and Denis R. Towill. 2001. "An integrated model for the design of agile supply chains." *International Journal of Physical Distribution & Logistics* 31 (4):235-246.

Chu, Miao, and Shaohui Tian;. 2010. "Research on Knowledge Management of Collaborative Design." *E-Business and E-Government (ICEE), 2010 International Conference on*:1890 - 1893. doi: 10.1109/ICEE.2010.478.

Cigolini, R., M. Cozzi, and M. Perona. 2004. "A new framework for supply chain management - Conceptual model and empirical test." *International Journal of Operations & Production Management* 24 (1-2):7-41. doi: Doi 10.1108/01443570410510979.

Cohen, Shoshanah, and Joseph Roussel. 2005. *Strategic Supply Chain Management - The five disciplines for top performance*. New York: MacGraw-Hill.

Corbett, Charles, and Luk Van Wassenhove. 1993. "Trade-Offs? What Trade-Offs? Competence and Competitiveness in Manufacturing Strategy." *California Management Review* 35 (4):107-122.

Corsten, Daniel, and Christoph Gabriel. 2004. *Supply-Chain-Management erfolgreich umsetzen: Grundlagen, Realisierung und Fallstudien; mit 20 Tabellen*: Springer.

Council, SCC - Supply Chain. 2010. Supply Chain Operations Reference (SCOR®) model Overview - Version 10.0. Accessed 24/07/2013.

Cousins, Paul D, and Robert Spekman. 2003. "Strategic supply and the management of inter-and intra-organisational relationships." *Journal of Purchasing and Supply Management* 9 (1):19-29.

Cox, Andrew. 1999. "Power, value and supply chain management." *Supply Chain Management: An International Journal* 4 (4):167-175.

Cravens, David W, Nigel F Piercy, and Shannon H Shipp. 1996. "New organizational forms for competing in highly dynamic environments: the network paradigm." *British Journal of management* 7 (3):203-218.

Cross, Mark E, Thomas G Brashear, Edward E Rigdon, and Danny N Bellenger. 2007. "Customer orientation and salesperson performance." *European Journal of Marketing* 41 (7/8):821-835.

Dalkir, Kimiz, and Marco Beaulieu. 2017. *Knowledge management in theory and practice*: MIT press.

Danese, Pamela, Pietro Romano, and Marco Formentini. 2013. "The impact of supply chain integration on responsiveness: The moderating effect of using an international supplier network." *Transportation Research Part E: Logistics and Transportation Review* 49 (1):125-140.

Davis, Stanley. 1996. Future Perfect. Addison-Wesley Pub Co, England.

de Treville, Suzanne, Roy D. Shapiro, and Ari-Pekka Hameri. 2004. "From supply chain to demand chain: the role of lead time reduction in improving demand chain performance." *Journal of Operations Management* 21 (6):613-627. doi: 10.1016/j.jom.2003.10.001.

Dee, Jon. 2010. *Sustainable Growth, in Small Business, Big Opportunity*. Edited by Jillian Bowen. Melbourne: Sensis Pty Ltd.

Diaz, Fernando Cela. 2001. "An Integrative Framework for Architecting Supply Chains." Msc, MDSIC, Massachusetts Institute of Technology.

Distelhorst, Greg, Jens Hainmueller, and Richard M Locke. 2016. "Does lean improve labor standards? Management and social performance in the Nike supply chain." *Management Science* 63 (3):707-728.

Doty, D Harold, and William H Glick. 1994. "Typologies as a unique form of theory building: Toward improved understanding and modeling." *Academy of management review* 19 (2):230-251.

Duclos, Leslie K., Robert J. Vokurka, and Rhonda R. Lummus. 2003. "A conceptual model of supply chain flexibility." *Industrial Management & Data Systems, Vol. 103 Iss: 6, pp.446 - 456* 103 (6):446-456.

Dudek, Gregor. 2009. *Collaborative Planning in Supply Chains - A Negotiation-Based Approach*. 2 ed: Springer Science & Business Media.

Dudek, Gregor, and Hartmut Stadtler. 2005. "Negotiation-Based Collaborative Planning Between Supply Chains Partners." *European Journal of Operational Research* 163 (3):668-687. doi: 10.1016/j.ejor.2004.01.014.

Dul, Jan, and Tony Hak. 2008. *Case Study Methodology in Business Research*: Elsevier.

Duray, Rebecca. 2002. "Mass customization origins: mass or custom manufacturing?" *International Journal of Operations & Production Management* 22 (3):314-328.

Durugbo, Christopher. 2015. "Modelling information for collaborative networks." *Production Planning & Control* 26 (1):34-52.

Dyer, Jeffrey H, and Harbir Singh. 1998. "The relational view: Cooperative strategy and sources of interorganizational competitive advantage." *Academy of management review* 23 (4):660-679.

Eaton, M. 2003. "Running the leagile marathon [lean/agile improvement programmes]." *Manufacturing Engineer* 82 (6):14-17.

Eisenhardt, Kathleen M, and Melissa E Graebner. 2007. "Theory building from cases: Opportunities and challenges." *Academy of management journal* 50 (1):25-32.

Eppinger, Steven D. 2002. "Patterns of product development interactions."

Ernst, Ricardo, and Bardia Kamrad. 2000. "Evaluation of supply chain structures through modularization and postponement." *European Journal of Operational Research* 124 (3):495-510. doi: Doi: 10.1016/s0377-2217(99)00184-8.

Eschinger, Chad, C. Dwight Klappich, and Tim Payne. 2009. "User Survey Analysis: Understanding Supply Chain Management Software Buyers, North America, 2009." *Gartner* G00165653:1-16.

Eschinger, Chad, and Andrew White. 2017. "Market Trends: Product Information Management Software, Worldwide, 2006-2011." *Gartner* G00151247:1-14.

Fan, Q., X. J. Xu, and Z. Y. Gong. 2007. "Research on Lean, Agile and Leagile Supply Chain." *2007 International Conference on Wireless Communications, Networking and Mobile Computing, Vols 1-15*:4902-4905.

Fantazy, K. A., V. Kumar, and U. Kumar. 2009. "An Empirical Study of the Relationships Among Strategy, Flexibility, and Performance in the Supply Chain Context." *Supply Chain Management - an International Journal* 14 (3):177-188. doi: 10.1108/13598540910954520.

Fawcett, Stanley E, Matthew W McCarter, Amydee M Fawcett, G Scott Webb, and Gregory M Magnan. 2015. "Why supply chain collaboration fails: the socio-structural view of resistance to relational strategies." *Supply Chain Management: An International Journal* 20 (6):648-663.

Ferdows, Kasra, Michael A Lewis, and Jose AD Machuca. 2004. "Rapid-fire fulfillment." *Harvard business review* 82 (11):104-117.

Fiala, P. 2005. "Information sharing in supply chains." *Omega* 33 (5):419-423. doi: DOI: 10.1016/j.omega.2004.07.006.

Fidel, Pilar, Walesska Schlesinger, and Amparo Cervera. 2015. "Collaborating to innovate: Effects on customer knowledge management and performance." *Journal of business research* 68 (7):1426-1428.

Filos, Erastos, and Eoin Banahan. 2001. "Towards the smart organization: An emerging organizational paradigm and the contribution of the European RTD programs." *Journal of Intelligent Manufacturing* 12 (2):101-119. doi: 10.1023/a:1011296325760.

Fisher, Marshall, Janice Hammond, Walter Obermeyer, and Ananth Raman. 2009. "Configuring a supply chain to reduce the cost of demand uncertainty." *Production and Operations Management* 6 (3):211-225.

Fisher, Marshall L. . 1997. "What Is the Right Supply Chain for Your Product?" *Harvard Business Review*:105-116.

Fixson, Sebastian K. 2005. "Product architecture assessment: a tool to link product, process, and supply chain design decisions." *Journal of Operations Management* 23 (3):345-369.

Folinas, Dimitris, Vicky Manthou, Marianna Sigala, and Maro Vlachopoulou. 2004. "E-volution of a supply chain: cases and best practices." *Internet research* 14 (4):274-283.

Ford, David, and IMP Group. 1990. *Understanding business markets: Interaction, relationships and networks*: Academic Press London.

Fornasiero, Rossana, Andrea Chiodi, Emanuele Carpanzano, and Luis Carneiro. 2010. "Research Issues on Customer-Oriented and Eco-friemdly Networks for Healthy Fashionable Goods." BASYS 2010, Valencia.

Forrester, Jay W. 1958. "Industrial Dynamics." *Harvard Business Review* 36 (4):37-66.

Frohlich, Markham T, and J Robb Dixon. 2001. "A taxonomy of manufacturing strategies revisited." *Journal of Operations Management* 19 (5):541-558.

Frow, Pennie, Suvi Nenonen, Adrian Payne, and Kaj Storbacka. 2015. "Managing co-creation design: A strategic approach to innovation." *British Journal of Management* 26 (3):463-483.

Fugate, Brian S, John T Mentzer, and Theodore P Stank. 2010. "Logistics performance: Efficiency, effectiveness, and differentiation." *Journal of Business Logistics* 31 (1):43-62.

Galavan, Robert, John Murray, and Costas Markides. 2008. *Strategy, innovation, and change: Challenges for management*: OUP Oxford.

Gallagher, Kevin, and James Worrell. 2008. "Organizing IT to promote agility." *Information Technology and Management* 9 (1):71-88.

Garcia, Daniel J, and Fengqi You. 2015. "Supply chain design and optimization: Challenges and opportunities." *Computers & Chemical Engineering* 81:153-170.

Garro, Andres. 2011. "New Product demand forecasting and distribution optimization: a case study at Zara." Msc, Department of Mechanical Engineering, Massachusetts Institute of Technology.

Gattorna, John. 2010. *Dynamic Supply Chains - Delivering value through people*. 2 ed: Pearson Education Limited.

Gattorna, John. 2015. *Dynamic supply chains*: Pearson Education Limited London.

Genovese, Yvonne; Woods, Jeff, Holincheck, James; Rayner, Nigel; Maoz, Michael 2008. "ERP, SCM and CRM: Suites Define the Packaged Application Market." *Gartner* G00158827:1-7.

Geoffrion, Arthur M, and Richard F Powers. 1995. "Twenty years of strategic distribution system design: An evolutionary perspective." *Interfaces* 25 (5):105-127.

Gheysari, Hamed, Amran Rasli, Parastoo Roghanian, and Nadhirah Norhalim. 2012. "A review on the market orientation evolution." *Procedia-Social and Behavioral Sciences* 40:542-549.

Goldman, Stevan L., Roger N. Nagel, and Kenneth Preiss. 1995. *Agile Competitors and Virtual Organizations - Strategies for Enriching the Customer*. New York: Van Nostrand Reinhold.

Goldsby, Thomas J, Stanley E Griffis, and Anthony S Roath. 2011. "Modeling lean, agile, and leagile supply chain strategies." *Journal of Business Logistics* 27 (1):57-80.

Golicic, Susan, Donna Davis, and Teresa McCarthy. 2005. "A Balanced Approach to Research in Supply Chain Management." In *Research Methodologies in Supply Chain Management*, edited by Herbert Kotzab, Stefan Seuring, Martin Müller and Gerald Reiner, 15-29. Physica-Verlag HD.

Gong, Yeming. 2013. *Global Operations Strategy: Fundamentals and Practice*: Springer Science & Business.

Gottfredson, Mark, Rudy Puryear, and Stephen Phillips. 2005. "Strategic sourcing." *Harvard Business Review* 83 (2):132-139.

Govil, Manish, and Jean-Marie Proth. 2002. *Supply Chain Design Management - Strategic and Tactical Perspectives*, *Academic Press*. San Diego: Elsevire Science Imprint.

Grandori, Anna, and Giuseppe Soda. 1995. "Inter-firm networks: antecedents, mechanisms and forms." *Organization studies* 16 (2):183-214.

Grefen, Paul, Nikolay Mehandjiev, Giorgos Kouvas, Georg Weichhart, and Rik Eshuis. 2009. "Dynamic Business Network Process Management in Instant Virtual Enterprises." *Computers in Industry* 60 (2):86-103.

Griffis, Stanley E, Martha Cooper, Thomas J Goldsby, and David J Closs. 2004. "Performance measurement: measure selection based upon firm goals and information reporting needs." *Journal of Business Logistics* 25 (2):95-118.

Gualandris, Jury, and Matteo Kalchschmidt. 2014. "Customer pressure and innovativeness: Their role in sustainable supply chain management." *Journal of Purchasing and Supply Management* 20 (2):92-103.

Gunasekaran, Angappa, Kee-hung Lai, and T. C. Edwin Cheng. 2008. "Responsive supply chain: A competitive strategy in a networked economy." *Omega* 36 (4):549-564.

Hagedoorn, John. 2002. "Inter-firm R&D partnerships: an overview of major trends and patterns since 1960." *Research policy* 31 (4):477-492.

Han, Jiawei, Micheline Kamber, and Jian Pei. 2006. *Data mining: concepts and techniques*: Morgan kaufmann.

Harland, Christine M., Richard C. Lamming, Jurong Zheng, and Thomas E. Johnsen. 2001. "A Taxonomy of Supply Networks." *Journal of Supply Chain Management* 37 (4):21-27. doi: 10.1111/j.1745-493X.2001.tb00109.x.

Harris, Gregory A. 2007. "Alignment of supply chain strategy with product characteristics." Ph.D Dissertation, University of Alabama in Huntsville.

Harrison, A., and C. New. 2002. "The role of coherent supply chain strategy and performance management in achieving competitive advantage: an international survey." *Journal of the Operational Research Society* 53 (3):263-271. doi: 10.1057/palgrave/jors/2601193.

Hausman, Warren H. 2004. "Supply chain performance metrics." In *The practice of supply chain management: Where theory and application converge*, 61-73. Springer.

Hayes, Robert H, and David M Upton. 2005. "Operations-based Strategy." *Operations Management: A Strategic Approach*:10.

Hayes, Robert H, and Steven C Wheelwright. 1984. "Restoring our competitive edge: competing through manufacturing."

Hayes, Robert H, and Steven G Wheelwright. 1979. "Dynamics of Process-Product Life-Cycles." *Harvard business review* 57 (2):127-136.

Herer, Yale T., Michal Tzur, and Enver Yücesan. 2002. "Transshipments: An emerging inventory recourse to achieve supply chain leagility." *International Journal of Production Economics* 80 (3):201-212. doi: Doi: 10.1016/s0925-5273(02)00254-2.

Hevner, Alan, and Samir Chatterjee. 2010a. *Design research in information systems: theory and practice*. Vol. 22: Springer Science & Business Media.

Hevner, Alan, and Samir Chatterjee. 2010b. "Design science research in information systems." In *Design research in information systems*, 9-22. Springer.

Hicks, Donald A. 1999. "The State of Supply Chain Strategy." *IIE Solutions* 31 (8):24.

Hilletofth, Per. 2011. "Demand-supply chain management: industrial survival recipe for new decade." *Industrial Management & Data Systems* 111 (2):184-211.

Hines, Tony. 2004. *Supply chain strategies: customer driven and customer focused*: Routledge.

Hines, Tony. 2014. *Supply chain strategies: Demand driven and customer focused*: Routledge.

Hirschman, Elizabeth C. 1986. "Humanistic Inquiry in Marketing Research: Philosophy, Method, and Criteria." *Journal of Marketing Research (JMR)* 23 (3):237-249.

Hoek, Remko I. Van. 1998. "Reconfiguring the Supply Chain to Implement Postponed Manufacturing." *International Journal of Logistics Management* 9 (1):95-110.

Hoek, Remko I. van. 2000. "The thesis of leagility revisited." *International Journal of Agile Management Systems* 2 (3):196-201.

Hofer, C, and Dan Schendel. 1978. "Strategy Formulation: Analytical Concepts, West Series in Business Policy and Planning." *St. Paul*.

Holweg, Matthias. 2005a. "An investigation into supplier responsiveness: Empirical evidence from the automotive Industry." *The International Journal of Logistics Management* 16 (1):96-119.

Holweg, Matthias. 2005b. "The three dimensions of responsiveness." *International Journal of Operations & Production Management* 25 (7):603-622.

Holweg, Matthias, Stephen Disney, Jan Holmström, and Johanna Småros. 2005. "Supply Chain Collaboration: Making Sense of the Strategy Continuum." *European Management Journal* 23 (2):170-181. doi: 10.1016/j.emj.2005.02.008.

Hoyer, Volker. 2008. "Modeling collaborative e-business processes in SME environments." *Journal of Information Science and Technology* 5 (46):59.

Huang, Samuel H., Mohit Uppal, and J. Shi. 2002. "A product driven approach to manufacturing supply chain selection." *Supply Chain Management-an International Journal* 7 (4):189-199.

Hudson, Bob. 2004. "Analysing network partnerships: Benson re-visited." *Public Management Review* 6 (1):75-94.

Hugos, M. 2006. *Essentials of Supply Chain Management*. New York: John Willey & Sons.

Hugos, Michael H. 2018. *Essentials of supply chain management*: John Wiley & Sons.

Inmon, William H. 1996. "The data warehouse and data mining." *Communications of the ACM* 39 (11):49-51.

Inoue, Masato, Yoon-Eui Nahm, Kenji Tanaka, and Haruo Ishikawa. 2013. "Collaborative engineering among designers with different preferences: Application of the preference set–based design to the design problem of an automotive front-side frame." *Concurrent Engineering*:1063293X13493447.

Iyer, Ananth V, Sridhar Seshadri, and Roy Vasher. 2009. *Toyota Supply Chain Management: A Strategic Approach to Toyota's Renowned System*: McGraw-Hill.

Jain, Anil K, M Narasimha Murty, and Patrick J Flynn. 1999. "Data clustering: a review." *ACM computing surveys (CSUR)* 31 (3):264-323.

Jeong, Ki-Young, and Don T Phillips. 2001. "Operational efficiency and effectiveness measurement." *International Journal of Operations & Production Management* 21 (11):1404-1416.

Johannessen, Stig. 2005. "Supply Chain Management and the Challenge of Organizational Complexity – Methodological Considerations." In *Research Methodologies in Supply Chain Management*, edited by Herbert Kotzab. Physica-verlag.

Jovane, F., E. Westkämper, and D. Williams. 2009. *The manufuture road: towards competitive and sustainable high-adding-value manufacturing*. Berlin: Springer-Verlag.

Jüttner, Uta, Martin Christopher, and Susan Baker. 2007. "Demand chain management-integrating marketing and supply chain management." *Industrial Marketing Management* 36 (3):377-392. doi: 10.1016/j.indmarman.2005.10.003.

Kache, Florian, and Stefan Seuring. 2017. "Challenges and opportunities of digital information at the intersection of Big Data Analytics and supply chain management." *International Journal of Operations & Production Management* 37 (1):10-36.

Kapuscinski, Roman, Rachel Q Zhang, Paul Carbonneau, Robert Moore, and Bill Reeves. 2004. "Inventory decisions in Dell's supply chain." *Interfaces* 34 (3):191-205.

Karlsson, C., and P. Ahlstrom. 1996. "Assessing changes towards lean production." *International Journal of Operations & Production Management* 16 (2):24-&.

Katayama, Hiroshi; Bennett, David 1999. "Agility, adaptability and leanness: A comparison of concepts and a study of practice." *International Journal of Production Economics* 60-61 (3):43.

Kaul, Anil, and Vithala R Rao. 1995. "Research for product positioning and design decisions: An integrative review." *International Journal of research in Marketing* 12 (4):293-320.

Kennedy, Michael N, and Kent Harmon. 2008. "Ready, Set, Dominate: Implement Toyota's Set-based Learning For Developing Products And Nobody Can Catch You Author: Mich."

Kennedy, Michael N, and Allen Ward. 2003. *Product development for the lean enterprise: why Toyota's system is four times more productive and how you can implement it*: Oaklea Press Richmond, VA.

Kilger, Christoph, and Boris Reuter. 2005. "Collaborative planning." In *Supply chain management and advanced planning*, 259-278. Springer.

Kirca, Ahmet H, Satish Jayachandran, and William O Bearden. 2005. "Market orientation: A meta-analytic review and assessment of its antecedents and impact on performance." *Journal of marketing* 69 (2):24-41.

Klaas-Wissing, Thorsten. 2002. *Logistik-Organisation: ein konfigurationstheoretischer Ansatz zur logistikorientierten Organisationsgestaltung*: Dt. Univ.-Verlag.

Klappich, C. Dwight 2016. "Roundup of Supply Chain Execution Research, 2008." *Gartner* G00164876:1-7.

Knoppen, D., E. Christiaanse, and M. Huysman. 2010. "Supply chain relationships: Exploring the linkage between inter-organisational adaptation and learning." *Journal of Purchasing and Supply Management* 16 (3):195-205. doi: DOI 10.1016/j.pursup.2010.03.001.

Kohli, Ajay K, and Bernard J Jaworski. 1990. "Market orientation: the construct, research propositions, and managerial implications." *The Journal of Marketing*:1-18.

Kotha, Suresh, and Daniel Orne. 1989. "GENERIC MANUFACTURING STRATEGIES: A CONCEPTUAL SYNTHESIS." *Strategic Management Journal* 10 (3):211-231.

Kouvelis, Panos, and Joseph M Milner. 2002. "Supply chain capacity and outsourcing decisions: the dynamic interplay of demand and supply uncertainty." *IIE transactions* 34 (8):717-728.

Kren, Leslie. 1992. "Budgetary participation and managerial performance: The impact of information and environmental volatility." *Accounting Review*:511-526.

Krishnamurthy, R., and C. A. Yauch. 2007. "Leagile manufacturing: a proposed corporate infrastructure." *International Journal of Operations & Production Management* 27 (6):588-604.

Kumar, Sameer, and P Malegeant. 2006. "Strategic alliance in a closed-loop supply chain, a case of manufacturer and eco-non-profit organization." *Technovation* 26 (10):1127-1135.

Kwong, CK, XG Luo, and JF Tang. 2011. "A methodology for optimal product positioning with engineering constraints consideration." *International Journal of Production Economics* 132 (1):93-100.

Laari, Sini, Juuso Töyli, Tomi Solakivi, and Lauri Ojala. 2016. "Firm performance and customer-driven green supply chain management." *Journal of cleaner production* 112:1960-1970.

Lambert, Denis, and Stanley F Slater. 1999. "Perspective: first, fast, and on time: the path to success. or is it?" *Journal of Product Innovation Management* 16 (5):427-438.

Lambert, Douglas M, and Martha C Cooper. 2000. "Issues in supply chain management." *Industrial marketing management* 29 (1):65-83.

Lamming, Richard, Thomas Johnsen, Jurong Zheng, and Christine Harland. 2000. "An initial classification of supply networks." *International Journal of Operations & Production Management* 20 (6):675-691.

Leavy, Brian. 2012. "Collaborative innovation as the new imperative–design thinking, value co-creation and the power of “pull”." *Strategy & Leadership* 40 (2):25-34.

Lee, Hau L. 2002. "Aligning supply chain strategies with product uncertainties." *California Management Review* 44 (3):105-119.

Lee, Hau L, Venkata Padmanabhan, and Seungjin Whang. 2004. "Information distortion in a supply chain: the bullwhip effect." *Management science* 50 (12_supplement):1875-1886.

Lee, Hau L. 2004. "THE TRIPLE-A Supply Chain." *Harvard Business Review* 82 (10):102-112.

Leung, Hau-nung. 2002. "A research in manufacturing strategy and competitiveness: models and practices." The Hong Kong Polytechnic University.

Li, Suhong, Bhanu Ragu-Nathan, TS Ragu-Nathan, and S Subba Rao. 2006. "The impact of supply chain management practices on competitive advantage and organizational performance." *Omega* 34 (2):107-124.

Li, X. M., Z. F. Mao, G. H. Xia, and F. Ja. 2008. "Study on Manufacturing Supply Chain Leagile Strategy Driven Factors Based on Customer Value." *2008 4th International Conference on Wireless Communications, Networking and Mobile Computing, Vols 1-31*:6948-6951; 13133.

Li, Y., Y. Chen, and J. H. Li. 2005. "Research on dynamic supply chain network." *Seventh International Conference on Electronic Commerce, Vols 1 and 2, Selected Proceedings*:379-384; 909.

Liker, Jeffrey K, Durward K Sobek, Allen C Ward, and John J Cristiano. 1996. "Involving suppliers in product development in the United States and Japan: Evidence for set-based concurrent engineering." *Engineering Management, IEEE Transactions on* 43 (2):165-178.

Lin, I-Ching. 2004. "To be Lean or to be Agile? The Choice of Supply Chain Strategy." *Graduate school of Business Management, Chung-Shan university*.

Liu, Shaoxuan, and Rick So. 2008. "The impact of uncertain supply on marketing and inventory decisions." Ph.D.

Lo, Wei-Shuo, Tzung-Pei Hong, and Rong Jeng. 2008. "A framework of E-SCM multi-agent systems in the fashion industry." *International Journal of Production Economics* 114 (2):594-614.

Loss, Leandro, and Servane Crave. 2011. "Agile Business Models: an approach to support collaborative networks." *Production Planning & Control* 22 (5-6):571-580.

Lou, Ping, Zu-de Zhou, You-Ping Chen, and Wu Ai. 2004. "Study on multi-agent-based agile supply chain management." *International Journal of Advanced Manufacturing Technology* 23 (3/4):197-203.

Luca, Luigi M De, and Kwaku Atuahene-Gima. 2007. "Market knowledge dimensions and cross-functional collaboration: Examining the different routes to product innovation performance." *Journal of marketing* 71 (1):95-112.

Lyons, Andrew C, Adrian E Coronado Mondragon, Frank Piller, and Raúl Poler. 2012. "Conceptualising the Customer-Driven Supply Chain." In *Customer-Driven Supply Chains*, 21-44. Springer.

MacCarthy, Bart L, and PGSA Jayarathne. 2012. "Sustainable collaborative supply networks in the international clothing industry: a comparative analysis of two retailers." *Production Planning & Control* 23 (4):252-268.

Mason-Jones, Rachel, Mohammed M. Naim, and Denis R. Towill. 1997. "The Impact of Pipeline Control on Supply Chain Dynamics." *International Journal of Logistics Management* 8 (2):47-62.

Mason-Jones, Rachel, Ben Naylor, and Denis R. Towill. 2000a. "Engineering the leagile supply chain." *International Journal of Agile Management Systems* 2 (1):54-61.

Mason-Jones, Rachel, Ben Naylor, and Denis R. Towill. 2000b. "Lean, agile or leagile? Matching your supply chain to the marketplace." *International Journal of Production Research* 38 (17):4061-4070.

Mason-Jones, Rachel, and Denis R. Towill. 1999a. "Total cycle time compression and the agile supply chain." *International journal of production economics* 62 (1-2).

Mason-Jones, Rachel, and Denis R. Towill. 1999b. "Using the Information Decoupling Point to Improve Supply Chain Performance." *International Journal of Logistics Management* 10 (2):13-26.

Mavrotas, George. 2009. "Effective implementation of the ε-constraint method in multi-objective mathematical programming problems." *Applied mathematics and computation* 213 (2):455-465.

McKnight, D Harrison, Larry L Cummings, and Norman L Chervany. 1998. "Initial trust formation in new organizational relationships." *Academy of Management review* 23 (3):473-490.

McKone-Sweet, Kathleen, and Yoo-Taek Lee. 2009. "Development and Analysis of a Supply Chain Strategy Taxonomy." *Journal of Supply Chain Management* 45 (3):3-24. doi: 10.1111/j.1745-493X.2009.03167.x.

Melnyk, Steven A, Ram Narasimhan, and Hugo A DeCampos. 2014. Supply chain design: issues, challenges, frameworks and solutions. Taylor & Francis.

Mensah, Peter, Yuri Merkuryev, and Francesco Longo. 2015. "Using ICT in developing a resilient supply chain strategy." *Procedia Computer Science* 43:101-108.

Mentzer, John T, William DeWitt, James S Keebler, Soonhong Min, Nancy W Nix, Carlo D Smith, and Zach G Zacharia. 2011. "Defining supply chain management." *Journal of Business Logistics* 22 (2):1-25.

Miettinen, Kaisa. 2012. *Nonlinear multiobjective optimization*. Vol. 12: Springer Science & Business Media.

Miller, Jeffrey G, and Aleda V Roth. 1994. "A taxonomy of manufacturing strategies." *Management Science* 40 (3):285-304.

Minor, Elliot D, Rhonda L Hensley, and D Robley Wood. 1994. "A review of empirical manufacturing strategy studies." *International Journal of Operations & Production Management* 14 (1):5-25.

Morash, Edward A. 2001. "Supply Chain Strategies, Capabilities, and Performance." *Transportation Journal* 41 (1):37.

Nagel, Roger N., and Rick Dove. 1991. *21st Century Manufacturing Enterprise Strategy*. Edited by Steven Goldman and Kenneth Preiss. Vol. 1. Bethlehem: Iaccoca Institute.

Nambisan, Satish. 2002. "Designing virtual customer environments for new product development: Toward a theory." *Academy of Management Review* 27 (3):392-413.

Narasimhan, Ram, and Ajay Das. 1999. "An Empirical Investigation of the Contribution of Strategic Sourcing to Manufacturing Flexibilities and Performance*." *Decision Sciences* 30 (3):683-718. doi: 10.1111/j.1540-5915.1999.tb00903.x.

Narasimhan, Ram, Soo Wook Kim, and Keah Choon Tan. 2008. "An empirical investigation of supply chain strategy typologies and relationships to performance." *International Journal of Production Research* 46 (18):5231-5259. doi: 10.1080/00207540600847137.

Narasimhan, Ram, and Santosh Mahapatra. 2004. "Decision models in global supply chain management." *Industrial Marketing Management* 33 (1):21-27. doi: 10.1016/j.indmarman.2003.08.006.

Narasimhan, Ram, Morgan Swink, and Soo Wook Kim. 2006. "Disentangling leanness and agility: An empirical investigation." *Journal of Operations Management* 24 (5):440-457. doi: http://dx.doi.org/10.1016/j.jom.2005.11.011.

Narver, John C, and Stanley F Slater. 1990. "The effect of a market orientation on business profitability." *The Journal of Marketing*:20-35.

Naylor, J. B., Mohamed M. Naim, and Danny Berry. 1999. "Leagility: Integrating the lean and agile manufacturing paradigms in the total supply chain." *International Journal of Production Economics* 62 (1-2):107-118. doi: Doi: 10.1016/s0925-5273(98)00223-0.

Nepal, Bimal, Leslie Monplaisir, and Oluwafemi Famuyiwa. 2012. "Matching product architecture with supply chain design." *European Journal of Operational Research* 216 (2):312-325.

Nishiguchi, Toshihiro. 1994. *Strategic industrial sourcing: The Japanese advantage*: Oxford University Press.

Novak, Sharon, and Steven D Eppinger. 2001. "Sourcing by design: Product complexity and the supply chain." *Management science* 47 (1):189-204.

Nunamaker Jr, Jay F, Minder Chen, and Titus DM Purdin. 1990. "Systems development in information systems research." *Journal of management information systems* 7 (3):89-106.

Ojha, Divesh. 2008. "Impact of Strategic Agility on Competitive Capabilities and Financial Performance." Ph.D Dissertation, Management, Clemson University.

Osmundsen, Petter. 1998. "Dynamic taxation of non-renewable natural resources under asymmetric information about reserves." *Canadian Journal of Economics*:933-951.

Pagh, Janus D., and Martha C. Cooper. 1998. "SUPPLY CHAIN POSTPONEMENT AND SPECULATION STRATEGIES: HOW TO CHOOSE THE RIGHT STRATEGY." *Journal of Business Logistics* 19 (2):13-33.

Parlar, Mahmut, and Z Kevin Weng. 1997. "Designing a firm's coordinated manufacturing and supply decisions with short product life cycles." *Management Science* 43 (10):1329-1344.

Pashaei, Sebastian, and Jan Olhager. 2015. "Product architecture and supply chain design: a systematic review and research agenda." *Supply Chain Management: An International Journal* 20 (1):98-112.

Payne, Tim. 2016. "Leverage Your S&OP Process When Reducing Your Supply Chain Costs." *Gartner* G00155683:1-5.

Payne, Tim, and Melvyn J. Peters. 2004. "What Is the Right Supply Chain For Your Products?" *International Journal of Logistics Management* 15 (2):77-92.

Perez-Franco, Roberto Joaquin. 2010. "A Methodology to Capture, Evaluate and Reformulate a Firm's Supply Chain Strategy as a Conceptual System." PhD, Engineering Systems Division, Massachusetts Institute of Technology.

Persson, Fredrik. 2011. "SCOR template—A simulation based dynamic supply chain analysis tool." *International Journal of Production Economics* 131 (1):288-294.

Piller, Frank T, and Mitchell M Tseng. 2003. "New directions for mass customization." In *The Customer Centric Enterprise*, 519-535. Springer.

Porter, Michael. 1980. *Competitive Strategy: Techniques for Analyzing Industries and Competitors*. New York: Free Press.

Power, Damien. 2005. "Supply chain management integration and implementation: a literature review." *Supply Chain Management: An International Journal* 10 (4):252-263.

Prajogo, Daniel, and Jan Olhager. 2012. "Supply chain integration and performance: The effects of long-term relationships, information technology and sharing, and logistics integration." *International Journal of Production Economics* 135 (1):514-522.

Prater, Edmund, Markus Biehl, and Michael Alan Smith. 2001. "International supply chain agility-Tradeoffs between flexibility and uncertainty." *International Journal of Operations & Production Management* 21 (5/6):823-839.

Prince, J., and J. M. Kay. 2003. "Combining lean and agile characteristics: Creation of virtual groups by enhanced production flow analysis." *International Journal of Production Economics* 85 (3):305-318.

Qi, Yinan. 2006. "Supply chain strategies and practices: An exploratory study." Ph.D Dissertation, Chinese University of Hong Kong (Hong Kong).

Qrunfleh, Sufian, and Monideepa Tarafdar. 2014. "Supply chain information systems strategy: Impacts on supply chain performance and firm performance." *International Journal of Production Economics* 147:340-350.

Quinn, James Brian. 1992. "The intelligent enterprise a new paradigm." *The Executive* 6 (4):48-63.

Reichhart, Andreas, and Matthias Holweg. 2007. "Creating the customer-responsive supply chain: a reconciliation of concepts." *International Journal of Operations & Production Management* 27 (11):1144-1172.

Rexhausen, Daniel, Richard Pibernik, and Gernot Kaiser. 2012. "Customer-facing supply chain practices—The impact of demand and distribution management on supply chain success." *Journal of Operations Management* 30 (4):269-281. doi: 10.1016/j.jom.2012.02.001.

Riezebos, Jan, and Warse Klingenberg. 2009. "Advancing lean manufacturing, the role of IT." *Computers in Industry* 60 (4):235-236.

Robertson, Michael, and Carole Jones. 1999. "Application of lean production and agile manufacturing concepts in a telecommunications environment." *International Journal of Agile Management Systems* 1 (1).

Robinson, Carol J, and Manoj K Malhotra. 2005. "Defining the concept of supply chain quality management and its relevance to academic and industrial practice." *International Journal of Production Economics* 96 (3):315-337.

Roh, James, Paul Hong, and Hokey Min. 2014. "Implementation of a responsive supply chain strategy in global complexity: The case of manufacturing firms." *International Journal of Production Economics* 147:198-210.

Romero, David, and Arturo Molina. 2011. "Collaborative networked organisations and customer communities: value co-creation and co-innovation in the networking era." *Production Planning & Control* 22 (5-6):447-472. doi: 10.1080/09537287.2010.536619.

Romero, David, Arturo Molina, and Luis M Camarinha-Matos. 2011. "Co-innovation and collaborative networks." *Production Planning & Control* 22 (5-6):445-446.

Roscoe, Samuel, and Peter Baker. 2014. "Supply chain segmentation in the sporting goods industry." *International Journal of Logistics Research and Applications* 17 (2):136-155.

Ross, David Frederick. 2010. *Introduction to supply chain management Technologies*: CRC Press.

Roy, S. 2005. " World Class Supply Chains in the Computer Industry." Massachusetts Institute of Technology.

Sarkis, Joseph. 2003. "A strategic decision framework for green supply chain management." *Journal of Cleaner Production* 11 (4):397-409. doi: 10.1016/s0959-6526(02)00062-8.

Satariano, Adam, and Peter Burrows. 2011. "Apple's Supply-Chain Secret? Hoard Lasers." *Bloomberg Businessweek, November* 3.

Schroeder, Roger G, John C Anderson, and Gary Cleveland. 1986. "The content of manufacturing strategy: an empirical study." *Journal of Operations Management* 6 (3):405-415.

Schroeder, Roger G, and TN Lahr. 1990. "Development of manufacturing strategy: a proven process." In *Manufacturing strategy*, 3-14. Springer.

Sen, Wang, Shaligram Pokharel, and Wang YuLei. 2004. "Supply chain positioning strategy integration, evaluation, simulation, and optimization." *Computers & Industrial Engineering* 46 (4):781-792.

Setia, Pankaj. 2008. "Information technologies as antecedents of demand management agility and supply chain performance." Ph.D Ph.D, Michigan State University.

Setia, Pankaj, Vallabh Sambamurthy, and David Closs. 2008. "Realizing business value of agile IT applications: antecedents in the supply chain networks." *Information Technology and Management* 9 (1):5-19.

Seuring, Stefan. 2004. "Integrated chain management and supply chain management comparative analysis and illustrative cases." *Journal of Cleaner Production* 12 (8):1059-1071.

Seuring, Stefan. 2012. "A review of modeling approaches for sustainable supply chain management." *Decision Support Systems* (0). doi: 10.1016/j.dss.2012.05.053.

Seuring, Stefan, and Martin Müller. 2008. "From a literature review to a conceptual framework for sustainable supply chain management." *Journal of Cleaner Production* 16 (15):1699-1710. doi: 10.1016/j.jclepro.2008.04.020.

Sezhiyan, DM, Tom Page, and Paivi Iskanius. 2011. "The impact of supply effort management, logistics capability, and supply chain management strategies on firm performance." *International Journal of Electronic Transport* 1 (1):26-44.

Shamsuzzoha, Ahm, Timo Kankaanpaa, Luis Maia Carneiro, Ricardo Almeida, Andrea Chiodi, and Rosanna Fornasiero. 2013. "Dynamic and collaborative business networks in the fashion industry." *International Journal of Computer Integrated Manufacturing* 26 (1-2):125-139.

Shapiro, Roy D. 1984. "Get leverage from logistics." *Harvard Business Review* 62 (3):119-126.

Sharma, Deven. 1987. "Manufacturing strategy: an empirical analysis." The Ohio State University.

Simchi-Levi, David. 2010. *Operation Rules - Delivering Customer Value through Flexible Operations*. Cambridge, Massachusetts: The MIT Press.

Simchi-Levi, David, Philip Kaminsky, and and Edith Simchi-Levi. 2004. *MANAGING THE SUPPLY CHAIN - The Definitive Guide for the Business Professional*. New York: McGraw-Hill.

Singh, Anil, and James TC Teng. 2016. "Enhancing supply chain outcomes through Information Technology and Trust." *Computers in human behavior* 54:290-300.

Singh, Satyendra, and Ashok Ranchhod. 2004. "Market orientation and customer satisfaction: Evidence from British machine tool industry." *Industrial Marketing Management* 33 (2):135-144.

Singhal, Piyush, Gopal Agarwal, and Murali Lal Mittal. 2011. "Supply chain risk management: review, classification and future research directions." *International Journal of Business Science & Applied Management* 6 (3).

Skinner, Wickham. 1969. *Manufacturing-missing link in corporate strategy*: Harvard Business Review.

Skinner, Wickham. 1978. *Manufacturing in the corporate strategy*. Vol. 12: Wiley New York.

Skinner, Wickham. 1985. *Manufacturing: the formidable competitive weapon*: Wiley New York.

Sobek, Durward K, Allen C Ward, and Jeffrey K Liker. 1999. "Toyota's principles of set-based concurrent engineering." *Sloan management review* 40 (2):67-84.

Sobek, Durward Kenneth. 1997. "Principles that shape product development systems: a Toyota-Chrysler comparison."

Sodhi, M, and Christopher S Tang. 2017. "Supply Chains Built for Speed and Customization." *MIT Sloan Management Review* 58 (4):58419.

Spekman, Robert E, and Edward W Davis. 2004. "Risky business: expanding the discussion on risk and the extended enterprise." *International Journal of Physical Distribution & Logistics Management* 34 (5):414-433.

Sridharan, Uma V, W Royce Caines, and Cheryl C Patterson. 2005. "Implementation of supply chain management and its impact on the value of firms." *Supply Chain Management: An International Journal* 10 (4):313-318.

Srivastava, Samir K. 2007. "Green supply-chain management: a state-of-the-art literature review." *International journal of management reviews* 9 (1):53-80.

Stadtler, Hartmut. 2008. *Supply Chain and Advanced Planning*. 3 ed: Spreinger Berlin - Heidelberg.

Stadtler, Hartmut. 2009. "A Framework for Collaborative Planning and State-of-the-Art." *OR Spectrum* 31 (1):5-30. doi: 10.1007/s00291-007-0104-5.

Stalk Jr, George. 1998. "The Time Paradigm." *Forbes* 162 (12):213-214.

Stark, John. 2011. *Product lifecycle management*: Springer.

Stevens, Graham C. 1989. "Integrating the supply chain." *International Journal of Physical Distribution & Logistics Management* 19 (8):3-8.

Stock, Gregory N, Noel P Greis, and John D Kasarda. 1999. "Logistics, strategy and structure: a conceptual framework." *International Journal of Physical Distribution & Logistics Management* 29 (4):224-239.

Storey, John, Caroline Emberson, and David Reade. 2005. "The barriers to customer responsive supply chain management." *International Journal of Operations & Production Management* 25 (3):242-260.

Stratton, R., and R.D.H. Warburton. 2003. "The strategic integration of agile and lean supply." *International journal of production economics* 85 (2).

Sukati, Inda, Abu Bakar Hamid, Rohaizat Baharun, and Rosman Md Yusoff. 2012. "The Study of Supply Chain Management Strategy and Practices on Supply Chain Performance." *Procedia - Social and Behavioral Sciences* 40 (0):225-233. doi: 10.1016/j.sbspro.2012.03.185.

Sukati, Inda, Abu Bakar Hamid, Rohaizat Baharun, Rosman Md Yusoff, and Melati Ahmad Anuar. 2012. "The Effect of Organizational Practices on Supply Chain Agility: An Empirical Investigation on Malaysia Manufacturing Industry." *Procedia - Social and Behavioral Sciences* 40 (0):274-281. doi: 10.1016/j.sbspro.2012.03.191.

Sull, Donald, and Stefano Turconi. 2008. "Fast fashion lessons." *Business Strategy Review* 19 (2):4-11.

Swafford, Patricia M., Soumen Ghosh, and Nagesh Murthy. 2008. "Achieving supply chain agility through IT integration and flexibility." *International Journal of Production Economics* 116 (2):288-297.

Tallon, Paul. 2008. "Inside the adaptive enterprise: an information technology capabilities perspective on business process agility." *Information Technology and Management* 9 (1):21-36.

Tan, Peng Kuan. 2006. "Demand management: a cross-industry analysis of supply-demand planning." Msc, Massachusetts Institute of Technology. Engineering Systems Division, Massachusetts Institute of Technology.

Teller, Christoph, Herbert Kotzab, and David B. Grant. 2012. "Improving the execution of supply chain management in organizations." *International Journal of Production Economics* 140 (2):713-720. doi: 10.1016/j.ijpe.2011.03.002.

Thatte, Ashish A. 2007. "Competitive advantage of a firm through supply chain responsiveness and SCM practices." Ph.D Dissertaton, University of Toledo.

Thatte, Ashish A, Subba S Rao, and TS Ragu-Nathan. 2013. "Impact of SCM practices of a firm on supply chain responsiveness and competitive advantage of a firm." *Journal of Applied Business Research* 29 (2):499.

Tokatli, Nebahat. 2008. "Global sourcing: insights from the global clothing industry—the case of Zara, a fast fashion retailer." *Journal of Economic Geography* 8 (1):21-38.

Towill, Denis. 2000. "Supply chain migration from lean and functional to agile and customised." *Supply Chain Management: An International Journal* 5 (4):206-213.

Trinkfass, Gabriele. 2013. *The Innovation Spiral: launching new products in shorter time intervals*: Springer-Verlag.

Tseng, Mitchell M, and S Jack Hu. 2014. "Mass customization." In *CIRP Encyclopedia of Production Engineering*, 836-843. Springer.

Turmo, Jordi, Alicia Ageno, and Neus Català. 2006. "Adaptive information extraction." *ACM Computing Surveys (CSUR)* 38 (2):4.

Ülkü, Sezer, and Glen M Schmidt. 2011. "Matching product architecture and supply chain configuration." *Production and Operations Management* 20 (1):16-31.

Vaishnavi, Vijay K, and William Kuechler. 2015. *Design science research methods and patterns: innovating information and communication technology*: Crc Press.

van Bommel, Harrie. 2011. "A conceptual framework for analyzing sustainability strategies in industrial supply networks from an innovation perspective." *Journal of Cleaner Production* 19 (8):895-904.

van Donk, Dirk Pieter. 2001. "Make to stock or make to order: The decoupling point in the food processing industries." *International Journal of Production Economics* 69 (3):297-306. doi: Doi: 10.1016/s0925-5273(00)00035-9.

Van Mieghem, Jan A. 2008. "Operations Strategy: Practices and Principles." *Dynamic Ideas, Belmont, Massachusetts*.

Vanhoucke, Mario. 2009. "A genetic algorithm for net present value maximization for resource constrained projects." In *Evolutionary Computation in Combinatorial Optimization*, 13-24. Springer.

Vanteddu, Gangaraju. 2008. "Strategic Supply Chain Modeling - A Supply Chain Perspective of Cost Efficiency and Responsiveness." Ph.D Dissertation, Industrial Engineering, Wayne State University.

Vonderembse, Mark A, Mohit Uppal, Samuel H Huang, and John P Dismukes. 2006. "Designing supply chains: Towards theory development." *International Journal of Production Economics* 100 (2):223-238.

Wadhwa, S., A. Saxena, and F. T. S. Chan. 2008. "Framework for flexibility in dynamic supply chain management." *International Journal of Production Research* 46 (6):1373-1404.

Wadhwa, Subhash, Madhawanand Mishra, and Avneet Saxena. 2007. "A network approach for modeling and design of agile supply chains using a flexibility construct." *International Journal of Flexible Manufacturing Systems* 19 (4):410-442.

Waller, Matthew A., Pratibha A. Dabholkar, and Julie J. Gentry. 2000. "Postponement, Product Customization, and Market-Oriented Supply Chain Management." *Journal of Business Logistics* 21 (2):133-159.

Wang, Tong. 2008. "Information and flexibility in supply chain management." Ph.D Ph.D, Institut Europeen d'Administration des Affaires (France).

Wang, X. G., G. Liu, and Y. Li. 2009. "A Strategy of Collaborative Negotiation for Dynamic Supply Chain Coordination." *First International Joint Conference on Artificial Intelligence*:59-62.

Ward, Allen C, and Durward K Sobek II. 2014. *Lean product and process development*: Lean Enterprise Institute.

Ward, Peter T., Rebecca Duray, G. Keong Leong, and Chee-Chuong Sum. 1995. "Business environment, operations strategy, and performance: An empirical study of Singapore manufacturers." *Journal of Operations Management* 13 (2):99-115. doi: Doi: 10.1016/0272-6963(95)00021-j.

Watts, Charles A, Kee Young Kim, and Chan K Hahn. 1992. "Linking purchasing to corporate competitive strategy." *Journal of Supply Chain Management* 28 (4):2.

Webster, Frederick E. 1997. "The future role of marketing in the organization." *Reflections on the Futures of Marketing*:39-66.

Weigelt, Carmen. 2013. "Leveraging supplier capabilities: The role of locus of capability deployment." *Strategic Management Journal* 34 (1):1-21.

Windischer, Anna, Gudela Grote, Fabienne Mathier, Séverine Meunier Martins, and Rémy Glardon. 2009. "Characteristics and Organizational Constraints of Collaborative Planning." *Cognition, Technology & Work* 11 (2):87-101. doi: 10.1007/s10111-007-0083-y.

Witte, James D. 1996. "Using static capacity modeling techniques in semiconductor manufacturing." Advanced Semiconductor Manufacturing Conference and Workshop, 1996. ASMC 96 Proceedings. IEEE/SEMI 1996.

Womack, J P, and D T Jones. 1996. *Lean Thinking: Banish Waste and Create Wealth in Your Corporation*. London: Simon & Shuster.

Womack, J P, D T Jones, and D Roos. 1990. *The machine that changed the world*. New York: Maxwell MacMillan International.

Yang, TL. 1992. "Self-Selection in the Fixed-Rate Mortgage Market." *Real Estate Economics* 20 (3):359-391.

Yusuf, Y. Y., A. Gunasekaran, E. O. Adeleye, and K. Sivayoganathan. 2004. "Agile supply chain capabilities: Determinants of competitive objectives." *European Journal of Operational Research* 159 (2):379-392. doi: 10.1016/j.ejor.2003.08.022.

Zangiacomi, Andrea, Rosanna Fornasiero, João Bastos, Américo Azevedo, Valentina Franchini, and Andrea Vinelli. 2013. "Reference Model Framework for Production of Small Series of Innovative and Fashionable Goods in Manufacturing Networks." In *Advances in Sustainable and Competitive Manufacturing Systems*, 1291-1303. Springer.

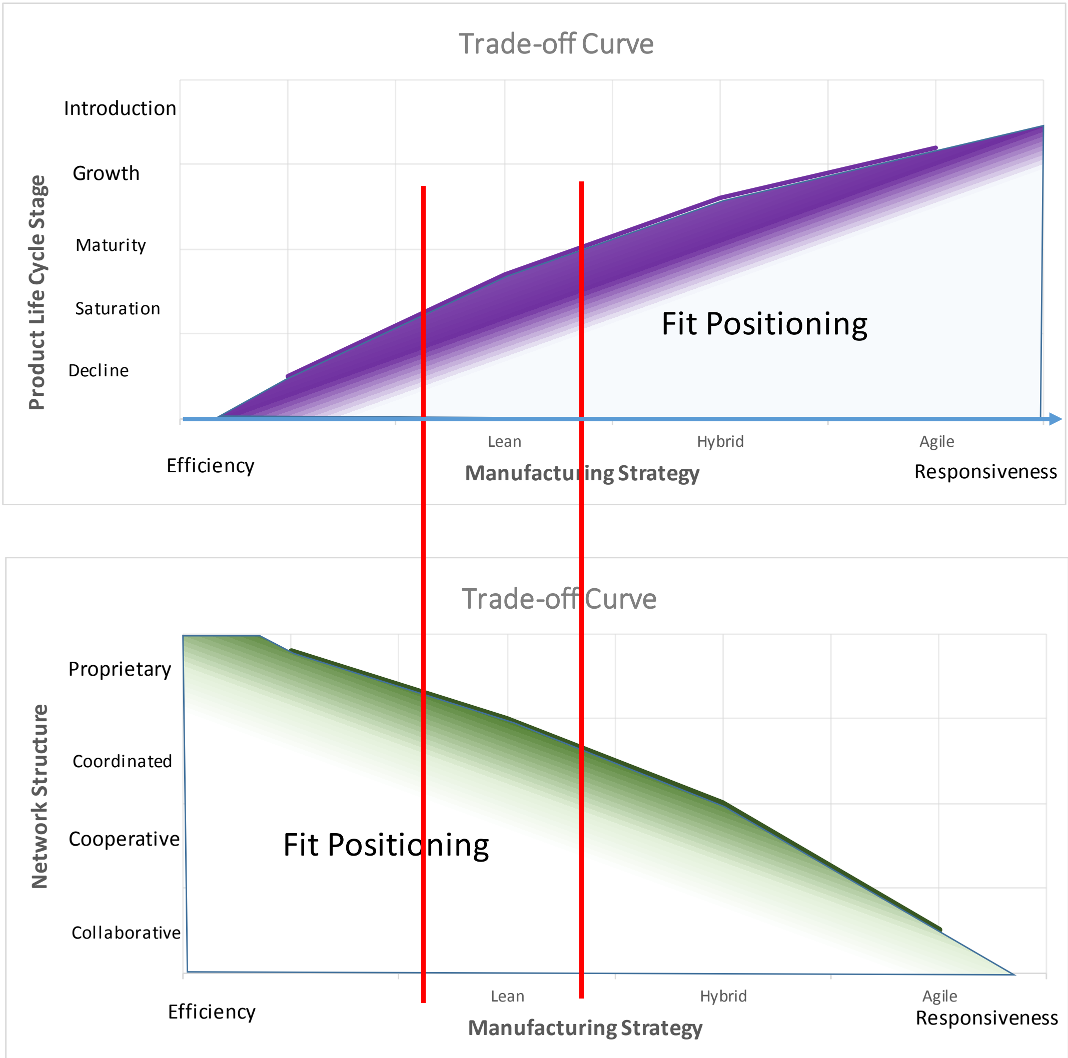
Zheng, J, Thomas Johnsen, CM Harland, and R Lamming. 1998. "Initial conceptual framework for creation and operation of supply networks."

Zhou, Honggeng, and WC Benton Jr. 2007. "Supply chain practice and information sharing." *Journal of Operations Management* 25 (6):1348-1365.

Zowghi, Didar, and Chad Coulin. 2005. "Requirements elicitation: A survey of techniques, approaches, and tools." In *Engineering and managing software requirements*, 19-46. Springer.

Annex A.

Classification Model Fitting Matrix


Trade-off Curve
Product Life Cycle Stage
Introduction
Growth
Maturity
Saturation
Decline
Fit Positioning
Lean
Hybrid
Agile
Efficiency
Manufacturing Strategy
Responsiveness
Trade-off Curve
Network Structure
Proprietary
Coordinated
Cooperative
Collaborative
Fit Positioning
Lean
Hybrid
Agile
Efficiency
Manufacturing Strategy
Responsiveness

Annex B.

Case Study Questionnaire

1 INTRODUCTION

1.1 Company characterization

a) Name of the company

b) Type of the company

c) Age of the company

d) Number of employees

e) Last three year turnover

f) Business objectives (vision, mission, …)

g) Type of core products

h) Products and services offered (identify the different product families)

i) Target markets

j) Type of customers

k) Number of customers per year

l) Percentage of customers that belong to the following target groups:

   a. Male
   b. Female
   c. Teenagers
   b. Disabled
   c. Obese
   d. Elderly

m) Position in the value chain(s)

n) Company's competitive advantages (differentiation factors; quality issues; time response; cost; etc.)

o) Company's competitive threats

1.2 Product structure

a) Number of products

b) Number of products families and characterization

c) Complexity of products (components and technology)

d) Number of components in BOM of end items

e) Number of production phases in the main product

f) Number of subcontracted stages in the main product

g) Does your partner have any influence on your Product Design (if so, how regular do you receive requests for changing Routings and BOM lists? Or work on a stand-alone process?

h) Does the customer participate in any form of co-design? If so, in which way? With which tools?

i) Does the company have specific products for elderly, disables, diabetics and obese people?

j) How the current specific needs of elderly, disables, diabetics and obese people are evaluated for new products?

2 KNOWLEDGE

(to cover and map partner competencies and knowledge to be shared in the network regarding product and processes)

2.1 Specific Customer Requirements

2.1.1 Best Fit

a) Are the customers involved in the production process?

b) Which practices do you implement for the customization?

c) Which components do you customize?

d) Which are the functionalities most requested? (specify if the different target groups required different functionalities)

e) Are there customized features in the products; in what kind?

f) Which is your level of customization (configuration, best fit or full customization)?

2.2 Production Process

2.2.1 Activities

a) What are the main activities developed?

b) What are the responsibilities/competences of the different partners in your network?

2.2.2 Resources

a) What resources are shared?

b) Did your company gain access to any critical resource thanks to collaborative activities in network?

c) How the company stores the information exchanged with the partners (emails, letters, CRM, memos, sales/purchase documents)?

d) How the employees share the information about the alerts, happenings etc among the partner network?

e) What kind of business documents are currently used with suppliers and customers (purchase order, PO confirmation, sales order confirmation, reclamation documents)?

f) What other type of information is shared, structured or not structured?

g) How the documents are currently exchanged?

h) How the data encryption of classified documents is managed?

i) Does the case company know top-10 suppliers in the sector, if so what methods are used?

2.2.3 Manufacturing strategy

a) Briefly describe the stages of production process

b) Which steps are performed in-house and which ones are outsourced

c) Do you have any particular technological equipment which makes your production process performing better than your competitors?

d) Does the company have a niche oriented focus?

e) Is the company focusing on regional markets (domestic) or for global markets (EU-wide, Global)

f) Are the main finished goods (based on the turnover) tailored or mostly generic?

g) How is the planning done in the company? Is the company using material requirements planning, how about net MRP? How do you consider/deal with "external" production capacity? How is production scheduling done? How often is it changed? How long is the frozen period?

h) Do you consider ATP (Available to Promise) or CTP (Capable to Promise)?

i) How is process planning done?

j) What are the reasons for subcontracting?

2.2.4 Order fulfilment strategy

a) Are there specific processes for order fulfilment?

b) How are collected the specific customer requirements if not a make-to-stock product?

c) Are the customized features just components that exist in inventory or a supplier is delivering?

d) Are the features that the customer wants to change exactly the same than BOM second level components?

e) Do the customers require engineering during the sales order fulfilment process?

f) How does the lead-time vary from order confirmation to final delivery?

g) How does the lead-time vary from the initial offer request to the final delivery?

h) What are the main sources of variability?

i) How long it takes to send a quotation, from the initial offer request (and how critical is for their business)?

j) What is the share of standard products in turnover?

k) Are the inventories of the final products located close to the customer?

l) If the customer can state: What is their main production typology: MTS, MTO, ATO or ETO?

m) How the data of customised product are shared with suppliers?

3 ICT

(to cover and map partner competencies and knowledge to be shared in the network regarding product and processes)

3.1 Distribution and customer interface

a) Define the sales channels of the company

b) How close the end-customers are the distributors locate?

c) What is the delivery time to the end-customer after sales order?

d) How does the company forecast demand? How visible are distributers / customers policies and final customers demand and market trends?

e) Does the company have web-based sales tools? How do they work?

f) Is there a web-based customer interface? How it works?

3.2 Design

a) Do you use any kind of ICT solution for the design phase?

b) Do you implement collaborative design?

c) Do you have any ICT solution that help you in this task?

d) Which kind of information do you exchange with your partner?

e) Do you implement LCA?

f) Are you in connection with the social networks in order to understand the customer requirements?

3.3 Production and control

a) Do you use any kind of ICT solution to integrate design and production?

b) Have you any ICT solution that help you in the supplier monitoring?

c) Have you implement RFID technology?

d) In which phase of the production do you use the RFID thecnology?

e) And for which scope? (monitor production status..)

f) Are you integrated with the outsourcers softwares?

g) Do you acquire directly the orders from POS?

3.4 Integrated systems

3.4.1 ICT-solutions

What ICT solutions are used in the company?

a) Name and version of ERP-application? Modules?

b) Name and application supporting for CRM processes?

c) Name and version of PDM- application?

d) Name and version of MES- application?

e) Name and version of CAD-application?

f) Name and version of Project management solution?

g) Name and version of email server solution?

h) Name and version of Production or Scheduler Optimizer system?

i) EDI or other interoperability solutions? What kinds of data formats are used? Other communication protocols?

j) Other planning ICT tools?

Do you use this ICT solutions to monitor internal or external aspects? Explain.

4 ORGANIZATIONAL

(to cover and map partner competencies and knowledge to be shared in the network regarding product and processes)

4.1 Strategic Decision

4.1.1 Key business partners and networks

a) Identify the company key business partners (identify the type of partners and give some examples of the main partners in each type).

b) Identify key networks which your company is participating.

c) What is the process/method for partner selection currently (social relationships, reputation, price...)?

d) What are the main criteria for entering/leaving existing networks?

e) What was the motivation and objectives to develop such partnerships or networks?

f) Are there processes of collaboration/integration within your supply network?

g) How do you search for new partner?

h) Which parameters do you use to evaluate them? (cost, quality, flexibility, sustainability..)

i) Do you monitor your partner along the time?

4.1.2 Relations

a) Describe the type of relationships established with your key business partners or networks (relation type, duration of partnership, supplier development, etc).

b) How is the relationship or network governed?

c) Are periodic governance meeting organized?

d) Does the company arrange any special event for the current suppliers/partners?

e) How do processes deal with unexpected events? (Identification of unexpected events within main processes, etc.)

4.1.3 Evaluation / Strategy

a) Strong and weak points in collaboration

b) Opportunities / threats for collaboration

c) Success and failure factors

d) Potential benefits (Has networking enabled you to gain the advantage of scale? Is there special advance that just network offers?).

e) Have you archived any of the following benefits from you network:

   a. Increased scale, scope of activities or sales volume

   b. Shared cost and risks

   c. Improved ability to deal with complexity

   d. Enhanced learning effect

   e. Positive welfare effect

   f. Flexibility

   g. Efficiency

   h. Speed

   i. Increased visibility

4.1.4 Performance Evaluation Improvement

a) What are the present mechanisms for performance evaluation in the company?

b) What are the implemented improvement practices?

c) How relevant is the performance evaluation relevant for current Business Processes in the company?

d) What is the motivation and objectives to develop performance evaluation improvement?

4.1.5 Sustainability

a) Do you implement some sustainable practices in the manufacturing process? (e.g. for the products: use of eco-friendly materials, use of bio material, …for the processes: integration of supply chain, optimization of delivery)

b) In which way the company measure the environmental performance?

c) The existing measures are relative to the internal processes that involve two or more actors?

d) In which way the company operate in order to improve the performance with respect to the above mentioned dimensions?

e) In which way the company measures the performance in terms of collaboration with suppliers, clients, stakeholders etc..

f) Does the company implement a continue development system with respect to sustainability?

g) Which are the expected result to implement a sustainable system for the design of supply chain?

4.2 Operational Decision

4.2.1 Business Processes

a) What are the main Business Processes in which the company perform?

b) Who are the Business Processes stakeholders?

c) Identify what are the relevant outcomes of each Business Process.

4.2.2 Sourcing strategy

a) How many suppliers do you have?

b) How many suppliers for each typology of components do you have?

c) Are they local or global suppliers?

d) Is the initial strategy one key supplier one backup instead of open competition in every purchase order?

e) Has the company annual agreements with the suppliers / partners?

f) If annual agreement how are they managed?

g) Is there a role for supplier management (job position – what)?

h) Number of potential suppliers in the market (many or few)?

i) Where are suppliers / partners located? Is distance an issue?

j) Has the company suppliers selection and evaluation practices?

4.2.3 Buffering mechanism

a) Is there variation in capacity utilization rate during the year - what kind of variation?

b) What types of buffer-inventories are used: material, semi-finished goods or final products? What is the share of each?

c) Are the finished good kept in distribution centres, how many?

d) Are there stored subassemblies in the manufacturing sites?

e) Are all the materials/components acquired on sales-order based?

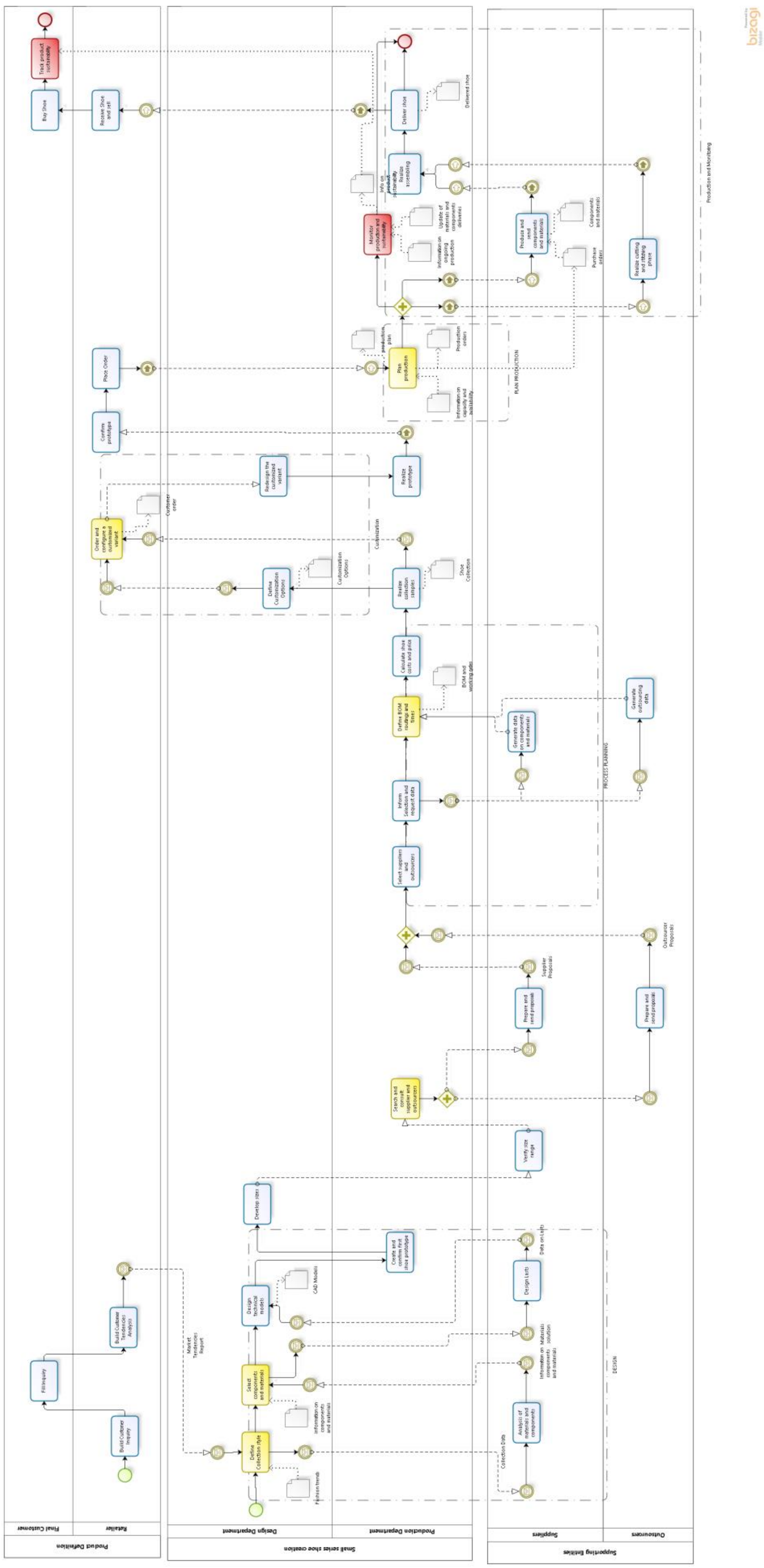
f) Do you have supplier material in your storage?

g) Does your subcontractors work with your material (is there bi-directional material flow between the supplier and you)'

h) Do you have to manufacture finished goods in very early stage balance the capacity to the seasons?

Annex C.

Overall Business Process Diagram



Annex D.

Collaborative Set-Based Design Optimization Code

```
%% Data
% With all points (H and CS)
%thickness=[4.0 5.2 6.0 8.6 10.0 11.9]';
%density=[36 40 50 62 75 82]';
%H=[47 52 50 56 49 61]';
%CS=[1.2 1.15 1.21 1.21 1.17 1.15]';
% With only C points
 thickness=[4.0 6.0 8.6 10.0 11.9]';
 density=[36 50 62 75 82]';
 H=[47 50 56 49 61]';
 CS=[1.2 1.21 1.21 1.17 1.15]';


%% fit data using interpolation (or regression)
P=linspace(min(thickness),max(thickness),50);
S=linspace(min(density),max(density),50);
[X,Y]=meshgrid(P,S);
% interpolating H using a natural model (f are the model coefficients)
f = scatteredInterpolant(thickness,density,H,'natural');
Z1=f(X,Y);
% interpolating CS using a natural model (g are the model coefficients)
g = scatteredInterpolant(thickness,density,CS,'natural');
Z2=g(X,Y);

% graph for H approximation
figure
mesh(X,Y,Z1)
axis tight; hold on
plot3(thickness,density,H,'.','MarkerSize',15)
xlabel('Thickness (mm)')
ylabel('Density (kg/m3)')
zlabel('H (ILD)')
grid on

%graph for CS approximation
figure
mesh(X,Y,Z2)
axis tight; hold on
plot3(thickness,density,CS,'.','MarkerSize',15)
xlabel('Thickness (mm)')
ylabel('Density (kg/m3)')
zlabel('CS (angle)')
grid on

%% multiobjectiv optimization using epsilon-contraint method
% constraints
A=[];
b=[];
Aeq=[];
beq=[];
lb=[min(thickness) min(density)];
ub=[max(thickness) max(density)];

% gap for epsilon variation
gap=0.001;
k=1;
% initial approximation
x0=[mean(thickness),mean(thickness)];
for epsilon=min(CS):gap:max(CS)
    % min f(x1,x2)
```

```
    v = @(x)f(x(1),x(2));
    % st g(x1,x2) <= epsilon
    c = @(x)g(x(1),x(2))-epsilon;
    ceq = @(x)[];
    nonlinfcn = @(x)deal(c(x),ceq(x));
    % optimize using SQP
    [x,fx, exitflag, output]=fmincon(v,x0,A,b,Aeq,beq,lb,ub,nonlinfcn);
    sol.x(k,:)=x';
    sol.fx(k,:)=fx;
    sol.f(k,:)=f(x(1),x(2));
    sol.g(k,:)=g(x(1),x(2));
    sol.e(k,:)=exitflag;
    sol.o(k,:)=output;
    sol.w(k,:)=epsilon;
    k=k+1;
end

%% Plot Pareto front
figure
plot(sol.f,sol.g,'x')
xlabel('H (ILD)')
ylabel('CS (angle)')
grid on

SOL=[sol.x sol.f sol.g];
%% compute knee solutions
% TODO
%% Plot Pareto front of knee points
figure
plot(H,CS,'o')
xlabel('H (ILD)')
ylabel('CS (angle)')
grid on
```

Annex E.

Collaborative Planning Optimization Code

```
%% Partner Selection Problem solved using Branch-and-Bound
%
clear all
close all
%%
% number of partners: N
N=4;
% number of stages: M
M=3;
% number of quotations: L
L=2;

%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% Dimension of C, F, Q; I and D must be N*M*L
% costs (N*M*L)
C=[1166
1040
1457
1273
950
865
1050
1000
505
441
644
570
701
624
603
548
1426
1180
1817
1440
1178
1124
1470
917]';

% partners reliability (N*M*L)
F=[90
90
100
100
95
95
85
85
75
75
82
82
85
85
90
90
100
100
95
95
```

```
90
90
85
85]';

% Quality (N*M*L)
Q=[1
1
1
1
0
0
0
0
1
1
1
1
0
0
0
0
1
1
1
1
0
0
0
0]';

% proposal initial dates (N*M*L)
I=[151
161
151
145
151
168
151
160
161
172
161
152
161
176
161
188
171
200
171
185
171
160
171
220]';

% proposal durations (N*M*L)
D=[9
7
9
```

```
10
9
7
9
10
9
13
9
10
9
8
9
7
9
15
9
20
9
16
9
15]';

% due date
T=240;


%% Aeq - Matrix containing the coefficients of equality constraints
(only partner selected for each phase): Aeq.x=beq%

Aeq=zeros(M,N*M*L); %Matrix of M lines (n° of stages) with N*M*L columns
(total number of variables NML)%
for j=1:M
    Aeq(j,((j-1)*N*L+1):((j-1)*N*L+N*L))=1;
end
beq=ones(M,1); %Vector of a (M lines by a column): second member of the
equality restrictions %

%% A - Matrix containing the coefficients of the inequality constraints
(proposals terminate before time limits): A.x<=b%
A=zeros(M,N*M*L); % M lines (number of phases) with N * M * L columns
(total number of NML variables)%
TD=I+D;
for j=1:M-1
    A(j,((j-1)*N*L+1):((j-1)*N*L+N*L))=TD(((j-1)*N*L+1):((j-
1)*N*L+N*L))';
    A(j,(j*N*L+1):(j*N*L+N*L))=-I((j*N*L+1):(j*N*L+N*L))';
end
A(M,((M-1)*N*L+1):((M-1)*N*L+N*L))=TD(((M-1)*N*L+1):((M-1)*N*L+N*L))'-T;

b=zeros(M,1);

%% Solver entire programming min cost; max reliability; max quality
%
Scmin=0;Scmax=0;
Sfmin=0;Sfmax=0;
Sqmin=0;Sqmax=0;
for j=1:M
    Scmin=Scmin+min(C(((j-1)*N*L+1):((j-1)*N*L+N*L)));
    Scmax=Scmax+max(C(((j-1)*N*L+1):((j-1)*N*L+N*L)));
    Sfmin=Sfmin+min(F(((j-1)*N*L+1):((j-1)*N*L+N*L)));
```

```
    Sfmax=Sfmax+max(F(((j-1)*N*L+1):((j-1)*N*L+N*L)));
    Sqmin=Sqmin+min(Q(((j-1)*N*L+1):((j-1)*N*L+N*L)));
    Sqmax=Sqmax+max(Q(((j-1)*N*L+1):((j-1)*N*L+N*L)));
end
cmin=Scmin;cmax=Scmax;
fmin=Sfmin;fmax=Sfmax;
qmin=Sqmin;qmax=Sqmax;

gap=0.05;
k=1;
for w1=0:gap:1
    for w2=0:gap:1-w1
        w3=1-(w1+w2);
        % f - Vector column containing the coefficients of the aggregate
function: min f'*x
        %f=w1*C-w2*F-w3*Q;
        f=w1*(C-cmin)/(cmax-cmin)-w2*(F-fmin)/(fmax-fmin)-w3*(Q-
qmin)/(qmax-qmin);
        %[x,fx, exitflag, output]=bintprog(f,A,b,Aeq,beq);
        [x,fx, exitflag,
output]=intlinprog(f,1:M*N*L,A,b,Aeq,beq,zeros(1,M*N*L), ones(1,M*N*L));
        sol.x(k,:)=x';
        sol.fx(k,:)=fx;
        sol.C(k,:)=C*x;
        sol.F(k,:)=F*x;
        sol.Q(k,:)=Q*x;
        sol.c(k,:)=(A*x-b)';
        sol.ceq(k,:)=(Aeq*x-beq)';
        sol.e(k,:)=exitflag;
        sol.o(k,:)=output;
        sol.w(k,:)=[w1 w2 w3];
        k=k+1;
    end
end


%% Plot Pareto front
figure
plot(sol.C,sol.F,'x')
xlabel('Custo')
ylabel('Fiabilidade')
grid on
%%
figure
plot(sol.C,sol.Q,'x')
xlabel('Custo')
ylabel('Qualidade')
grid on
%%
figure
plot(sol.F,sol.Q,'x')
xlabel('Fiabilidade')
ylabel('Qualidade')
grid on
%%

figure
plot3(sol.C,sol.F,sol.Q,'.')
xlabel('Custo')
ylabel('Fiabilidade')
```

```
zlabel('Qualidade')
grid on

figure
col={'*m', '*b', '*g', '*r'}c;
hold on
for i=1:length(sol.C)
    plot(sol.C(i),sol.F(i),char(col(round(sol.Q(i)+1))));
end
xlabel('Custo')
ylabel('Fiabilidade')
grid on
title(['\fontsize{12} {\color[magenta} Qualidade 0} -
{\color{blue}Qualidade 1} - {\color[green}Qualidade 2} -
{\color{red}Qualidade 3}'])

% weights for the evaluation of solutions
pesos=[0.7 0.2 0.1];

solcmin=min(sol.C);
solfmax=max(sol.F);
solqmax=max(sol.Q);

% cost=cmin./sol.C;
% fiab=sol.F/fmax;
% qual=sol.Q/qmax;

cost=solcmin./sol.C;
fiab=sol.F/solfmax;
qual=sol.Q/solqmax;
aval=pesos(1)*cost+pesos(2)*fiab+pesos(3)*qual;


SOL=sortrows(unique([aval sol.C sol.F sol.Q round(sol.x)],'rows'));

figure
bar3(sortrows(unique([aval,cost,fiab,qual,round(sol.x)],'rows')));
legend('Avaliação','Custo','Fiabilidade','Qualidade')
```

ANNEX E – COLLABORATIVE PLANNING OPTIMIZATION CODE

Annex F.

Related Published References

- Roberto Piedade Francisco, João Bastos, Américo Azevedo, (2010) "Using the Life-Cycle Paradigm to Support Factory Planning Approaches" *published in Balanced Automation Systems for Future Manufacturing Networks, 224-232*.
- Américo Azevedo, Roberto Piedade Francisco, João Bastos, António Almeida (2010). "Virtual factory framework: an innovative approach to support the planning and optimization of the next generation factories" *published in IFAC Proceedings Volumes, 43(17), 320-325.*
- Roberto Piedade Francisco, Américo Azevedo, João Bastos (2010) "Managing performance to align the participants of collaborative networks: case studies result" *published in Collaborative Networks for a Sustainable World, 545-552.*
- Américo Azevedo, João Bastos, António Almeida, Carlos Soares, Nicola Magaletti, Andrea Chiodi (2011) "Customer-Oriented and Eco-friendly Networks for Health Fashionable Goods–The CoReNet Approach" *published Working Conference on Virtual Enterprises (pp. 69-76). Springer, Berlin, Heidelberg.*
- Roberto Piedade Francisco, Américo Azevedo, João Bastos, António Almeida (2011). "Using Key Alignment Indicators for Performance Evaluation in Collaborative Networks" *published in Adaptation and Value Creating Collaborative Networks, 159-166*.
- João Bastos, António Almeida, Américo Azevedo, Paulo Ávila (2012) "A flexibility reference model to achieve leagility in virtual organizations" *published in Virtual and Networked Organizations, Emergent Technologies and Tools, 196-206.*
- Valentina Franchini, João Bastos, Américo Azevedo, Rosanna Fornasiero (2012) "Proposal of a reference model for fashionable and healthy goods production in SME networks" *published in Engineering, Technology and Innovation (ICE), 2012 18th International ICE Conference on (pp. 1-11) IEEE*.
- Valentina Franchini, João Bastos, Américo Azevedo (2012) "Strategies for supply chain configurations" *published in Engineering, Technology and Innovation (ICE), 2012 18th International ICE Conference on (pp. 1-10) IEEE*.
- João Bastos, António Almeida, Américo Azevedo (2012) "Collaborative planning in customer-oriented supplier networks - The CoReNet approach" *published in Engineering, Technology and Innovation (ICE), 2012 18th International ICE Conference on (pp. 1-10) IEEE.*
- João Bastos, António Almeida, Américo Azevedo, Paulo Ávila (2012). "A flexibility reference model to achieve leagility in virtual organizations" *published in Virtual and Networked Organizations, Emergent Technologies and Tools, 196-206.*
- João Bastos, Valentina Franchini, Américo Azevedo, Rosanna Fornasiero (2012) "Collaborative Networks Model for Clothing and Footwear Business Sector" *published in Working Conference on Virtual Enterprises (pp. 349-359). Springer, Berlin, Heidelberg*.
- Eva Coscia, Rosanna Fornasiero, João Bastos, Américo Azevedo, Silvio Piccione (2012) "Advanced services for supply chain design processes in collaborative networks" *published in Collaborative Networks in the Internet of Services, 289-298.*

- Andrea Zangiacomi, Rosanna Fornasiero, João Bastos, Américo Azevedo, Valentina Franchini, Andrea Vinelli (2013) "Reference model framework for production of small series of innovative and fashionable goods in manufacturing networks" *published in Advances in Sustainable and Competitive Manufacturing Systems (pp. 1291-1303). Springer, Heidelberg.*
- António Almeida, João Bastos, Roberto Piedade Francisco, Américo Azevedo, Paulo Ávila (2013) "Sustainability Assessment Framework for Proactive Supply Chain Management" *published in International Journal of Industrial and Systems Engineering.*
- Daniel Soares, João Bastos, Diana Gavazzo, João P. Pereira, António Baptista (2013). "Lean Management Methods in Product Development: A Case Study" *published in Advances in Sustainable and Competitive Manufacturing Systems (pp. 1385-1399). Springer, Heidelberg*.
- António Baptista, Inácio Ribeiro, João P. Pereira, João Bastos (2014). "Lean and efficient project management: new concepts and tools" *published in 14th International Conference on Project Management and Scheduling (p. 16).*
- Paulo Ávila, Alzira Mota, Goran Putnik, Lino Costa, João Bastos, Manuela Cruz-Cunha (2015). "Proposal of an Empirical Model for Suppliers Selection" *published to International Journal for Quality Research, 9(1).*
- João Bastos, Américo Azevedo, Paulo Ávila (2015) "Towards a customer-driven value chain framework–a set-based oriented approach" *published in Working Conference on Virtual Enterprises (pp. 209-222). Springer, Cham.*
- João Bastos, Américo Azevedo, Paulo Ávila (2016) "A Lean Set-Based Design Approach for Development of Customizable Products in Collaborative Networks" *accepted to be published in Working Conference on Virtual Enterprises (pp. 420-432). Springer, Cham.*
- Rosanna Fornasiero, Andrea Zangiacomi, Valentina Franchini, João Bastos, Américo Azevedo, Antonio Vinelli (2016). "Implementation of customisation strategies in collaborative networks through an innovative Reference Framework" *published to International Journal Production Planning & Control, 27(14), 1158-1170.*
- João Bastos, Lino Costa, Paulo Ávila, Américo Azevedo, Goran Putnik (2017) "Complex Products Design in Collaborative Networks: A Set-Based Design Approach" submitted to *International Journal of Intelligent Enterprise*.
- João Bastos, Lino Costa, Alzira Mota, Paulo Ávila, Américo Azevedo (2018) "Collaborative Planning in Non-Hierarchical Networks - An Intelligent Negotiated Framework" submitted to *Journal of Production Planning & Control – The Management of Operations.*