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Mestre em Engenharia Industrial

Modelling Lean and Green Supply Chain

Dissertação para obtenção do Grau de Doutor em
Engenharia Industrial

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FACULDADE DE CIÊNCIAS E TECNOLOGIA
UNIVERSIDADE NOVA DE LISBOA

Dezembro 2013

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Faculdade de Ciências e Tecnologia and Universidade Nova de Lisboa

Acknowledgements

A special thanks to my Ph.D. supervisor V. Cruz Machado who encouraged me to pursue this topic, help me to shape the path of my thesis and to achieve a clearer structure.

My sincere thanks to Fundação para a Ciência e a Tecnologia; without their support this dissertation was not possible to perform (PhD fellowship: SFRH/BD/60969/2009).

To project entitled "Lean, agile, resilient and green supply chain management" (LARG_SCM) which facilitated the development of my case study and make possible the submission of papers at several International Meetings and Conferences.

To all companies that participated in the case study and helped to link the academic with the industrial world.

Thanks to my Ph.D. colleague Helena Carvalho who contributed to make this period less of a solitary initiative and more of a shared intellectual journey.

I also thank to Unidade de Investigação e Desenvolvimento em Engenharia Mecânica e Industrial (UNIDEMI) for providing me with all necessary facilities.

A special thanks to my family, particularly to my children, my husband, my mother, my father, and my parents-in-law for the patience, understanding, support, affection and encouragement, they always gave me during the development of the work.

This thesis is in memory of my friend and colleague Marta Forte who encouraged me to choose the Industrial Engineering degree course. Since then my life has always been about working and studying Industrial Engineering.

Resumo

O sucesso de uma organização depende do controlo efetivo de sua cadeia de abastecimento. É importante reconhecer novas oportunidades para a organização e para a sua cadeia de abastecimento.

Nos últimos anos a abordagem aos paradigmas *lean*, ágil, resiliente e *green* da cadeia de abastecimento têm sido endereçados na literatura científica. Pesquisa neste domínio mostra que a integração desses conceitos revelou algumas contradições entre tantos paradigmas. Esta tese está principalmente focalizada para as abordagens *lean* e *green*. Treze diferentes *frameworks* de gestão, incorporados como prémios, *standards* e ferramentas foram estudados para entender se estes poderiam contribuir para o processo de modelação de uma abordagem *lean* e *green*. O estudo revela uma série de categorias que são comuns na maioria dos *frameworks* de gestão, proporcionando condições adequadas para a transformação da cadeia de abastecimento *lean* e *green*. Foi proposto um *framework* conceptual para a avaliação de uma cadeia de abastecimento *lean* e *green* de uma organização. O *framework* considera seis critérios-chave, a saber, liderança, pessoas, planeamento estratégico, partes interessadas, processos e resultados. Foi proposto um método de avaliação, considerando uma pontuação para cada um dos critérios. O objetivo é entender como a cadeia de abastecimento *lean* e *green* podem ser integrados e testar a sua compatibilidade, aplicando princípios, práticas, técnicas e ferramentas (isto é, elementos) que suportam ambos, uma abordagem *lean* e uma abordagem *green*, em todos os critérios-chave.

Um estudo de caso foi realizado na indústria automóvel, a montante na cadeia de abastecimento para compreender mais profundamente se os elementos propostos para o *framework* conceptual poderiam ser implementados num cenário da vida real. Com base no *framework* conceptual e no estudo de caso, é apresentado um mapa para alcançar uma transformação *lean* e *green*. O mapa proposto revelou a sua contribuição para a compreensão de como e quando a cadeia de abastecimento de uma organização deve aplicar os elementos *lean* e *green*. Este estudo é relevante para a prática, pois pode auxiliar os gestores na adoção de uma abordagem na cadeia de abastecimento *lean* e *green* dando conhecimento para a implementação de uma cadeia de abastecimento híbrida.

Palavras-chave: *Lean*; *Green*; Cadeia de abastecimento; *Framework*; Modelação; Caso de estudo

Abstract

The success of an organization depends on the effective control of its supply chain. It is important to recognize new opportunities for organization and its supply chain.

In the last few years the approach to lean, agile, resilient and green supply chain paradigms has been addressed in the scientific literature. Research in this field shows that the integration of these concepts revealed some contradictions among so many paradigms. This thesis is mainly focused on the lean and green approaches. Thirteen different management frameworks, embodied in awards, standards and tools were studied to understand if they could contribute for the modelling process of a lean and green approach. The study reveals a number of categories that are common in most management frameworks, providing adequate conditions for a lean and green supply chain transformation. A conceptual framework for the evaluation of a lean and green organization`s supply chain was proposed. The framework considers six key criteria, namely, leadership, people, strategic planning, stakeholders, processes and results. It was proposed an assessment method considering a criteria score for each criterion. The purpose is to understand how lean and green supply chain can be compatible, using principles, practices, techniques or tools (i.e. elements) that support both, a lean and a green approach, in all key criteria.

A case study in the automotive upstream supply chain was performed to understand more deeply if the elements proposed for the conceptual framework could be implemented in a real-scenario. Based on the conceptual framework and the case study, a roadmap to achieve a lean-green transformation is presented. The proposed roadmap revealed its contribution to the understanding on how and when an organization`s supply chain should apply the lean and green elements. This study is relevant to practice, as it may assist managers in the adoption of a lean and green supply chain approach, giving insights for the implementation of a hybrid supply chain.

Keywords: Lean; Green; Supply chain; Framework; Modelling; Case study

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List of Abbreviations

ASC - Agile Supply Chain
BSC - Balanced Scorecard
DMAIC - Define, Measure, Analyze, Improve and Control
DP - Deming Prize
EDI - Electronic Data Interchange
EFQM - European Foundation for Quality Management
EMS - Environment Management System
EMAS - Eco-Management and Audit Scheme
ERP - Enterprise Resource Planning
FC - Focal Company
GRI - Global Reporting Initiative
GSC - Green Supply Chain
GVSM - Green Value Stream Mapping
IP - Industrial Park
ISO - International Organization for Standardization
JIT - Just-in-time
LARG_SCM - lean, agile, resilient and green supply chain management
Lean-Green - Lean and Green integrated approach
LCA - Life Cycle Assessment
LSC - Lean Supply Chain
LSP - Logistics Service Provider
MBNQA - Malcolm Baldrige National Quality Award
Mthg - Methodology
NIST - National Institute of Standards and Technology
NP - Portuguese Norm
OH&S - Occupational Health and Safety
OHSAS - Occupational Health and Safety Assessment Series
QMS - Quality Management System
PDCA - Plan, Do, Check and Act
RDI - Research, Development and Innovation
RSC - Resilient Supply Chain
SC - Supply Chain
SCC - Supply Chain Council
SCM - Supply Chain Management

SCOR - Supply Chain Operation Reference

SP - Shingo Prize

TPM - Total Productive Maintenance

TQM - Total Quality Management

VSM - Value Stream Mapping

3R - Reduce, Reuse and Recycle

5S - Sort, Straighten, Shine, Standardize, and Sustain

6S - Sort, Straighten, Shine, Standardize, Sustain and Safety

1. Introduction

This chapter introduces the research aim and its objectives; the research question is formulated, and the methodology applied in the development of the thesis is described. It concludes with a brief description of the thesis structure, indicating the papers that have been published to support the development of each chapter.

1.1. Aim

The extremely competitive business environment, with rapid changes in markets and the focus on customer orientation, have forced organizations to adjust their supply chain (Shepherd and Gunter, 2006). Organizations worldwide are continuously trying to develop new and innovative ways to develop competitive advantage and strengthen their brand image (Rao and Holt, 2005).

Several factors are becoming increasingly critical and may influence the business environment namely, globalization, technology innovation, new organizational skills, design of products and services, customized customer demand, or environmental protection and resource scarcity (Broek, 2010; Shepherd and Gunter, 2006; Carvalho *et al.*, 2011a; Cetinkaya, 2011); these factors affect organization`s supply chains in various ways, resulting in new requirements on supply chain management (Broek, 2010).

Supply chain promotes interdependency between organizations - organizations are entities of the supply chain management considering suppliers, focal companies and customers which are linked by information, material and cash flows (Kainuma and Tawara, 2006; Seuring and Muller, 2008). The objective is to satisfy the customer needs to the lowest possible cost for all entities, with the right product or service, in the right quantities, in the right time and in the right place, assuring a continuous flow through the supply chain (Cruz-Machado, 2007).

To stay competitive in the market, organizations must achieve a product or service with higher quality, with a reduced cost and in less time than ever before. They also want to be seen as the ones that conduct their business in a responsible manner, being aware of supply chain activities` impact on environment (Srivastava, 2007; Zhu *et al.*, 2008; Mollenkopf *et al.*, 2010).

Supply chain activities have become a critical part of operations; they must be seen as a system that needs to be improved. Opportunities are then emerging for supply chain

improvement: exploring new paradigms as lean, agile, resilient and green in supply chain may change practices in order to obtain a more efficient and sustainable supply chain. The importance to be both lean and green begins to be a business concern (Broek, 2010).

The lean paradigm improves quality and productivity by eliminating waste and at the same time reduces cost and time, satisfying customer needs (Ryder, 2011; Venkat and Wakeland, 2006); lean is focused in optimizing the processes of all the supply chain, searching for simplification and reducing activities that do not add value. The lean paradigm asks for workforce reduction, space reduction, increased capacity utilization, higher system flexibility and use of standard components (Pettersen, 2009).

The green paradigm aims to reduce environmental impacts while eliminating environmental waste in organizations (EPA, 2007); green is centered in achieving profit and market share objectives, by reducing environmental risks and impacts while improving ecological efficiency of organizations and their partners (Zhu *et al.*, 2008). The green paradigm asks for practices such as reduce, reuse, rework, recycle, return or remanufacturing (Srivastava, 2007). This paradigm becomes an approach that effectively establishes strategic differentiation (Broek, 2010).

Recent studies have highlighted the importance of this topics; research with both paradigms (lean and green) is found in Dües *et al.* (2013) where the relationships between lean and green in supply chain are explored. Kainuma and Tawara (2006) propose a lean and green supply chain extended the supply chain to include reuse and recycling throughout the life-cycle of products and services, considering a reverse supply chain. Mollenkopf *et al.* (2010) evaluate the convergence and divergence of both paradigms and indicates how organizations can manage the supply chain applying the synergies available.

The supply chain can be considered as a hybrid system, deploying a number of principles, practices, techniques and tools - which will be considered to in this thesis as "elements" - for both paradigms. Gordon (2001) mentioned that organizations should determine the products to supply, the type of containers to use, and the type of the transport mode to use and the exact information to share and consequently minimizing the cost and the lead-time and, at the same time, reducing the environment impact. Vais *et al.* (2006) considered lean and green through the deployment of the 3R`s (reuse, reduce and recycle). Others elements are considered as starting points namely Kaizen events, 5S or Value Stream Mapping (EPA, 2007; AME, 2008; Venkat and Wakeland, 2006; Torielli *et al.*, 2011). The leadership empowerment, continuous improvement, waste elimination, resource optimization, employee engagement, stakeholder

relationship and information sharing are further elements mentioned in a lean and green supply chain (Puvanasvaran *et al.*, 2011; EPA, 2007; Johansson and Winroth, 2009; Bergmiller and McCright, 2009).

The deployment of lean and green elements seems to be vital for the business to stay competitive. However, it is still very difficult to integrate a number of supply chain elements, as they seem to be contradictory and may lead to tradeoff situations. A well-known example by academicians is the need for frequent replenishment, required by lean approach with just-in-time delivery or small lot size that generates more transportation and high levels of carbon dioxide emissions (Zhu and Sarkis, 2004; Venkat and Wakeland, 2006; Sawhney *et al.*, 2007).

Supply chains need to answer to customer needs and combining these two paradigms requires additional attention and research (Johansson and Winroth, 2009; Azevedo *et al.*, 2012). Organizations must develop solutions that mitigate undesirable consequences to optimize the supply chain performance (Mollenkopf *et al.*, 2010). Conventional management practices are not enough to ensure the long-term success of businesses (Talwar, 2011). There are a number of management frameworks to help organizations to streamline the supply chain processes and improve the organizational performance (Talwar, 2011). There are management frameworks to assist the lean transformation (SP, 2010) and others for the green transformation (ISO 14001, 2004). For example, the Shingo Prize framework evaluates a lean transformation (Cruz-Machado, 2007). For a green transformation, the management system ISO 14001 assist in the implementation of green supply chain issues (Nawrocka *et al.*, 2009).

The lean and green approaches should act at different business levels to influence supply chain activities. The understanding of paradigms` influence at strategic, tactical or operational level should be important for the lean and green supply chain transformation. Dües *et al.* (2013) mentioned that to establish the best lean and green integration, it is necessary to understand the characteristics of the both paradigms; they consider that lean and green can have a positive influence in current business practices. The lean and green considerations should be part of every business decision and must be aligned with supply chain management. Be aware of the compatibility among lean and green paradigms will assist to draw a lean and green integrative supply chain.

1.2. Objectives

This research work intends to study how lean and green can be compatible in a supply chain context and how to develop an improved synchronized implementation. To attain this purpose, two main objectives were considered. The first, is to develop a framework for the implementation and evaluation of a lean and green organization`s supply chain; the second objective is to propose a roadmap to indicate how to achieve and progress a lean and green supply chain transformation. To accomplish these objectives, the fundamental research questions addressed in this thesis are the following:

- *How supply chain management paradigms are being applied and integrated?* A literature review on supply chain management paradigms is carried out, to analyze the paradigms characteristics and how they are integrated into supply chain management.

- *How management frameworks give insights to modeling the supply chain?*A literature review on different management frameworks is carried out, to investigate their similarities in order to link data between these frameworks and consider as referentials for supply chain management.

- *How to model the lean and green paradigms in the supply chain management context? How to evaluate the lean and green implementation?* A lean-green supply chain conceptual framework for the implementation and evaluation of a lean-green organization`s supply chain is proposed.

- *How organizations implement the lean-green supply chain elements in a real-scenario?* A case study in the upstream supply chain is performed to test qualitatively the validity of the proposed conceptual framework.

- *How lean-green elements should be deployed to have a lean-green supply chain transformation?* An oriented-tool is developed to indicate in which moment the lean-green elements should be implemented so that the organization`s supply chain may achieve and progress to a lean-green transformation; that is, to explain when and where the lean-green elements should be deployed to transform the actual supply chain in a lean-green supply chain.

1.3. Methodology

This scientific research was integrated in an international research project entitled "Lean, agile, resilient and green supply chain management", funded by Fundação para a Ciência e a Tecnologia (project MIT-Pt/EDAM-IASC/0033/2008). The purpose of this research project was to develop a deep understanding of the relationships between lean, agile, resilient and green paradigms in the context of supply chain management. The participation in this project was vital for the development of this dissertation.

The research methodology involves different phases to achieve the main objectives. The first objective could be reached through the literature review. Two different areas were under study:

First, by the identification of the supply chain paradigms it could understand their characteristics and combinations. The study focused on four different supply chain paradigms, to recognize the importance of each on the supply chain and for academicians and practitioners. Therefore, a structured literature review was carried out, to provide a comprehensive understanding on the paradigms implementation in supply chain management context. A state-of-the-art literature review was performed in order to identify the principal configurations and contributions of lean, agile, resilient and green supply chain paradigms and their combinations and tradeoffs. A classification scheme was developed with the intention of providing a comprehensive review of the available literature.

Second, another study was developed to obtain understanding on different management frameworks. A contribution proposed by this research is to study the characteristics of different management frameworks and their similarities in order to link data between them. Each of these management frameworks have different purposes, but were selected as referentials for modelling a supply chain. A characterization of each management framework, namely awards, standards and tools, is presented and discussed. Thirteen management frameworks were under study, namely:

- business awards (such as Deming Prize, Shingo Prize, Malcolm Baldrige National Quality Award and European Foundation for Quality Management, all of them are worldwide recognized);
- management standards (i.e. as Quality Management, Environmental Management, Health and Safety Management, Innovation Management, Six Sigma and Social Responsibility); and

- management tools (namely, Supply Chain Operations Reference Model, Eco-Management and Audit Scheme and Global Reporting Initiative).

This study helped to understand that almost all the management frameworks mentioned similar characteristics, the need for leadership, people, strategic planning, stakeholders, processes and results. Moreover, a literature review on performance measurement system was carry out, to understand how supply chain performance can be evaluate. These analyses provide some inspiration for modelling a lean and green supply chain environment.

The contribution to modelling a lean and green supply chain was developed through a conceptual framework. This conceptual framework seeks to cross-data between the information collected from management frameworks and the lean and green supply chain approach; the six categories common to management frameworks were considered important to model a lean and green supply chain. Thus, the conceptual framework assumed six main criterions, namely leadership, people, strategic planning, stakeholders, processes and results. It was considered for each criterion a number of lean and green supply chain elements and the guidelines were designed. In addition, it was proposed a criteria score for each criterion and an assessment method for lean-green supply chain implementation. This framework was designed with the intention to assist organizations to evaluate their business in terms of a lean-green supply chain.

The research took into consideration that it was necessary to examine how lean-green elements are being implemented in a real-scenario. Therefore, a case study approach was considered in the methodology for this research. The case study was conducted at a Portuguese automotive supply chain to test qualitatively the validity of the proposed conceptual framework. This kind of industry was selected due to the high levels of implementation of lean and green paradigms. The research covers different companies of the same supply chain to understand the integration between lean approach and green approach. To conduct the case studies a structured interview protocol was designed to guide the interviews. The study focused on a focal company and their suppliers located in an Industrial Park, nearby. The case study helped to understand how elements are implemented in a real supply chain.

The second objective is reached by the outputs from the conceptual framework and from the findings and evidences of the case study. A roadmap oriented-tool was developed; it considered the stages of a lean-green supply chain transformation, indicating when and where activities should be executed. The objective of this model is to give know-how to implement a supply chain based on a lean-green approach.

In this research the "lean-green" term represents the lean and green integrated approach, considering lean-green supply chain as a hybrid supply chain.

1.4. Contents

This dissertation consists of seven chapters plus references and annexes. The research followed the strategy of trying to publish papers that would result in chapters of the thesis in order to receive feedback from members of the wider academic community. This has allowed progressively incorporating new ideas and improving the dissertation. Therefore, the indication of which paper helps to develop this dissertation is specified in Figure 1. In addition, to help to enrich this dissertation, this research work was presented in the EurOMA Doctoral seminar, for first year (Duarte, 2010) and for second year (Duarte, 2011) attendance.

This dissertation is organized as follows: the first chapter provides an overall introduction to the research and its direction. In the subsequent chapter, a main review of the literature related to four different supply chain management paradigms namely lean, agile, resilient and green are presented. A characterization of actual paradigms in supply chains is presented studying their relationships and comparing their characteristics to the supply chain strategies. In addition, this chapter focuses on the methodology used to explore and analyze which paradigms in supply chain will be more effectively contributing to useful new research. This chapter was subject of publications (Cruz-Machado and Duarte, 2010; Duarte *et al.*, 2010; Duarte and Cruz-Machado, 2011; Carvalho *et al.*, 2011a; Duarte *et al.*, 2011b) on which the body of the text was considered.

Chapter three presents a characterization of various management frameworks representing awards, standards and tools under study with a comparison between them. The outputs taken from this chapter is that there are "near-common" characteristics considered in almost all frameworks under study, namely, leadership, people, strategic planning, stakeholders, processes and results. The body text of this chapter is part of the publications made (Duarte and Cruz-Machado, 2012a; Duarte and Cruz-Machado, 2013b).

In addition, management frameworks provide monitoring and measuring schemes for the aspects of "value". Therefore a briefly literature review on supply chain performance was made, where the Balanced Scorecard (BSC) approach was considered. The papers (Duarte and Cruz-Machado, 2010; Duarte *et al.*, 2011a) helped in the development of this subject.

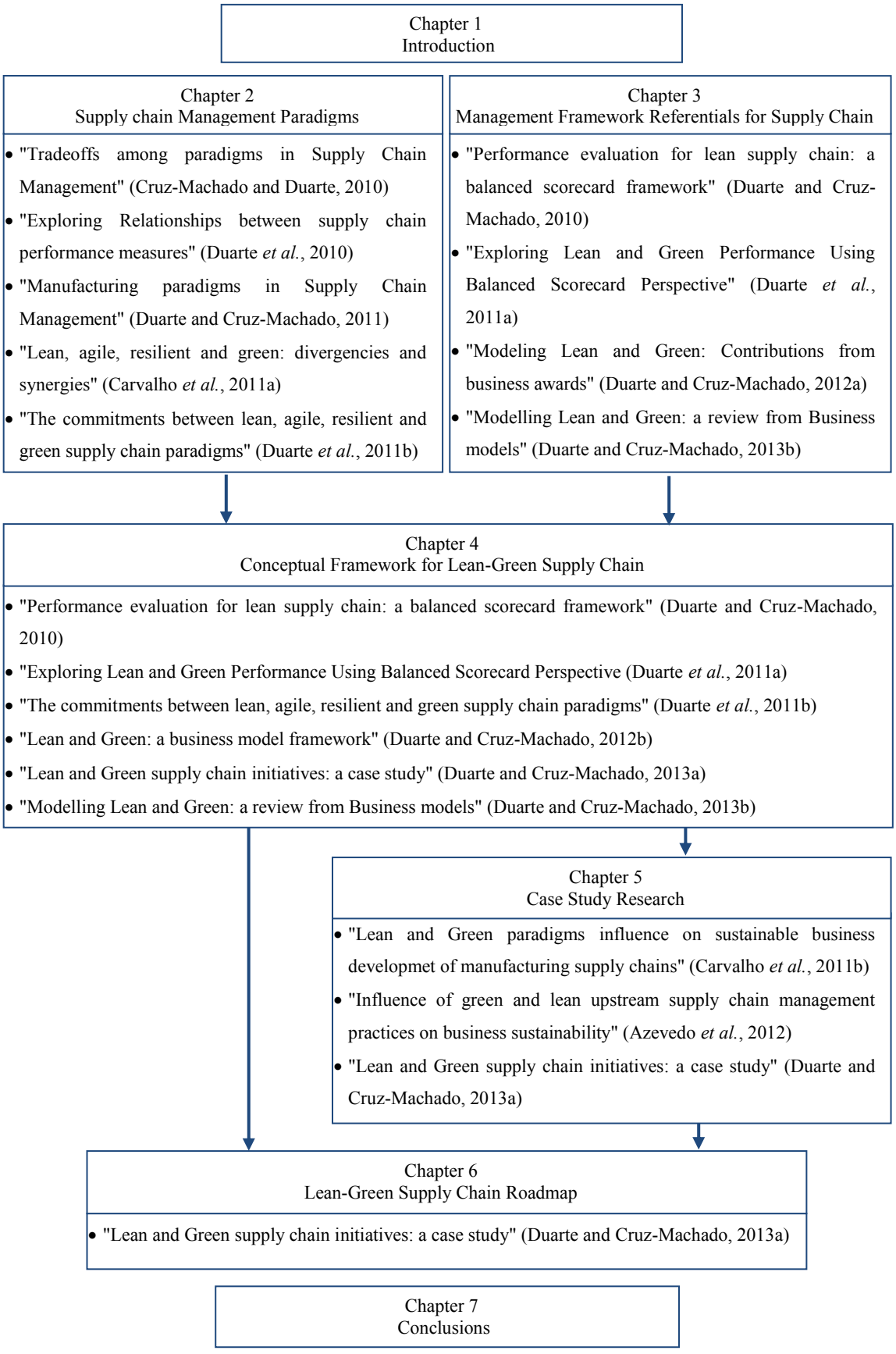

Figure 1. 1 - Thesis organization

The outputs from chapter two and chapter three helped in the conception of the next chapter. Chapter four proposes a conceptual framework to model a lean-green supply chain. This chapter is comprised by: first, it is explained the reasons that lead the research on a study about lean-green supply chain paradigms; second, the lean-green conceptual framework is developed. The published papers (Duarte and Cruz-Machado, 2010; Duarte *et al*, 2011a; Duarte *et al*., 2011b; Duarte and Cruz-Machado, 2012b; Duarte and Cruz-Machado, 2013a; Duarte and Cruz-Machado, 2013b) helped to delineate the structure of the chapter.

Chapter five presents the case study; the chapter considers the research strategy, selection of cases, data collection and records the findings and discussion. A paper (Duarte and Cruz-Machado, 2013a) was published to help to validate the case study. In addition, two more papers (Carvalho *et al.*, 2011b; Azevedo *et al.*, 2012) assist for the maturity of this chapter.

Chapter six presents a roadmap to help managers in the transformation of a lean-green supply chain. This chapter has the evidences taken by both chapters four and five. A paper (Duarte and Cruz-Machado, 2013a) assisted in the validation of content.

Finally some concluding remarks are drawn. This chapter contains an overview of the thesis, the main results and the research implications in terms of theoretical and managerial support, finishing with future research suggestions.

1.5. Chapter overview

This chapter provided an overall introduction to the research and an orientation to the research context. It was identified the purpose of the research; this thesis intends to study the lean and green supply chain theme. Two main objectives were considered for this research and the methodology to achieve those objectives was described. The organization of the thesis is presented and the papers published during the development of the thesis were identified.

2. Supply Chain Management Paradigms

Supply Chain Management (SCM) has been a topic of interest among organizations. It is possible, in the definition of supply chain (SC), to find a number of subjects such as cost, time and quality, as well as concepts like lean, agile and responsiveness, and more recently, vulnerable and resilient (Xu, 2008) as well as green supply chains (Srivastava, 2007). In this chapter were selected four different supply chain paradigms. These paradigms were focussed on a research project, that have been developed during the last 4 years, with the title "Lean, agile, resilient and green supply chain management" with the acronym "LARG_SCM". This chapter discusses these paradigms and the strategies and methodologies for designing supply chains that meet specific customer expectations. The objective of this chapter is to analyze their characteristics and whether these paradigms are being integrated at the SCM.

2.1. Supply Chain Pressures and Paradigms

2.1.1. Supply Chain Management

SCM has become a new and promising way of obtaining competitive advantages in the market (Shepherd and Gunter, 2006). In an operating system there are dependencies and fluctuations, and when these are combined in a delivery system the fundamental characteristics can be observed at the SC level (Stratton and Warburton, 2003). The SCM can be defined as a set of interdependent organizations that act together to control, manage and improve the flow of materials, products, services and information, from the point of origin to the point of delivery (the end customer) in order to satisfy the customer needs at the lowest possible cost to all members (Lambert *et al.*, 1998). According to Speckman *et al.* (1998), the essence of SCM is seen as a strategic weapon by which to develop a sustainable competitive advantage by limiting the investment to be made without sacrificing customer satisfaction.

According to Vonderembse *et al.* (2006) SCM integrates suppliers, manufacturers, distributors and customers through the use of information technology to meet customer expectations efficiently and effectively. Consequently, groups of companies can respond quickly and in an unified manner with high quality, differentiated products demanded by particular final consumers while achieving system wide advantages in cost, time and quality.

Gunasekaran *et al.* (2001) propose that SC is a system whose constituent parts include material suppliers, production facilities, distribution services and customers linked together via the feedforward flow of materials and feedback flow of information. Lambert and Cooper (2000) consider "members of a supply chain include all companies/organizations with whom the focal company interacts directly or indirectly through its suppliers or customers, from point of origin to point of consumption". Christopher and Peck (2004) defined the SC as "the network of organizations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services to the ultimate consumer." Additionally, providing the customer (in an efficient, effective way) with the right products and services at the right place and at the right time, in the right quantities and with the required specifications must be attended properly to ensure a continuous flow in the supply chain (Cruz-Machado, 2007). Thus there are three different continuous main flows in a typical SC: material flow, information flow and cash flow. The SC partners may openly share information that facilities their ability to jointly meet end-customers needs (Speckman *et al.*, 1998). According to Seuring and Muller (2008), focal company is who rule the supply chain, provide the direct contact to the customer and design the product or service offered. Based on the authors Lambert and Cooper (2000) and, Anand and Kodali (2008) Figure 2.1 shows a supply chain structure.

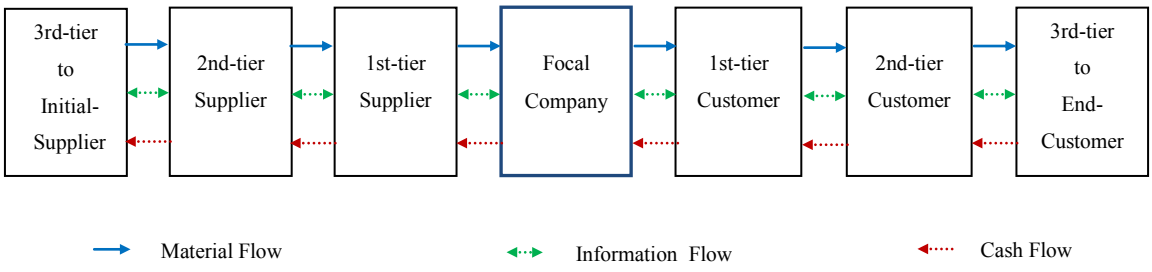

Figure 2. 1 - Supply chain structure

The good management of the SC means it is necessary that the entire set of processes and activities must be viewed as a single system. The full strategy in SCM has three points of focus (Kim *et al.*, 2004): i) structure, which deals with the issue of the location of facilities and processes by stage within the supply chain; ii) organizational, which includes the determination of which organization takes direct responsibility for each stage of the supply process and the inter-organizational relationships; and iii) process, which covers the issues of planning, performing, controlling operations and processes that need to be coordinated.

Vonderembse *et al.* (2006) assert that questions remain about how SCs works and how deeply SC concepts are established in manufacturing organizations. In their view, researchers are investigating the factors needed to design and build effective SCs.

The lean, agile, resilient and green paradigms have thus far been explored from an independent perspective but can be integrated in supply chain. Therefore SCs can be influenced by the different management practices of each paradigm. However they also can merge to have a better way of work where the materials flows, the information flows and cash flows are optimized.

2.1.2. Lean Supply Chain

The production system developed by Taiichi Ohno at Toyota Motor Corporation, in post-war Japan, created what became known as the Toyota Production System (TPS). Since then, TPS has continuously evolved and become known in the West, initially as just-in-time (JIT) production (Womack and Jones, 2003; Reichhart and Holweg, 2007). Subsequently, it was popularized as lean production or lean thinking (Reichhart and Holweg, 2007; Ozelkan *et al.*, 2007).

Lean thinking helps to understand the principles of lean (Womack and Jones, 2003; Melton, 2005; Venkat and Wakeland, 2006):

- the identification of value and the definitions of value propositions for specific customers;
- the elimination of waste, whereby any activity in a process that does not add value to the customer is called waste (determine the best sequence for value creating steps);
- the generation of flow (perform the activities without interruption when a customer requests them);
- and continually improve the process.

The basic forms on the reduction and elimination of waste have been identified as: overproduction, waiting, transportation, inappropriate processing, inventory, unnecessary motion, and defects (EPA, 2007; Qi *et al.*, 2007; Bhasin and Burcher, 2006).

According to Hines *et al.* (2004), lean had moved away from being merely a "shop-floor focus" on waste and cost reduction to an approach that consistently sought to increase value for customers by adding product or service features and removing wasteful activities.

Considering it at the operational level, the lean paradigm is implemented using a number of tools and techniques that included Kanban (visual signal to support flow by "pulling" product through the manufacturing process as required by the customer), 5S (a visual housekeeping technique that devolved control to the shop floor), Visual Control (a method of measuring performance), Poke Yoke (an "error-proofing" technique), SMED (a technique for the reduction of changeover) and takt time (the rhythm of sales) (Melton, 2005; Bhasin and Burcher, 2006). The application of these tools and techniques brings improvements such as: i) decreased lead times for customers; ii) reduced inventories for manufacturers; iii) increased process understanding; iv) less process waste; v) less reworking and vi) financial savings (Vonderembse *et al.*, 2006). According to Bhasin and Burcher (2006), it is important that organizations practice most of those techniques and tools.

The term "lean" comes from the upside of the production method that uses less of everything: "half the human effort, half the manufacturing space, half the investment and half the engineering hours to develop a new product in half the time" (Melton, 2005; Qi *et al.*, 2007). Lean manufacturing is associated with "zero inventory" and the JIT (Just-in-time) approach. The lean approach has been considered to perform better when there is high volume, low variety and stable, predictable demand with certainty of supply and low level inventory (Vonderembse *et al.*, 2006; Naylor *et al.*, 1999).

Today, this paradigm is dominant in manufacturing and reaches from customer needs right back to raw material sources (Venkat and Wakeland, 2006; Reichhart and Holweg, 2007; Hines *et al.*, 2004). This provided the link between the lean paradigm and the supply chain because, for the first time, the production pull was extended beyond the boundary of the single factory to include the upstream and downstream partners (Hines *et al.*, 2004). Reichhart and Holweg (2007) identify three different moments that in turn define the lean concept in the value chain: the principles of lean production began to evolve in the 1950s and were extended to supplier operations from the 1970s onwards; the distribution function only started from the late 1980s.

According to Melton (2005), lean is about the complete change of our business, how the supply chain operates, how the directors direct, how the managers manage and how employees go about their daily work. He defined that lean can be applied to all aspects of the SC and should be applied if the maximum benefits within the organization are to be sustainably realized.

The creation of a lean supply chain (LSC) requires the examination of each process and the identification of unnecessary resources that can be measured in costs, time or inventory (Cruz-Machado, 2007; Womack and Jones, 2003; Vonderembse *et al.*, 2006), as well as the elimination of waste or non-value steps along the chain and the low-cost delivery of a standardized, stable product (Stratton and Warburton, 2003). Therefore, improvements in competitiveness and overall profitability are expected (Vonderembse *et al.*, 2006). LSC is supported by efforts to achieve internal manufacturing efficiencies and reductions in setup time, which facilitate the economic production of small quantities and, to some degree, enhance cost reduction, profitability and manufacturing flexibility (Vonderembse *et al.*, 2006).

According to Naylor *et al.* (1999), the lean paradigm can be applied to the SC upstream of the decoupling point (the point at which strategic stock is often held) because the demand is smooth and standard products flow through a number of value streams. Reichhart and Holweg (2007) discussed lean distribution or the downstream system, defining it as the minimization of waste in the downstream supply chain. By demanding a certain quantity of a product that information propagates upstream through the supply chain, the right amount of product can move downstream in the shortest possible time with a minimum of waste (Reichhart and Holweg, 2007; Venkat and Wakeland, 2006). Lean logistics, as extended to the entire SC, requires frequent replenishment of goods in small amounts at every point in the provision stream as well as the compression of the provision stream in time and distance (Venkat and Wakeland, 2006).

There are many research opportunities and contributions with this issue: Reichhart and Holweg (2007) explore the conflicts between lean distribution and lean production and emphasize the strategies by which to solve this issue; Ozelkan *et al.* (2007) present a case study on the implementation of lean system concepts; Melton (2005) gives the background on lean thinking; Hines *et al.* (2004) provide a framework for understanding the evolution of lean (as a concept and implementation) and point out areas for future research; Bhasin and Burcher (2006) present a conceptual paper in which they argue that an aspiring lean enterprise can only succeed if it views lean as a philosophy rather than another strategy.

However, some difficulty in implementing a lean SC may appear. The lean approach has been criticized in many respects, such as its limited applicability outside high-volume or repetitive manufacturing environments (Hines *et al.*, 2004); the resulting lack of definition has led to confusion and fuzzy boundaries with other management concepts (Hines *et al.*, 2004). Implementing a lean philosophy is not easy, and corporate culture has been blamed for

numerous lean failures. Managers must view lean as a long-term strategy (Bhasin and Burcher, 2006).

2.1.3. Agile Supply Chain

Given the era of time-based competition, high-speed and low cost, organizations are unable to respond to unexpected changes in demand and supply (Lee, 2004). Agility is a business wide capability that embraces organizational structures, information systems and logistics processes (Christopher and Towill, 2000). Most organizations ignore the idea that a SC should be agile (Lee, 2004).

An agile supply chain (ASC) has the ability to rapidly align its activities and operations for response to changes in customer needs and markets (Naylor *et al.*, 1999, Qi *et al.*, 2007; Baramichai *et al.*, 2007). It calls for a high level of rapid reconfiguration and will eliminate as much waste as possible, but it does not emphasize the elimination of all waste as a prerequisite (Naylor *et al.*, 1999).

Agile has its origin in the flexible manufacturing system (Christopher and Towill, 2000; Qi *et al.*, 2007). Subsequently, the flexible manufacturing was extended into the wider business context and the concept of agility as an organizational orientation was born (Qi *et al.*, 2007). Indeed, ASC has emerged as a generic term with particular tendencies, and it is commonly referred to as a distinctly different paradigm from LSC (Stratton and Warburton, 2003; Bernardes and Hanna, 2009; Christopher and Towill, 2000). Most SCs survive by pitting speed against costs, but agile ones respond both quickly and cost efficiently (Lee, 2004).

The agility of a SC may determine the organization`s survival. The key components of agile capabilities are considered to be speed, quality, flexibility and responsiveness (Vonderembse *et al.*, 2006; Qi *et al.*, 2007; Baramichai *et al.*, 2007; Christopher and Towill, 2000; Stratton and Warburton, 2003). The unpredictable business environment can disturb and cause changes to any SC segment, such as purchasing, manufacturing and distribution; these changes require that the organization search for new ways to improve its agile capabilities in order to maintain its competitive advantages (Baramichai *et al.*, 2007). Thus the organization needs to improve the agility of its supply chain by: i) implementing the right approach in configuring the supply chain; ii) establishing relationships with its partners (Christopher and Towill, 2000); iii) allowing the mobilization of global resources to develop changes in technology and material development as well as market and customer expectations (Yusuf *et al.*, 2004); and iv) being

prepared for shocks such as natural disasters, epidemics and computer viruses (Lee, 2004). It is important to draw up contingency plans and develop crisis management teams (Lee, 2004).

The drivers for agility include ever shorter response cycles, representing a change from static systems with significant time allowances; batched information flows and periodic decision making; and dynamic systems where change, information flow and decision-making are continuous (Baramichai *et al.*, 2007).

According to Baramichai *et al.* (2007), "An agile supply chain is an integration of business partners to enable new competencies in order to respond to rapidly changing, continually fragmenting markets. The key enablers of the agile supply chain are the dynamics of structures and relationship configuration, the end-to-end visibility of information and the event-driven, event-based management."

Naylor *et al.* (1999) assert that the agile paradigm "means using market knowledge and a virtual corporation to exploit opportunities in a volatile marketplace." These authors used the decoupling-point concept to separate two distinct parts in the supply chain. In their view the agile paradigm must be applied downstream from the decoupling point (where demand is variable, with less predictable environments and high product variety).

Agarwal *et al.* (2007) have shown that the agility of the SC depends on customer satisfaction, quality improvement, cost minimization, speed of delivery, new product introduction, service-level improvement and lead-time reduction. For them, three variables, namely the use of IT tools, centralized and collaborative planning and process integration are significant drivers. Consequently, they must be the top priority for an agile SC. The literature on SC agility describes the dependence of agility on the characteristics of certain performance variables, but the influence of interrelationships among the variables has barely been considered (Agarwal *et al.*, 2007). Lee (2004) presents four methods for becoming an ASC:

- continuously provide supply chain partners with data on changes in supply and demand, so they can respond promptly;
- develop collaborative relationships with suppliers and customers in order to redesign processes, components and products;
- finish products only when you have accurate information on customer preferences;
- and keep a small inventory of inexpensive, key components in order to prevent delays.

Various approaches to agile supply chain management practice have been identified: Khan K *et al.* (2009) identify the critical distribution practices of agile supply chains and tests their association with organizational performance; Baramichai *et al.* (2007) focus their research on ASC capability improvements and propose a tool whereby the approach is to achieve agility in the supplier-buyer supply chain; Yusuf *et al.* (2004) propose a conceptual model for assessing the capability of an ASC, and explore the relationship between the emerging patterns and the attainment of competitive goals; Agarwal *et al.* (2007) develop a framework that identifies variables influencing SC agility and establishes interrelationships; Lee (2004) compares three terms in the supply chain, namely "agile," "adapted" and "aligned"; Bernardes and Hanna (2009) propose a study on the related terms "flexibility," "agility" and "responsiveness," and try to clarify the differences between those terms.

However, there is a lack of understanding on how to help organizations to improve their agility and which tools, methodology and techniques can be used in practice (Baramichai *et al.*, 2007). Supply chain agility can be founded on business processes and structures that facilitate speed, adaptation and robustness, and which are capable of achieving competitive performance in a highly dynamic, unpredictable business environment (Khan K *et al.*, 2009).

2.1.4. Resilient Supply Chain

Many types of unpredictable disasters have occurred during the past several years, including terrorist attacks, wars, earthquakes, economic crises, tsunamis, strikes, computer virus attacks, hurricanes, storms, extreme weather conditions, diseases, political instability, vandalism and theft, among others. Historical data indicate that the total number of natural and man-made disasters has risen dramatically over the past 10 years (Tang, 2006; Carvalho and Cruz-Machado, 2007).

Today's business environment is characterized by higher levels of turbulence and volatility (Carvalho and Cruz-Machado, 2007), and SCs tend to break down and take a long time to recover, particularly when major disruptions occur. Disruptions can arise from many sources, and every activity that a SC conducts faces the inherent risk that an unexpected disruption could occur (Ponomarov and Holcomb, 2009). Long and complex global SCs are usually slow to respond to changes, and they are more vulnerable to business disruptions (Tang and Tomlin, 2008). The management of supply chain disruptions turns one`s perspective around, making it possible to completely understand the potential of identified risks and increase the capacity of

the supply chain (within reasonable limits) to sustain and absorb disruptions without serious impact (Xu, 2008).

Organizations need to find the right balance of capacity because, with exceptionally open boundaries, they face substantial risks of being disrupted by outside events (AMA, 2006). According to the American Management Association (AMA, 2006), SCs are important focuses of disruptions and are targets for building-up resilience. Supply chains have been designed to optimize cost and/or customer service, but rarely has resilience been an objective in the optimization process.

The resilient concept is rooted in materials science as "the physical property of a material that can return to its original shape or position after a deformation that does not exceed its elastic limit" (Xu, 2008). According to Peck (2005), this concept was adopted because it fits comfortably with the view of SCs as interacting networks. The resilient paradigm focuses on how well an organization resists disturbances and how quickly it can return to its original state or move to a new, more desirable one after being disturbed (Christopher and Peck, 2004; Christopher and Rutherford, 2004; Peck, 2005; Xu, 2008).

The concept of resilience is directly related to important issues such as ecological and social vulnerability, the politics and psychology of disaster recovery, and risk management under increasing threats (Ponomarov and Holcomb, 2009). Xu (2008) asserts that resilience can potentially be a competitive advantage to respond more favourably to disruptions than the competitors. There are cases where disruptions will affect the competitors equally and it is important not to underestimate the company culture that responds quickly to the implications of the changes that occur around it (Sheffi and Rice, 2005).

A case study reported in the literature (Sheffi and Rice, 2005; Tang, 2006; Xu, 2008), for example, is the "Albuquerque accident": "In 2000, a fire at the Philips Electronics plant in Albuquerque, New Mexico, disrupted the flow of chips to cell-phone makers Nokia and Ericsson. Both competitors depended solely on Philips for these particular chips and were equally affected by the fire, but their reactions were very different. Nokia immediately sensed the disruption and responded aggressively, invoking a special process developed for such situations. It quickly became clear that the fire was a major disruption and the plant would be out for months. Nokia dedicated 30 employees to work with Philips and other suppliers in order to restore the supply. It also used different manufacturers, designed its handsets to use different chips where possible and secured Philips entire worldwide capacity for manufacturing the necessary chips. Ericsson, however, was not proactive and did not realize the seriousness of the disruption until weeks later. By the time it mounted a recovery effort, the worldwide supply of

chips had already been committed to Nokia. Consequently, Nokia achieved the sales plant while Ericsson missed a critical new product introduction that resulted in an estimated revenue loss of 400 million Euros. Ericsson ultimately exited the business of making cellular phones."

The need to make a supply chain efficient and resilient has established different, robust supply chain strategies (Tang, 2006). These strategies allow the organization to organize the associated contingency plans efficiently and effectively when facing a disruption, making the organization`s supply chain more resilient. This author proposes strategies based on: i) postponement; ii) strategic stock ; iii) flexible supply; iv) make-and-buy ; v) economic supply incentives; vi) flexible transportation; vii) revenue management; viii) dynamic assortment planning and ix) silent product rollover. According to Christopher and Peck (2004), to create a resilient supply chain (RSC), a number of principles must be applied:

- supply chain understanding, i.e., mapping and critical path analysis;
- choose supply chain strategies that keep several options open, i.e., opportunity to reduce the impact of a disruption;
- re-examine the "efficiency vs. redundancy" tradeoff, i.e., the strategic disposition of additional capacity and/or inventory at potential "pinch points" can be extremely beneficial in the creation of resilience within the supply chain;
- a high level of collaboration across the supply chain can mitigate the risk, which in turn be identified and managed;
- develop a clear view of the upstream and downstream inventories, demand and supply conditions, production and purchasing schedules;
- and improve supply chain velocity and acceleration, i.e., streamlined processes, reduced inbound lead times and non-value-added time reduction.

Peck (2005) concluded that supply chain resilience is more wide-ranging than integrated supply chain management, business continuity planning, commercial corporate risk management or political and public policy. For her, a degree of slackness in the system, whether in the form of inventory, capacity, capability or even time, plus constant awareness and vigilance, are needed if the supply chain is to become and remain resilient.

The attainment of resilience requires flexibility and redundancy (Xu, 2008): i) the flexibility entail the creation of the organization`s ability to respond. These capabilities are mainly developed through investments in infrastructure and resources before they actually are needed.

By using flexibility, the company redeploys some existing capacity in one area so as to make up for lost or delayed capacity in another area; and ii) the redundancy entails maintaining the ability to respond to disruptions in the supply network, largely through investments in capital and capacity prior to the point of need (Xu, 2008). However, according to Tang and Tomlin (2008) it remains unclear how much flexibility is needed and to which level the flexibility can produce benefits. It is difficult to invest in flexibility when consistent data, exact cost and benefit analysis are difficult to obtain (Tang and Tomlin, 2008).

Because RSC is a relatively new area of research, there are many opportunities for study: Peck (2005) presented a framework for understanding SC vulnerability and a discussion of the drivers of vulnerability; Sheffi and Rice (2005) discussed the stages of a disruption and provided high-level recommendations for improved flexibility in the SC; Carvalho and Cruz-Machado (2007) developed a framework for the design of a RSC and proposed a conceptual "SC Resilient Index" and an "SC Resilience Indicator"; Ponomarov and Holcomb (2009) presented an integrated perspective on resilience through a literature review and proposed a conceptual framework for the relationship between logistics capabilities and SC resilience; Tang (2006) identified several robust strategies to encourage success before, during and after a major disruption; Xu (2008) delivered a framework for risk analysis in SCs, and developed approaches for the creation of RSCs.

The frequency of events may be minimized by promoting best practices for increased safety. However, it is impossible to control all risk factors and accidents, and eventually they may occur (Xu, 2008; Carvalho and Cruz-Machado, 2007). The ability to avoid the events is vital for the success of the SC and it is considered a supply chain resilience property.

2.1.5. Green Supply Chain

Organizations are becoming aware of environmental issues and global warming. Such issues became even more complicated when entire SCs are considered (Venkat and Wakeland, 2006). SCM started to experience a paradigm shift with the growth of the environmental movement, particularly the global consensus regarding humankind's impact on climate change (Lu *et al.*, 2008). Organizations will have to expect questions about how green their manufacturing processes and supply chain are (Lee, 2008). Some variables may come into play: Customers will be making environmental requests about the products they are purchasing; and government involvement may occur as technical and financial support or as tax-cut and infrastructure development for environmentally friendly industrial complexes (Lee, 2008).

Therefore, there is a growing need for integrating environmentally choices into SCM research and practice (Vachon and Klassen, 2006). Green supply chain management (Srivastava, 2007) or environmentally sustainable green supply chain management (Zhu *et al.*, 2008) has its influence and relationships between SCM and the natural environment (Vachon and Klassen, 2006; Rao and Holt, 2005; Srivastava, 2007). There are keywords related with the definition of "green" as, for example, "environmental", "ecology" and "sustainable". Sustainable is defined as "a development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Seuring and Muller, 2008).

Green supply chain management (GSCM) emerged as a philosophy that practices implementations ranging from green purchasing to integrated life-cycle management supply chains flowing from the supplier to the manufacturer and then the customer, closing the loop with reverse logistics (Zhu *et al.*, 2008; Lee, 2008; Rao and Holt, 2005; Vachon and Klassen, 2006; Lu *et al.*, 2008). The definitions of GSCM are similar to the concept of SCM, which is dependent on researcher goals and the problems at hand (Zhu *et al.*, 2008).

Various research papers discussing the problem have been published over the past few years: Srivastava (2007) presented a state-of-the art literature review; Vachon and Klassen (2006) defined a methodology to develop the linking between green supply chain (GSC) practices and SC integration; Zhu *et al.* (2008) presented a methodology by which to develop and validate the implementation of GSCM practices with a validated measurement scale in order to evaluate their strengths and weaknesses; Rao and Holt (2005) developed a conceptual model to examine the link between green supply chain management, economic performance and competitiveness; Seuring and Muller (2008) offered a literature review and provided a conceptual framework based on two distinct strategies, namely, supplier management for risks and performance, and SCM for sustainable products; Lee (2008) used a framework and adopted a hierarchical linear regression to examine buyers' green supply chain management practices, government involvement, as well as the internal readiness of suppliers, as possible drivers to participate in green supply chain initiatives; Hsu and Hu (2008) established the consistency and priority approaches for implementing GSCM in response to environmental regulations, and generated a generic hierarchy model for decision-makers to determine the weights among various approaches to the implementation of GSCM, and provided the priority of those approaches for enterprise to adopt and adjust their current GSCM practices; Sarkis (2003) presented a strategic decision framework in which the goal was to help the evaluation of a number of alternatives such as projects, partnerships, systems and technologies, which impact various factors, such as the product life cycle, operational life cycle, performance measures and

environmentally influential organizational policy elements (whereby the decision framework was modelled and solved as an analytical network process).

According to Srivastava (2007), GSCM is defined as "integrating environmental thinking into supply chain management, including product design, material sourcing and selection, manufacturing processes, delivery of the final product to the consumer as well as the end-of-life management of the product after its useful life." In his view, the key challenges of GSCM are divided in two main areas: green design which is divided into two important issues: the environmentally conscious design and life-cycle analysis of the product. The other is green operation, which was divided into green manufacturing and remanufacturing; reverse logistics and network design; and waste management. However, other relevant aspects and areas exist, such as green purchasing, industrial ecology and industrial ecosystems.

According to Zhu *et al.* (2008), "eco" is a critical factor governing the environmental impact of a manufactured product, since the materials and processes are selected at the design stage. The green design or eco-design is concerned with the development of products that are more durable and energy-efficient; products that avoid the use of toxic materials and can be easily disassembled for recycling (Gottberg *et al.*, 2006). These activities provide opportunities to minimize waste and improve the efficiency of resource use through modifications in product size, serviceable life and recyclability (Gottberg *et al.*, 2006). On the other hand, they may present certain potential limitations or disadvantages, which include the following: the easily recyclable materials may have substantial environmental impact during other life-cycle stages; the obsolescence of the products in fashion-driven markets; the compatibility with existing infrastructure and systems; the increased complexity; and the increased risk of failure (Gottberg *et al.*, 2006). The life-cycle analysis of the product is referred to as a cradle-to-grave approach, which is a quantitative process for evaluating the total environmental impact of a product over its life cycle (Craig *et al.*, 2009).

Green purchasing is related to the increasingly heightened environmental awareness, the decisions will impact through the purchase of materials that are either recyclable or reusable or have already been recycled (Zhu *et al.*, 2008; Sarkis, 2003).

Green manufacturing aims to reduce the ecological burden by using appropriate materials and technologies, while remanufacturing refers to an industrial process in which worn-out products are restored to like-new condition (Srivastava, 2007). The operations are intended to reduce, recycle, production planning and scheduling, inventory management, remanufacturing, reuse, and product and material recovery (Srivastava, 2007).

Reverse logistics focuses primarily on the return of recyclable or reusable products and materials to the forward SC (Sarkis, 2003). For this author, the reverse logistics process has identified a number of stages: collection, separation, densification, transitional processing, delivery, and integration. Distribution and transportations operations are also important operational characteristics in GSCM. These operations are more complicated when the entire SC is considered. With the rapid increase of long-distance trade, SCs are increasingly covering larger distances, consuming significantly more fossil-fuel energy for transportation and emitting much more carbon dioxide than they did a few decades ago (Venkat and Wakeland, 2006). Transportation is the fastest-growing energy consumer in the European Union. Packaging is another characteristic that has impact on the distribution and affects the transport characteristics of the goods such as size, shape and material content. Better packaging, along with rearranged loading patterns, can reduce material usage, increase space utilization in the warehouse and in the trailer, and reduce the amount of handling required (Sarkis, 2003).

Waste management makes it possible to know how well the processes are designed for the prevention of waste. The management of waste passes through several sources: reduction, pollution prevention and disposal, which in turn include collection, transportation, incineration, composting, recycling and disposal (Srivastava, 2007). Consequently, there will be a number of system and process requirements that may change among the stages, depending on the organization, industry and product type (Sarkis, 2003).

It is generally perceived that GSCM promotes efficiency and synergy among business partners and their direct organizations, and that it helps to enhance environmental performance, eliminate waste and achieve cost savings (Rao and Holt, 2005), resource savings and productivity improvements (Srivastava, 2007), and ecological efficiency (Zhu *et al.*, 2008). Despite the shift of focus, the goals of visibility, efficiency and cost reduction do not have to be discarded (Rao and Holt, 2005). For instance, organizations have specific criteria with recognized standards (ISO 14001), technical and performance specifications that its suppliers must meet in order to be recognized as preferred suppliers. There are expectations that the environmental risk associated with these suppliers is lessened (Hsu and Hu, 2008; Sarkis, 2003), and therefore it is important to incorporate green practices into the entire SC (Zhu *et al.*, 2008).

The perspective changes from greening as a burden to greening as a potential source of competitive advantage (Srivastava, 2007; Rao and Holt, 2005; Zhu *et al.*, 2008). Organizations are starting to take environmental output as a measurement of supply chain performance (Lu *et al.*, 2008). However, as Zhu *et al.* (2008) assert, the advanced investigation in GSCM requires

an appropriate scale of measurement. One important measurement in SCM is the impact on climate change as carbon dioxide emission (Lu *et al.*, 2008; Venkat and Wakeland, 2006).

According to Craig *et al.* (2009), the most important agreement intended to fight climate change was the Kyoto Protocol where established limits and required to certain industrialized countries to measure their greenhouse gas emissions and then reduce those emissions. The Intergovernmental Panel on Climate Change Guidelines provided a single standard of measurement for six different categories of emission generating activities: Energy; Industrial Processes; Solvents and Other Product Uses; Agriculture; Land-Use Change and Forestry; and Waste (Craig *et al.,* 2009). Other environmental performance metrics include scrap or non-product output, materials use, hazardous materials use, energy use, water use, air emissions, hazardous waste, and water pollution (EPA, 2007; Venkat and Wakeland, 2006).

Srivastava (2007) concludes that GSCM can reduce the ecological impact of industrial activity without sacrificing quality, cost, reliability, performance or energy utilization efficiency. It involves a paradigm shift, going from end-of-pipe control in order to meet environmental regulations to the situation of not only minimizing ecological damage but also leading to overall economic profit.

The green has moved from a trend to a business imperative to improve supply chain (Broek, 2010). Therefore, it is necessary to integrate the green approach into the SCM to achieve a sustainable supply chain and maintain a competitive advantage (Carvalho *et al.*, 2011a).

2.2. Supply Chain Paradigms Combination

2.2.1. Hybrid Supply Chain

Organizations have to answer to actual market pressures and volatility. In today's business environment the challenge is to combine and integrate the previous four paradigms. It may be difficult to categorize an industry or even a single organization as being lean, agile, resilient or green; SCs satisfy different segments and products, which require that different paradigms degrees be addressed. Further, as Kim *et al.* (2004) assert, SCs do not always behave as expected or desired. Many authors report paradigm combinations in the SC, such as:

- How to combine lean practices with an agile response (Naylor *et al.*, 1999; Qi *et al.*, 2007);
- How to combine lean paradigm when organizations are subject to disruptions and cannot be resilient enough to recover the loosed competitiveness (Christopher and Rutherford, 2004);
- How compatible the green level is, with aspects of the lean paradigm (Venkat and Wakeland, 2006; EPA, 2007; Florida, 1996);
- How organizations can face various obstacles to develop greater agility and resilience (AMA, 2006);
- How important the resilient paradigm is as a means by which the organization can become green (Fiksel, 2003).

Prescriptive models for the implementation of measures and practices with the focus on a hybrid supply chain have been developed. Table 2.1 summarizes the literature review on the combination of paradigms.

Although the lean and agile concepts have demonstrated efficacy in their respective fields, the present era demands a more robust strategy incorporating the salient features of the two paradigms (Chan and Kumar, 2009). Researchers have examined the lean and agile paradigms that have been successfully designed and operated in total supply chains of various industries, and have concluded that neither paradigm is better or worse than the other and is therefore not to be viewed in opposition to or isolation from the other (Naylor *et al.*, 1999; Christopher and Towill, 2000; Stratton and Warburton, 2003; Vonderembse *et al.*, 2006; Qi *et al.*, 2007; Chan and Kumar, 2009). They can coexist if properly managed.

Naylor *et al.* (1999) coined the concept of "leagility" by integrating and combining the lean and agile paradigms in a total SC strategy, particularly in consideration of market knowledge and the position of the decoupling point. The authors separate lean and agile principles through a decoupling point (the point at which strategic stock is often held): upstream of the decoupling point the processes are applied to be lean, while the agile paradigm must be applied downstream from the decoupling point (Naylor *et al.*, 1999).

Christopher and Towill (2000) see this hybrid supply chain as being facilitated by two decoupling points in the SC: one for material flow and other for information flow. The decoupling point separates both strategies and is defined as the point separating the part of the supply chain oriented marketplace from the part based on planning (Christopher and Towill,

2000). According to Chan and Kumar (2009), the leagile principle defines that the decoupling point must be as far as possible from the supplier end, and consequently near to the customer end so that the total lead time (to deliver the products) can be minimized; it also acts as a point where a strategic stock is held as a buffer (between unpredictable customer demand and product variety and level production output).

Table 2. 1 - Examples of the literature on hybrid supply chain

Paradigms	Contributions	Author(s)
Lean vs. Agile	Demonstrate the combination of the lean and agile paradigms within the same supply chain, with the aid of a decoupling point and how the decoupling point satisfies different manufacturing types.	Naylor *et al.* (1999)
	Proposed a migratory model which describes the PC supply chain attributes during its evolution from traditional to its present customized leagile supply chain.	Christopher and Towill (2000)
	Define business specific conflicts (lean and agile supply chains) through data analysis and dialogue. Explore how TRIZ separation principles and TOC tools may be combined in the integrated development of responsive and efficient supply chains.	Stratton and Warburton (2003)
	A framework is presented for modeling performance of lean, agile and leagile supply chain on the basis of interdependent variables.	Agarwal *et al.* (2006)
	Provides a framework for understanding lean, agile, and hybrid supply chains, and it relates the adoption of these supply chains to the characteristics of the products and the needs of the customers.	Vonderembse *et al.* (2006)
	Focuses on the performance optimization of a leagility inspired supply chain model. Proposed a hybrid Chaos-based Fast Genetic Tabu Simulated Annealing (CFGTSA) algorithm in order to resolve the complexity of the problem.	Chan and Kumar (2009)
Lean vs. Resilient	Provided a conceptual framework that reflects the joint activities of risk assessment and risk mitigation that are fundamental to disruption risk management in supply chains.	Kleindorfer and Saad (2005)
Lean vs. Green	Examined the relationship between advanced production practices and innovative approaches to environmentally conscious manufacturing. The study was designed to collect original data on the relationship between advanced manufacturing systems and innovative approaches to environ-mentally conscious manufacturing.	Florida (1996)
	A conceptual framework investigates relationship between a supplier and organization`s level of environmental management activity and the structure of the customer supplier manufacturing relationship.	Simpson and Power (2005)
	A conceptual framework was developed in order to identify the potential linkages in GSCM as an initiative for environmental enhancement, economic performance and competitiveness.	Rao and Holt (2005)
	Provided a simulation model of SC with which to investigate a key performance indicator in lean SC using carbon dioxide emissions as the key performance indicator.	Venkat and Wakeland (2006)
	Developed a toolkit to enable Lean practitioners to improve both their business performance and their environmental performance by identifying and eliminating environmental wastes at their organizations.	EPA (2007)

The lean paradigm focuses on eliminating waste and achieving the low-cost delivery of a standardized, stable product (Stratton and Warburton, 2003), being a response to competitive pressures with limited resources (Bernardes and Hanna, 2009). The agile paradigm is a response to the complexity brought about by constant and typically unpredicted changes (Bernardes and Hanna, 2009); it is focused on the need to deliver a variety of products with uncertain demand (Stratton and Warburton, 2003) and must represent availability (Christopher and Towill, 2000). The two paradigms can complement each other. They share a common objective: meeting customer demands at the lowest total cost (Qi *et al.*, 2007).

As seen from the standpoint of strategic inventory, Vonderembse *et al.* (2006) argue that a LSC "generates high (inventory) turns and minimizes inventory throughout the chain"; in an ASC it is "make in response to customer demand"; and in a hybrid supply chain it is "postpone product differentiation and minimize functional components inventory." There is an emphasis on inventory reduction in each of these SC classifications.

A leagile supply chain functions well based on the development of trust, as well as the consistent and predictable acts of the partners over the time. Growing interest in the field of the implementation of the leagile supply chain can be found from the examples of the cloud industry (Stratton and Warburton, 2003) and the electronic industry (Naylor *et al.*, 1999; Christopher and Towill, 2000; Qi *et al.*, 2007). Chan and Kumar (2009) concluded that "the leagile supply chain has proven to be efficient and has gained considerable popularity."

One more hybrid supply chain is developing compatibility with lean and green. Organizations implementing lean practices continually seek to reduce the materials, energy, water, space and equipment, trying to make environmental improvements. Venkat and Wakeland (2006) have investigated whether LSCs have actually been green, using carbon dioxide emissions as the key performance indicator. The lean principles call for the distances on a supply chain to be as short as possible, but in actual global trade very few SCs can consist entirely of short transportation links. The authors concluded that as distances increase, it is quite possible for lean and green to be in conflict, which may require additional modifications to the supply chain, like moving it away from the ideal lean configuration, if emissions are to be minimized.

Another analysis was made by Rao and Holt (2005), who identified the different phases of the SC as an initiative for environmental development, economic performance and competitiveness. In their research the lean paradigm was considered. In their view, lean production is also expected to improve the organization`s environmental performance through good housekeeping practices, such as general waste reduction, minimized hazardous wastes and

reduced lead times, material and staff costs, and by simultaneously increasing production activity and enhancing quality. They concluded that greening the SC has the same potential to lead to competitiveness and economic performance.

Simpson and Power (2005) have noticed that the practices that support lean manufacturing are similar to the practices that support green environmental performance. The result of their study is that suppliers can see the benefits of sharing the knowledge and practices in environmental management and relating this to their ongoing viability as suppliers. There was also evidence suggesting that environmental practices may be developed as part of a close relationship in a low-transaction-cost manner as a direct and indirect feature of any lean transformation.

The United States Environmental Protection Agency (EPA, 2007) adds environmental metrics to lean metrics and refers that "using environmental metrics in lean efforts will allow companies to document the environmental benefits that are part of lean implementation, as well as identify targets for future improvement efforts". Kainuma and Tawara (2006) examined both paradigms extending the range of supply chain to include re-use and recycling throughout the life cycle of products and services in a reverse SC. Another perspective is provided by Johansson and Winroth (2009) who claim a lack of understanding of lean and green relationship concepts. Gordon (2001) provides a summary of practices after lean and green implementation. Zhu and Sarkis (2004) investigate how lean manufacturing influence the relationship between Green SCM practices and performance. These are examples of studies between lean and green.

Today's business environment requires a mix of strategic agility and resilience. Sufficient literature exists in regard to the various aspects and facets of agile and resilient. Christopher and Peck (2004) have concluded: "Resilience implies agility. Being able to react quickly to unpredictable events is clearly a distinct advantage in an uncertain environment."

A contribution from AMA (2006) shows that there is a lack of clarity regarding the functional knowledge and skills needed to help individuals, teams and organizations become more agile or resilient. For them the "distinction between agility and resilience is much less important than the fact that building and sustaining mutually is essential to survival in turbulent environments. Agility without resilience can create an overexposed organization that emphasizes leanness, boundary destruction, openness and speed so much that severe shocks and disruptions can severely damage its performance, even threaten its survival." For the authors, resilience is what is needed when agility alone fails to protect the organization in a turbulent environment (AMA, 2006).

The mixture of lean and resilient gives some important aspects to be considered. One example is to increase the capacity of the supply chain. Capacity can also be removed if the intention is to become leaner, or it can be maintained if the aim is to achieve a more resilient supply chain. Kleindorfer and Saad (2005) argue that "extreme leanness and efficiency may result in increasing the level of vulnerability, at both the individual firm level and across the supply chain". They state: "Resilient supply chains are not opposed to efficiency and lean operations, but the dimensions of resilience and robustness to supply chain disruptions must be explicitly considered in the design process if they are to be captured."

Christopher and Rutherford (2004) have studied the ways that process risk in SCs can be managed through the application of the "six sigma" approach, analyzing the agile and lean six-sigma and its resilience. They have concluded that the objective is a lean six-sigma process performance that must not be tempted to become too lean. The agile six-sigma leads to a resilient supply chain of robust processes with extra process capacity. Moreover, it refers to the total cost in which adding the expected cost of risk recovery into the equation will shift the optimum away from a totally lean solution. In this way the optimal level of leanness (i.e., not being tempted to become too lean) will be resilient.

2.2.2. Paradigms Characteristics

The literature review shows that various researchers (Naylor *et al.*, 1999; Christopher and Towill, 2000; Agarwal *et al.*, 2006) compare leanness and agility as well as the leagile attributes, but they do not consider the attributes related to resilient and green paradigms. Only a few papers provide a characteristic overview over the lean, agile and hybrid supply chains (Vonderembse *et al.*, 2006). Carvalho *et al.* (2011a) goes further on and makes a comparison between the four paradigms. Table 2.2 was created based on the information provided by all these authors. This table provides the lean, agile, resilient and green paradigm characteristics in SCM. It summarizes the different ways in which each paradigm acts, allowing identification of the differences and matching the paradigms to specific characteristics.

The selected characteristics were based on the information given by the authors mentioned above and were selected in consideration of the following issues: market type, manufacturing focus, product design strategy, information enrichment, alliances, approach to choosing suppliers, inventory strategy, organizational structure, lead time focus, product variety, product life cycle and key metrics. For example, the lead-time focus is based on lead-time compression for all paradigms; regarding the inventory strategy, the lean, agile and green paradigms promote

inventory minimization instead of the resilient paradigm, which demands the existence of strategic inventory buffers. From Table 2.2 it is possible to conclude that there are characteristics of equal, similar and different importance, but the purpose is to analyze the better form in order to manage the supply chain.

Table 2. 2 - Comparison of paradigms supply chains: summary of selected characteristics

Characte-ristics	**Lean**	**Agile**	**Resilient**	**Green**
Market	Serve only the current market segments with predictable demand (Vonderembse *et al.*, 2006; Agarwal *et al.*, 2006; Christopher and Towill, 2000).	Acquire new competencies, develop new product lines and open up new markets, with a volatile demand (Vonderembse *et al.*, 2006; Agarwal *et al.*, 2006; Christopher and Towill, 2000).	Have the ability to act on and anticipate changes in markets and overcome demand risk (Ponomarov and Holcomb, 2009; Christopher and Peck 2004; Tang and Tomlin, 2008).	Demands from at least some customer segments for more environmentally friendly practices (Vachon and Klassen, 2006).
Manufac-turing focus	Maintain high average utilization rate (Vonderembse *et al.*, 2006).	Deploy excess buffer capacity to ensure that raw materials/component s are available to manufacture the innovative products according to market requirements (Vonderem-bse *et al.*, 2006).	Flexible manufacturing process (Tang and Tomlin, 2008; Ponomarov and Holcomb, 2009).	Green manufacturing use appropriate material and technologies (Srivastava, 2007). Realize improvements in productivity and environmental performance as pollution prevention, production process modernization, materials substitution and waste minimization (Florida, 1996)
Product design Strategy	Maximize performance and minimize cost (Vonderembse *et al.*, 2006).	Design products to meet individual customer needs (Vonderembse *et al.*, 2006).	Postponement strategy (Tang, 2006).	Eco-design or green design; development of products that are more durable, energy efficient, avoid the use of toxic materials and which can be easily disassembled for recycling (Gottberg *et al.*, 2006; Srivastava, 2007).

Table 2. 2 - Comparison of paradigms supply chains: summary of selected characteristics (cont.)

Characte-ristics	Lean	Agile	Resilient	Green
Information Enrichment	Highly desirable (Christopher and Towill, 2000).	Obligatory (Christopher and Towill, 2000).	Obligatory (Tang and Tomlin, 2008; Christopher and Peck, 2004).	Highly desirable (Vachon and Klassen, 2006; Hsu and Hu, 2008).
Alliances	May participate in traditional alliances such as partnerships and joint ventures at the operating level (Vonderembse *et al.*, 2006).	Exploits a dynamic type of alliance known as a "virtual organization", which works on product design (Vonderembse *et al.*, 2006).	Strengthening the market by providing information to match suppliers with customers. Collaborative partnerships help mitigate risk (Ponomarov and Holcomb, 2009; Christopher and Peck, 2004).	Inter-organizational collaboration involves activities of transferring or disseminating green knowledge to partners with a view to developing new capabilities for effective action (Cheng *et al.*, 2008).
Approach to choosing suppliers	Supplier attributes involve low cost and high quality (Vonderembse *et al.*, 2006).	Supplier attributes involve speed, flexibility, and quality. (Vonderembse *et al.*, 2006)	Flexible strategies, with multiple suppliers for strategic parts (Tang and Tomlin, 2008; Tang, 2006).	Green purchasing (Srivastava, 2007; Zhu *et al.*, 2008).
Inventory strategy	Generates high turns and minimizes inventory throughout the chain (Vonderembse *et al.*, 2006).	Make in response to customer demand (Vonderembse *et al.*, 2006).	Increases product availability; safety stock inventories of certain critical components to ensure that the supply chain can continue to function smoothly when facing a disruption in supply (Tang, 2006).	Reduced product dimensions; making products foldable for storage and transport (Gottberg *et al.*, 2006). Introduce remanufactured or re-used parts in the material inventory (Srivastava, 2007).
Organiza-tional Structure	Uses a static organizational structure with few levels in the hierarchy (Vonderembse *et al.*, 2006). Require employee empowerment (Dües *et al.*, 2013)	Create virtual organizations by creating alliances with partners that vary with different product offerings that change frequently (Vonderembse *et al.*, 2006)	Approach to the supply chain risk management (Christopher and Peck, 2004).	Approach that integrates environmental thinking (Srivastava, 2007; Sarkis, 2002). Internal environmental management (Zhu *et al.*, 2008). Require employee involvement (Dües *et al.*, 2013)

Table 2. 2 - Comparison of paradigms supply chains: summary of selected characteristics (cont.)

Characte-ristics	Lean	Agile	Resilient	Green
Lead time focus	Shorten lead time as long as it does not increase cost (Vonderembse *et al.*, 2006); essential lead time compression (Naylor *et al.*, 1999; Agarwal *et al.*, 2006)	Invest aggressively in ways to reduce lead times (Vonderembse *et al.*, 2006); essential lead time compression (Naylor *et al.*, 1999; Agarwal *et al.*, 2006)	Lead time reduction (Tang, 2006; Christopher and Peck, 2004) by redesigning the supply chain network (Tang, 2006).	Reduce transportation lead time. Time compression as long as it implies lower carbon dioxide emissions (Venkat and Wakeland, 2006).
Product variety	Low (Agarwal *et al.*, 2006; Christopher and Towill, 2000).	High (Agarwal *et al.*, 2006; Christopher and Towill, 2000).	High (Christopher and Peck, 2004).	For a multiproduct analysis, environmental management decisions become increasingly complex (Sarkis, 2003).
Product life cycle	Long (Agarwal *et al.*, 2006; Christopher and Towill, 2000); standard products have relatively long life cycle times (more than 2 years) (Vonderembse *et al.*, 2006).	Short (Agarwal *et al.*, 2006; Christopher and Towill, 2000); innovative products have short life cycle times (3 months–1year) (Vonderembse *et al.*, 2006).	Relatively long (Tang, 2006).	The product life cycle is influenced by the design for environmental issues, the improvement of processes and having an efficient reverse logistics system in place (Sarkis, 2003).
Key metrics	Lead time; costs; quality (Naylor *et al.*, 1999).	Lead time; service; quality (Naylor *et al.*, 1999).	Risk (Ponomarov and Holcomb, 2009).	Scrap or non-product output, materials use, hazardous materials use, energy use, water use, air emissions, hazardous waste and water pollution (EPA, 2007).

2.2.3. Tradeoff Paradigm

A number of tradeoffs may occur in the management of supply chain paradigms. The tradeoff paradigm indicates that raising one characteristic of one paradigm can imply reductions in other characteristics and/or in other paradigms. The tradeoffs identification and analysis are important in order to identify which of them are relevant for the operations and which require improvement. The manager must find a way to balance the conflicting objectives and tradeoffs.

In context of organizations` supply chains, it is necessary analyze which tradeoffs are considered important to them.

At the operational level, lean and green paradigms have some identified tradeoffs. Many academicians and practitioners try to balance numerous options. The impact of the frequent replenishment and the additional carbon dioxide emissions is the most mentioned (Zhu and Sarkis, 2004; Venkat and Wakeland, 2006; Sawhney *et al.*, 2007). Some lean characteristics as the use of small lot productions (Sawhney *et al.*, 2007), just-in-time deliveries (Azevedo *et al.*, 2012) or reduction on inventory level (Venkat and Wakeland, 2006) involve more frequent replenishment that cause a negative impact on environment relative to air emissions (Sawhney *et al.*, 2007; Toke *et al.*, 2010). To reduce the impact, some of these issues are mitigated with close proximity of suppliers with the manufacturer. Furthermore, another lean characteristic is to have fewer suppliers and that means better forecasting and fuller loads could be planned (Toke *et al.*, 2010).

Another tradeoff mentioned is that with small lot, production may have frequent shutdown and start-up (more setups) resulting in a negative impact on environment relative to the energy use (Sawhney *et al.*, 2007) or cleaning waste from cleaning of equipment (Zhu and Sarkis, 2004). Toke *et al.* (2010) gives the freight consolidation example that waiting for freight to become a full load may lead to longer lead times but may yield savings and be environmentally preferable. Another issue is some transport modes like rail and ship use less energy or use energy more efficiently than other modes like by road or air (Toke *et al.*, 2010).

In a strategic level Sawhney *et al.* (2007) mentioned that lean and green relationship may be positive for regular processes but may be negative for environmental processes that are highly regulated. Moreover, the continuous improvement and environment regulations may not go in same strategic direction.

According to the culture of the organization, Johansson and Winroth (2009) state that investments on environmental friendly equipment (which reduce air emissions), from a lean perspective, may be seen as superfluous as it does not directly contribute to customer value, but from a green perspective it is motivated to reduce negative impacts on the environment. Another tradeoff is when employee`s involvement and empowerment don`t take into considerations the environment issues and when employees don`t know nor care about impact on environment which may result in a negative impact (Sawhney *et al.*, 2007).

Carvalho *et al.* (2011a) conclude that having excess of capacity is a characteristic of agile and resilient SC, since it allows the response to changes in customers' needs or to unexpected

events; in the opposition the lean and green paradigms ask for high levels of capacity utilization (lean fix higher utilization rate of the supply chain resources and green prescribe the efficiency of resources consumption contributing to the reduction of the excess capacity along the SC). Another tradeoff experienced in this study was related to inventory level since the lean, agile and green paradigms prescribe the minimization of inventory levels: lean ask for inventory reduction, agile ask for inventory level in response to customer demand and green ask for the reduction of redundant and necessary material. The resilient SC prescribes a strategic stock, at least for critical materials that should be maintained in low levels. The SC will be more vulnerable to unexpected events that affect these materials supply.

An example is given in another research work where it is mentioned a possible tradeoff between lean and resilient (Duarte *et al.*, 2011b): "the lean paradigm compulsively seeks the reduction of production and transportation lead times to reducing the total lead time and minimizing the total waste. The resilient paradigm, although it prescribes this reduction in lead times, it is not so compulsive, since the objective is to increase the supply chain visibility and capability to respond to unexpected events".

Shahbazpour and Seidel (2006) have presented a case study with which to better understand the manufacturing tradeoffs involving sustainability. Four tradeoffs are identified between key performance indicators (cost, quality, delivery and flexibility) and sustainability as new criteria. A four-step process is proposed by Shahbazpour and Seidel (2006): i) identify and classify the tradeoffs; ii) find the root causes of the tradeoffs; iii) systematically eliminate the root causes of tradeoffs; and iv) capture the knowledge.

Other studies have revealed a tradeoff analysis among service level, inventory and lead time for a supply chain (Jain, 2004). A number of examples are presented: i) high service levels can be achieved using high inventories, but the purpose (in push) is to reduce inventory while improving the service levels; ii) the cost of potentially lost sales has to be balanced with the cost of carrying large amounts of inventory; iii) the need to maintain high service levels while keeping the transportation costs low. Jeffery *et al.* (2008) captured the tradeoffs between the customer service level, inventory and additional factors such as order lead time, variability of demand and forecast accuracy. Prater *et al.* (2001) used case studies to demonstrate a tradeoff between vulnerability and supply chain agility.

According to Mollenkopf *et al.* (2010) some strategies do not seem naturally synergistic however the benefits gained by understanding the tradeoffs and the possible optimization could lead to future performance improvement.

The tradeoffs among the lean, agile, resilient and green management paradigms must be understood, since they may contribute to the more efficient, sustainable competitiveness of SCs and organizations. To determine where the tradeoffs should occur is vital to identify the best combinations between paradigms in a supply chain. If the combinations have been well investigated and evaluated it is possible to make a faster and easy implementation and to achieve the success of paradigms implementation in the organizations and in its supply chain in a real-scenario.

2.3. Supply Chain Paradigms Classification

To find which SC paradigms and the combinations thereof would require further studies, it is proposed a research method based on a literature classification. This research intended to provide a useful perspective for academicians and practitioners of which paradigms is the most studied. The search methodology was based on the choice of the most convenient bibliographical databases, keywords and criteria for the selection of relevant papers. The core theme of the paper literature reviewed has been mainly collected from well-known library databases, namely: EBSCO; Emerald; IEEEXplore; ISI Web of Knowledge and ScienceDirect.

The intention was to know whether there was any interaction among these paradigms. Attempts to understand and integrate these paradigms led to the development of a classification scheme. The scheme presents 15 different combinations but focuses primarily on research that explicitly addresses "lean," "agile," "resilient" and "green" in supply chain management. The term "supply chain" was present in all searches in order to limit the study. Also, the search for papers publications was mainly conducted as a structured keyword search, delimitating only to the title, abstract and keywords. Due the type of searching, in the "EBSCOhost" database, the papers were selected by abstract. In the beginning of this dissertation it was made an evaluation considering papers that were published between the years 2000 and 2009 (the last decade was considered).

The "ScienceDirect" database research covered the following subjects: business, management and accounting; computer science; decision science; engineering; environmental science; material science, and earth and planetary science. In "ISI Web of Knowledge" database research was removed the citation databases and chemical databases. Table 2.3 shows the number of papers that include the paradigms under study. It is possible to confirm the existence of few papers with reference to more than two paradigms. This search revealed that the most

popular issue is "green and supply chain", followed by "agile and supply chain". At the other extreme it was found that the results were not considerable for papers that addressed relationships between "lean", "agile", "resilient", and "green and supply chain". The record found in "ISI Web of Knowledge" was a paper resulting from the project research LARG_SCM.

Table 2. 3 - Number of papers in library databases (from 2000 to 2009)

Library database / Classification Scheme	Science Direct	ISI Web of Knowledge	Emerald	EBSCO Host	IEE Explore
Lean & SC	25	159	58	67	55
Agile & SC	33	224	65	36	102
Resilient & SC	6	25	4	4	8
Green & SC	37	244	26	64	105
Lean & Agile & SC	6	39	23	3	16
Lean & Resilient & SC	0	1	1	0	0
Lean & Green & SC	2	8	1	0	1
Agile & Resilient & SC	0	1	0	0	0
Agile & Green & SC	0	3	0	0	0
Resilient & Green & SC	0	1	0	0	0
Lean & Agile & Resilient & SC	0	1	0	0	0
Lean & Agile & Green & SC	0	2	0	0	0
Lean & Resilient & Green & SC	0	1	0	0	0
Agile & Resilient & Green & SC	0	1	0	0	0
Lean & Agile & Resilient & Green & SC	0	1	0	0	0

When analyzing the selected papers more deeply, different main methods appear. Consequently, papers were divided in different classifications, namely: i) research paper (tools, surveys and modelling papers); ii) theory paper (theoretical and conceptual papers); iii) case study paper; and iv) literature review paper. The investigation concluded that the "research paper" type is the most developed, followed by the "case study paper". Additionally, the survey was conducted in a chronological overview concluding that, over ten years (from 2000 to 2009), the tendency has been to have more papers on this subject.

Because the literature review was carried out in the beginning of this research work, the same study was repeated for the last 4 years. The study between January 2010 and April 2013 was carried out with the same methodology and criteria. Table 2.4 shows the number of papers published in the same library databases. This revaluation was important to effectively

understand the available literature produced in the last four years, validating which remains important to the scientific community, academicians and practitioners, in the world.

It is central to mention the boom of papers on "green and supply chain". In the "ISI Web of Knowledge" database, the number of papers published has doubled (507 papers) compared to those published in the previous decade (from 2000 to 2009). It may be added that the green has been, in recent times, an important approach to the supply chain. Moreover, the number of papers published in the issue "agile and supply chain" is reducing, regarding the number of paper published to "lean and supply chain", in the last 3 years.

Table 2. 4 - Number of papers in library databases (from Jan. 2010 to Apr. 2013)

Library database / **Classification Scheme**	**Science Direct**	**ISI Web of Knowledge**	**Emerald**	**EBSCO Host**	**IEE Explore**
Lean & SC	19	141	42	39	43
Agile & SC	24	136	18	15	48
Resilient & SC	9	38	4	6	20
Green & SC	123	507	61	90	218
Lean & Agile & SC	6	35	9	6	9
Lean & Resilient & SC	0	9	1	2	6
Lean & Green & SC	3	16	3	4	10
Agile & Resilient & SC	0	6	1	2	6
Agile & Green & SC	1	7	3	0	8
Resilient & Green & SC	1	6	1	0	7
Lean & Agile & Resilient & SC	0	6	1	2	6
Lean & Agile & Green & SC	0	7	4	0	7
Lean & Resilient & Green & SC	0	6	3	0	6
Agile & Resilient & Green & SC	0	6	1	0	6
Lean & Agile & Resilient & Green & SC	0	6	1	0	6

In the "ISI Web of Knowledge" database it was found an increasing number of papers relative to the interaction of the four paradigms. This issue has been subject of study which is confirmed by the number of papers produced in recent times compared to those produced in the last decade. These themes, especially the green, lean and agile separately and in the context of SCM, are the focus of study by academicians and practitioners.

2.4. Chapter Overview

The actual market competition is very aggressive, and supply chains must be designed to ensure minimal lead time. The challenge in today's business environment, where organizations must respond to market volatility, is to combine new paradigms and integrate them in their supply chains.

The integration of the lean, agile, resilient and green supply chain paradigms require evaluating its commitments and conflicts to contribute to the more efficient, sustainable competitiveness of SCs and organizations. These four paradigms have the same goal, which is to satisfy customer needs at the lowest possible cost to all members of the supply chain. The principal difference between them is that the lean SC seeks to reduce waste and increase value-added; the agile SC focuses on the rapid alignment of its activities and operations for quick response to market changes; the resilient SC should have the ability to respond efficiently to disturbances; and the green SC seeks to minimize environmental impacts and integrating environmental thinking.

The purpose of this study was to analyze supply chain paradigm research works, putting into perspective the eventual contributions from integrated approaches. A state-of-the-art literature review was performed in order to identify the principal configurations and contributions on each SC paradigm, but it also registered the paradigm combinations in the SC.

A classification scheme was developed with the intention of providing a comprehensive review of the available literature. The findings show that SC paradigms combination need additional contributions and further studies should be carried out. The analysis was based on papers collected from scientific journals included in well-known library databases. The study carried out felt on the terms "lean," "agile," "resilient," "green" and "supply chain," whereby 15 different combinations were identified. It is possible to confirm that few papers exist with reference to more than two paradigms. The same study was made for two different moments: the first between 2000 and 2009 and the second between 2010 and 2013. This study revealed that the tendency has been to increase the research creativity on this subject.

3. Management Framework Referentials for the Supply Chain

In this chapter thirteen different management frameworks considered as referentials for the organization`s supply chain were selected for study. This research is based on a deep analysis of awards, standards and tools in order to achieve an impartial model, able to evaluate the organization`s supply chain. These frameworks provide only high level guidelines to improve performance (Politis and Siskos, 2010). The objective is to evaluate their similarities to attain a starting point for a new framework that will be developed in a subsequent chapter.

3.1. Management Frameworks Characteristics and Perspectives

The supply chain management is connected to business by having into consideration issues such as SCM goals, customer benefits, financial benefits and SCM improvements (Brewer and Speh, 2000). In addition, the supply chain takes into consideration issues such as environment protection, resource protection, social and safety topics (Centikaya, 2011). To achieve those issues the organizations must adjust their way of working. Organizations from any sector, of any size and structure need an appropriate management framework (Politis and Siskos, 2010). Management frameworks were developed to assist organization in their processes and procedures, and to improve their performance.

The term management framework was considered, in this chapter, to define the awards, standards and tools under study. This term definition was based on authors Rouse and Putterill (2003) who comment that "when review the literature, it became apparent that the terms, frameworks, systems and models were often used interchangeably"; they consider framework as a useful way of thinking for modelling purposes. In addition the term management can be defined as the "control of action".

3.1.1. Awards

Professional institutions have developed quality models, in the sense of awarding prizes in recognition of the best practices developed by organizations. These quality awards provide guidelines and may be used as self-assessment models. The awards that are recognized worldwide, are (Talwar, 2011):

- The Deming Prize (DP) which is the oldest, established in 1951 by the Union of Japanese Scientists and Engineers (JUSE),
- The Malcolm Baldrige National Quality Award (MBNQA) established in 1987 in the United States of America (USA),
- The European Foundation for Quality Management Excellence Model (EFQM) which was founded in 1991, and
- The Shingo Prize (SP) establish in 1988 in the USA.

There have been many attempts to compare the various awards looking for common and missing elements (Talwar, 2011; Kumar, 2007). The procedure includes the development of a report describing what an organization achieves with regard to a predefined set of criteria (Politis and Siskos, 2010). However, the awards are a non-prescriptive assessment framework and the assessment criteria differ by model (Kumar, 2007).

The Deming Prize was the first to be established back in 1951 and it was set up by the Union of Japanese Scientists and Engineers to commemorate Dr. William Edwards Deming who contributed to the Japanese industry and to promote further the continuing development of quality control in Japan. The evaluation criteria for DP consists of three independent criteria namely "basic categories", "unique activities" and "role of top management". The DP only provides a framework, as shown in Figure 3.1 for the evaluation items and their linkage for "basic categories" giving prime focus to "Core Quality Systems" (Talwar, 2011) (which represents 50% of the weight of the overall assessment process).

The assessment focuses on the following key principles (JUSE, 2011):

- customer-oriented business objectives and strategies are established according to the management, type of industry, business scale and business environment;
- TQM has been implemented properly to achieve business objectives and strategies; and
- the business objectives and strategies have been achieving effects as an outcome of the TQM implemented.

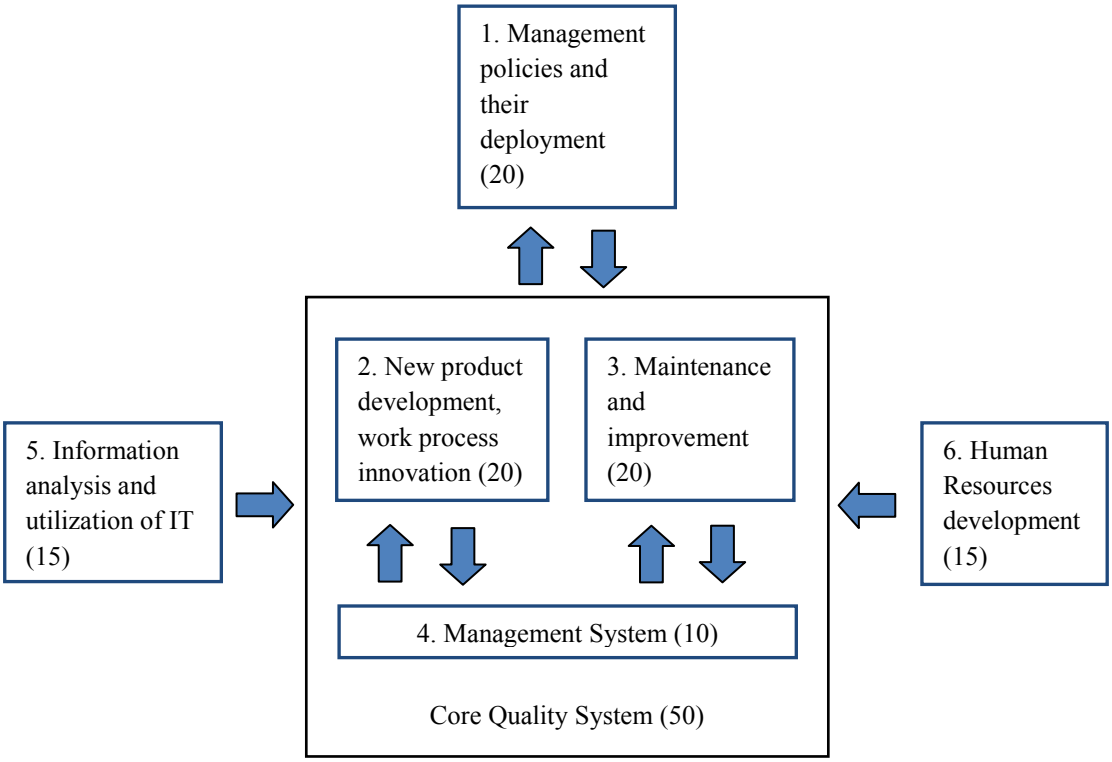

Figure 3. 1 - Deming Prize Framework

(Source: JUSE, 2011)

The Baldrige Performance Excellence Program which is the basis for the Malcolm Baldrige National Quality Award (MBNQA) process is manage by the National Institute of Standards and Technology (NIST), an agency of the United States of America Department of Commerce. The model framework consists in seven criteria that are interconnected: "leadership", "strategic planning" and "customer focus" (representing the leadership triad), "measurement, analysis and knowledge management", and "workforce focus", "operations focus" and "results" (representing the results triad). Figure 3.2 shows the MBNQA framework: at the top of the figure is the organizational profile identifying the context where the organization operates; in the centre of the framework, "leadership", "strategic planning" and "customer focus" are all integrated and flow into "workforce focus" and "operations focus" which achieve the "results"; in the bottom of the framework and linked to the six criteria is the "measurement, analysis and knowledge management" who serve as a foundation for the performance management system (MBNQA, 2011). With this framework the organizations can assess their progress efforts, identify their overall performance management system and identify their strengths and opportunities for improvement, sharing best practices and provide a systems perspective of how the criteria are defined (MBNQA, 2011).

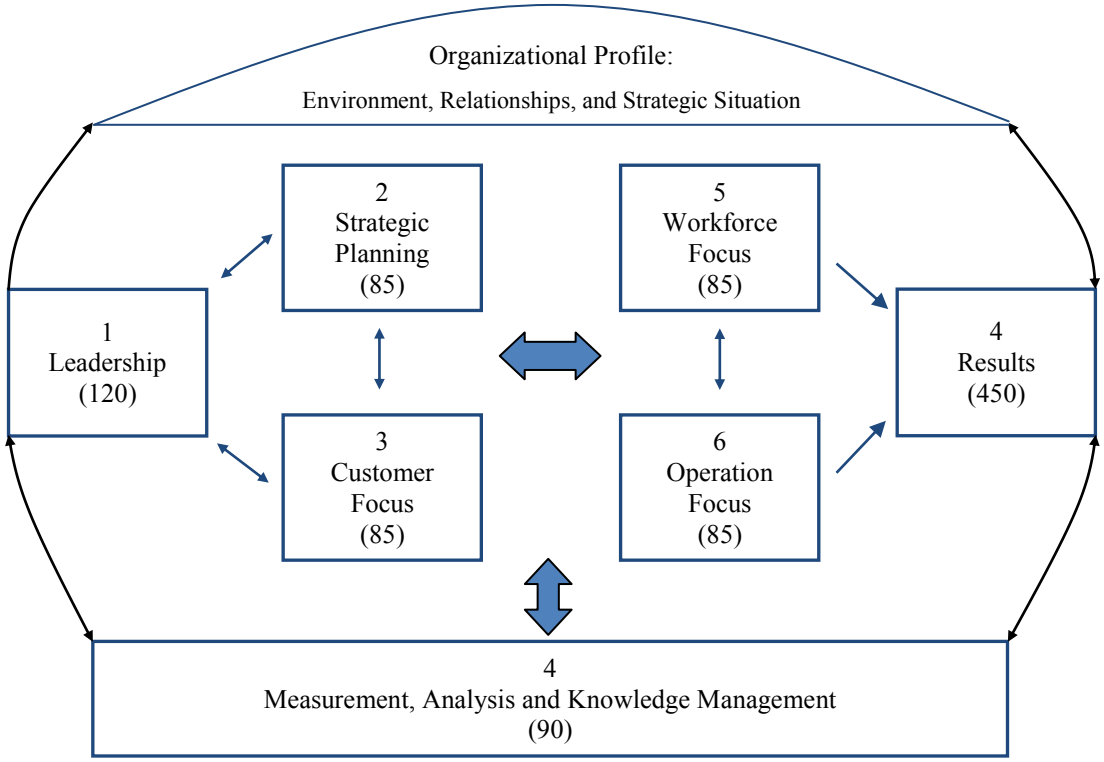

Figure 3. 2 - MBNQA Framework

(Souce: MBNQA, 2011)

The assessment model is focuses on a set of interrelated core values and concepts namely (MBNQA, 2011):

- visionary leadership;
- customer-driven excellence;
- organizational and personal learning;
- valuing workforce members and partners;
- agility;
- focus on the future;
- managing for innovation;
- management by fact;
- societal responsibility;
- focus on results and creating value;
- systems perspective.

Another example is the European Foundation for Quality Management (EFQM) which is considered a counterpart of the MBNQA in Western Europe. The European Quality Award (EQA) was established in 1991 with the support of the European Organization for Quality and the European Commission, the European Foundation for Quality Management (Kumar, 2007). This model framework is based in nine criteria: five enablers and four results. According to this framework the enablers ("leadership", "people", "strategy", "partnership and resources", and "processes, products and services") cover what an organization does and how it does it, and the results ("people results", "customer results", "society results" and "key results") are related to what an organization achieves. Finally, the enablers are improved by the feedback given by the results (EFQM, 2011a). Figure 3.3 shows the EFQM framework.

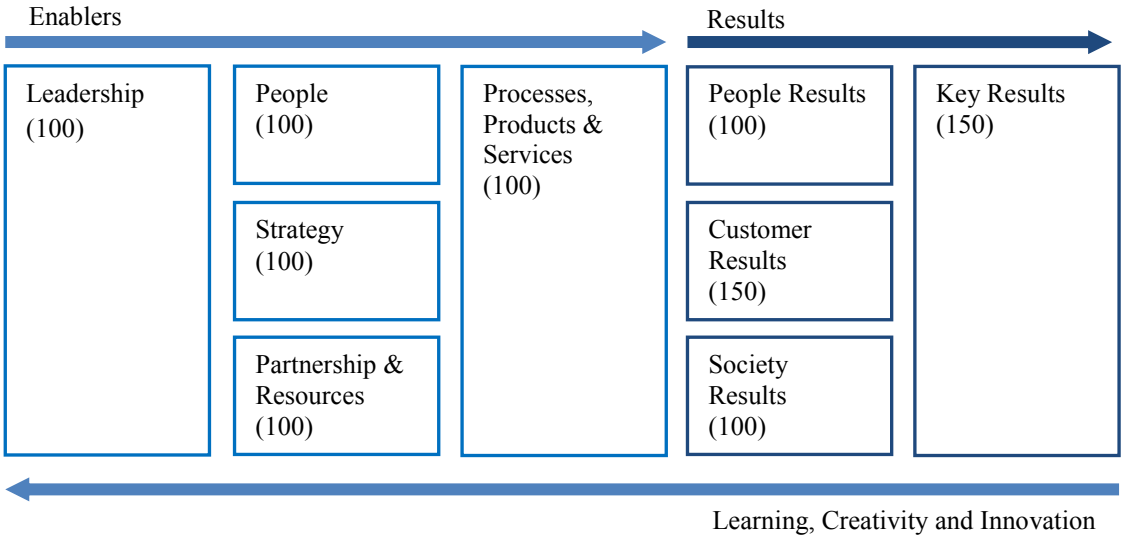

Figure 3. 3 - EFQM Excellence Framework

(Source: EFQM, 2011a)

The fundamentals of this award pass through (EFQM, 2011a):

- achieving balanced results;
- adding value for customers;
- leading with vision, integrity and inspiration;
- managing by processes;
- succeeding through people;

- nurturing creativity and innovation;
- building partnerships;
- taking responsibility for a sustainable future.

A different definition is presented in the Shingo Prize (SP) model. The SP is a model oriented to assess the organization transformation to a lean management approach. The SP is named for Japanese industrial engineer Shigeo Shingo, who distinguished himself as one of the world's leading experts in improving manufacturing processes. As a lean certification is a multi-level program recognizing tactical, integrative, and strategic application of standard Lean principles. The model and guidelines provide a framework for identifying and evaluating the standard for operational excellence that generally do not prescribe one single best method, system, or route to attaining operational excellence (SP, 2010). The model`s fundamentals are, as follows (SP, 2010):

- respect every individual;
- lead with humility;
- seek perfection;
- assure quality at the source;
- follow and pull value;
- embrace scientific thinking;
- focus on process;
- think systematically;
- create constancy of purpose;
- create value for the customer.

One of the keys to implementation is to balance all of these principles, rather than picking one or two with a narrow focus (SP, 2010). The principles are categorized into four criteria or as defined as dimensions: "cultural enablers", "continuous improvement", "enterprise alignment" and "results".

The SP is comprised of two elements: the house and the diamond. The house details the principles of operational excellence and the power of balancing effort across all the dimensions (Figure 3.4). The pie in the centre of the house represents all business and management support processes within an organization (SP, 2010) namely: i) product/service development, ii) customer relations, iii) operations, iv) supply and v) a variety of management support processes

(SP, 2010). The diamond represents the transformation process for embedding the principles of operational excellence into the organizational culture. It is designed as a baseline to help managers identify where their company is on the journey to operational excellence, and to assess the range and depth of transformation inside the organization.

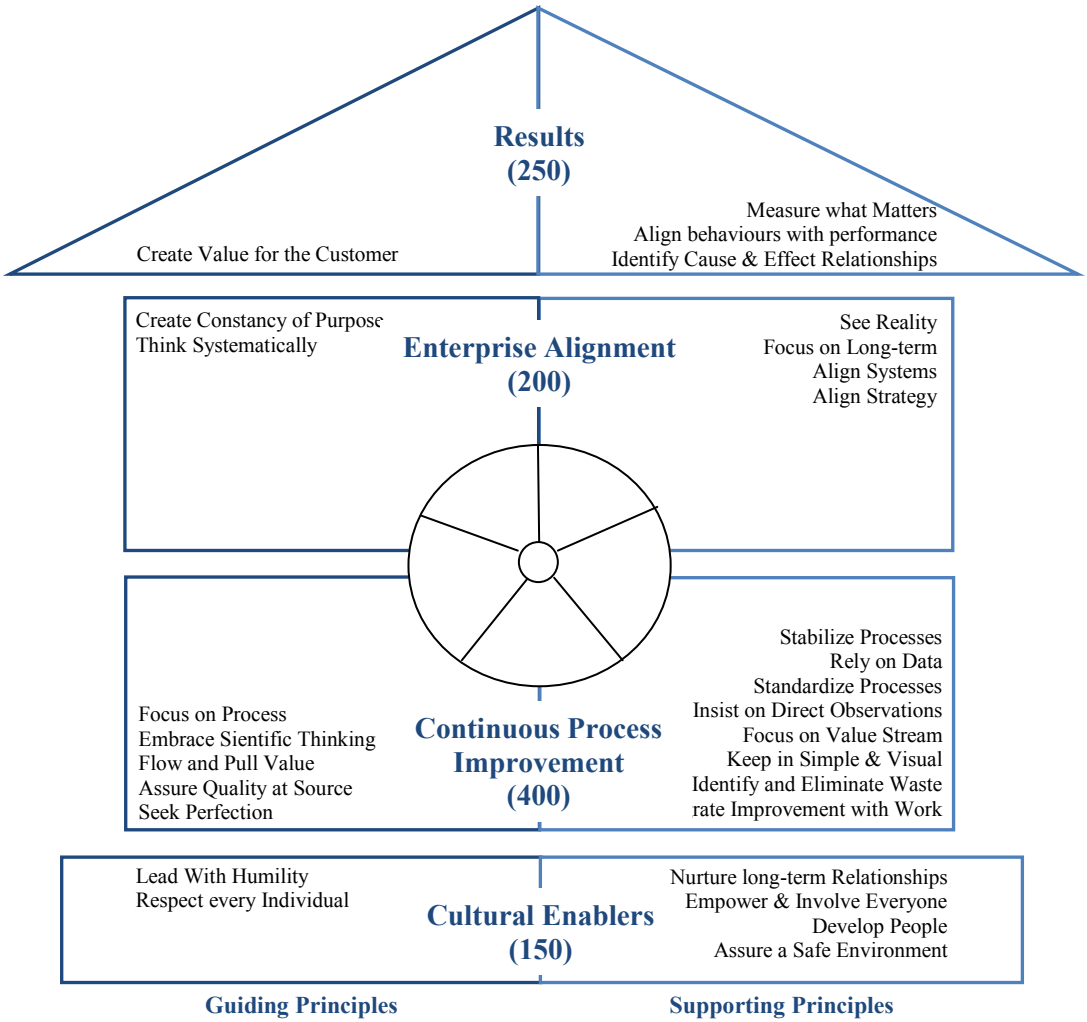

Figure 3. 4 - The House of Shingo Prize Framework

(Source: SP, 2010)

This award should be used to assess the progress that an organization has made in its lean transformation all over their organization`s business processes. The ultimate goal when pursuing the award is clear: cultural transformation through integration of principles of operational excellence across the organization and its value streams to create a complete,

systemic view, leading to consistent achievement of results (SP, 2010).

The value of any of these awards is the benefit derived from the process itself which serves to drive continuous improvement. They indicate what it should be doing, and then the organization based on that defines how to do it. The DP model is quite different in its focus and framework in comparison with most other models, because the prime focus is on "Core Quality Systems" rather than the performance results focus in the other models (Talwar, 2011). MBNQA, EFQM and SP mentioned the performance results as assessment criteria. These three models have an assessment total score of 1000 points. Nevertheless, looking at the evaluation criteria it is possible to conclude that all the awards emphasize customer satisfaction, employee satisfaction and community satisfaction (Kumar, 2007). Table 3.1 characterizes the four distinguished quality awards by assessment framework and criteria score.

However, in what concerns to framework, requirements, assessment criteria and criterion weighting, these awards have been experiencing changes over time. Table 3.2 put in evidence the changes over time for each award.

Furthermore, the awards make mention of a panoply of issues, for example learning, creativity and innovation. They take into consideration the environment, and the social and safety issues. Among environment aspects, DP and EFQM mention the implementation of an environment management system as a way to maintain the environment, and save resources and energy (JUSE, 2011). The SP (2010) mentions aspects of value, including environmental impact, conservation of resources, industrial waste reduction and appropriate handling of hazardous waste and management of the carbon footprint. MBNQA (2011) mentions reducing environmental impact through the use of green technology and resource-conserving activities.

Another relevant issue in nowadays is the social aspect. These models also consider the organization`s social responsibilities and protection of the community. One criterion for the EFQM is that applicants should manage their impact on society, which includes environmental management and social responsibility. MBNQA (2011) refers specifically to how the organization ensures legal and ethical behavior, fulfills its societal responsibilities, and supports its key communities.

Table 3. 1 - Characteristics of distinguished quality awards

	Deming Prize (JUSE, 2011)	**Shingo Prize** (SP, 2010)	**MBNQA** (MBNQA, 2011)	**EFQM** (EFQM, 2009; EFQM, 2011a)
Assessment Framework	The Deming Prize assesses an organization on three different dimensions, namely "Basic categories", "Unique activities" and "Role of top management". The "Basic categories" is under the evaluation criteria with six items. The "Unique activities" refer to the applicant's core quality related activities for its development that it focuses on, employs unique ideas to and achieves the favorable results from; and the "Role of top management" intends to evaluate their understanding, enthusiasm, establishing and deploying policies.	It contains two elements: the house and the diamond. The house details the principles of operational excellence and the power of balancing effort across all the dimensions. The diamond represents the transformation process for embedding the principles of operational excellence in the organizational culture.	It consists of seven categories that are interconnected and works as follows: it starts at the top with the organizational profile, the environment, the relationships and strategic situation that are the influences and the challenges facing the organization. At the bottom there are measurement, analysis and knowledge management and how they feed into the remaining six categories: leadership, strategic planning and customer focus are all integrated and flow into workforce focus, operations focus and results categories.	It is based in nine criteria. Five of these are Enablers and four are Results. The Enablers cover what an organization does and how it does it, while the Results refer to what an organization achieves, caused by the Enablers. Finally, the Enablers are improved by the feedback given by the Results.
Criteria Score	There are three different Dimensions: - Basic categories; - Unique activities; - Role of top management. Categories: • Management policies and their deployment (20 pts.) • New product development and/or work process innovation (20 pts.) • Maintenance and improvement of product and operational qualities (20pts.) • Management system (10 pts.) • Information analysis and utilization of IT (15 pts.) • Human resources development (15 pts.)	Categories: • Cultural enablers (150 pts.) • Continuous improvement (400 pts.) • Enterprise alignment (200 pts.) • Results (250 pts.)	Categories: • Leadership (120 pts.) • Strategic Planning (85 pts.) • Customer Focus (85 pts.) • Measurement, Analysis and Knowledge Management (90 pts.) • Workforce Focus (85 pts.) • Operations Focus (85 pts.) • Results (450 pts.)	Categories: • Leadership (100 pts.) • People (100 pts.) • Strategy (100 pts.) • Partnerships and Resources (100 pts.) • Processes, Products and Services (100 pts.) • People results (100 pts.) • Customer results (150 pts.) • Society results (100 pts.) • Key results (150 pts.)

Table 3. 2 - Changes in the awards over time

Deming Prize	- The TQM (Total quality management) definition was revised in 1998 and again ten years later in 2009. - In 2009 (JUSE, 2011) the "organization`s objectives" was defined based on "company objectives" considered in 1998 (JUSE, 2004). - In the year 1992 the "quality oriented training" shifted to "human resources development" in 2000 (Kumar, 2007) and maintain to nowadays (JUSE, 2011). - "The entire "policy" viewpoint of the year 1992 became part of the "policy management" under "TQM framework" from the year 2000" (Kumar, 2007). In 2011 is considered as "management policies and their deployment" evaluation item. This is in line with MBNQA and EFQM model. - "Cross-functional management, environment management, safety, hygiene and work, and cost management were individualized entries in the year 2000 which were not there in the year 1992" (Kumar, 2007). This definition maintain to the last evaluation document covering the year 2011 (JUSE, 2011). - "The "information on quality" of 1992 was replaced by more general "information system" from the year 2000" (Kumar, 2007). - The "basic categories" was already considered in 2004 (JUSE, 2004) and maintain to 2011 (JUSE, 2011) with 100 points. - The "unique categories" and "top management role" were already considered in 2004 (JUSE, 2004). - The "management systems" was considered on the year 2000 (Khoo and Tan, 2003) and is considered in "basic categories" with 10 points as evaluation item, in 2011 (JUSE, 2011). - Leadership got more emphasis from the year 2000 as five additional viewpoints (Kumar, 2007) were included (JUSE, 2011): i) TQM understanding and enthusiasm; ii) Insights into top management leadership, visions, strategic policies and environmental changes; iii) organizational strength (core technology, speed and vitality); iv) employee development and v) organization`s social responsibilities.
Shingo Prize	- In the year of 2012 the three dimensions (cultural enablers, continuous improvement and enterprise alignment) consider the behavior by the role ("leadership", "management" and "associates") and what action should take, which in 2009 the document do not mentioned it (SP, 2009; SP, 2012). -The criteria weight has change over time. The "cultural enablers" change from 175 points in 2009 (SP, 2009), to 150 points in 2010 (SP, 2010) and with 250 points in 2012 (SP, 2012). The continuous improvement criteria also have been changes over time as from 400 points in 2009 to 350 points in 2012 (SP, 2009; SP, 2012). - The criteria "Consistent Lean Enterprise Culture" with a weigh of 150 points have changing to the definition "Enterprise alignment" with 200 points in the year 2010 (SP, 2010). - The "results" criteria changes from a weight of 275 in 2009 to 250 in the year 2010 and after with 200 points in 2012. Therefore it has been decreasing over time which is not happen with EFQM and MBNQA that remain with 500 points and 450 points, respectively. -The award is given more importance to "cultural enables" where emphasis more the Leadership and People over time; in the opposite direction the award is given less importance to results. - In 2012, the results stress some new performance measures, giving more emphasis to environment, morale and safety rather than people development of 2009 (SP, 2009; SP, 2012). This now is in line with EFQM that mentioned in society results, the environmental measures (since ever). - In 2012 the scoring system has changed to a different assessment scale. To evaluate the three dimensions the scoring system has been subdivided in three important roles (leadership, management and associates). The scoring system for the fourth dimension (results) has also subdivided in four different types of performance system (SP, 2012).

Table 3. 2 - Changes in the awards over time (Cont.)

MBNQA	-""leadership" weight criteria increased from 90 points per cent in 1992 to 12 per cent in 2005" (Kumar, 2007). - The "public responsibility and citizenship" considered in 2001 (Khoo and Tan, 2003) was changed for "governance and societal responsibilities" (MBNQA, 2011). - The current "voice of customer" is considered in "customer focus" criteria which in 2001 was defined as "customer relationship and satisfaction" (Khoo and Tan, 2003). In 2011, the criteria "customer focus" has a criteria weight of 8.5 per cent (MBNQA, 2011), in 1992 was a considered weight of 30 per cent (Kumar, 2007). - The criteria weight on "human resource management" reduced from 14 per cent in 1992 to 8.5 per cent in 2005 (Kumar, 2007). In 2011, the criteria item was defined as "workforce focus" considering the workforce environment and workforce engagement (MBNQA, 2011). -The "work system" sub-criteria change from the "human resource focus" criteria, in 2001 (Khoo and Tan, 2003) to "operation focus" criteria, in 2011 (MBNQA, 2011). - In 2005 the "business results" criteria item was based on "quality results" of 1992. The weight on "business results" was 45 per cent in 2005 while the weight on "quality results" was 18 per cent in 1992 (Kumar, 2007). In 2011 (MBNQA, 2011) the "results" criteria have the same weight. Results are in line with EFQM and SP.
EFQM	- In the year 1995 the criterion weight was defined and only modified in 2010 (IPQ, 1995). The weighting of the criteria was reviewed and simplified (EFQM, 2009). The criterion leadership and key results remained. In 2010 version all five enablers criteria changed for a weight of 100 points each (EFQM, 2009). - The weight on "people" change from 9 per cent in 1995 to 10 per cent in 2010 (IPQ, 1995; EFQM, 2009) - The criterion "policy and strategy" was adapted to "strategy" and increased from 8 per cent in 1995 to 10 per cent in 2010 (IPQ, 1995; EFQM, 2009). - The criterion "resources" was changed for "resources and partnerships" from 9 per cent in 1995 to 10 per cent in 2010 (IPQ, 1995; EFQM, 2009). -The criterion "process" was adapted to "processes, products and services" and reduced from 14 per cent in 1995 to 10 per cent in 2010 (IPQ, 1995; EFQM, 2009). - The "results" have been changed. However it continues to represent 50 per cent of the total score. The weight on customer results reduced from 20 per cent in 1995 to 15 per cent in 2010. The weight of people results increased 1 per cent (from 9 to 10) between 1995 and 2010. The weight of society results increased from 6 per cent in 1995 to 10 per cent in 2010 (IPQ, 1995; EFQM 2009). - Only in the year 2010 was the first time that a fully consistent and direct link was made between each concepts and each of the criterion parts (EFQM, 2009). - Each concept has been enriched significantly. As example the concept in 2003 "corporate social responsibility" changed in 2010 for "taking responsibility for a sustainable future". Another is the definition on 2003 "partnership development" which shift and extended to include partnerships beyond the supply chain with the definition "building partnerships" in 2010 version (EFQM, 2009). -In 2010 version the "feedback arrow below the 9 boxes extended with "creativity". Besides the "learning" and "innovation" as the desired effect of understanding how enablers integrate with results and vice versa, this highlights creativity as a factor highly impacting success, it shows the dynamic nature of the model" (EFQM, 2009).

A principle defined by the SP (2010) is respect for every individual, including customers, suppliers, the community, and society in general. Another principle related to this issue is assuring a safe environment that promotes the health and safety of employees creating and protecting employment for employees and the protection of the environment and the community. It promotes the protection of the environment, classifying this as an aspect of value and also as a powerful element of continuous improvement (SP, 2010).

In addition, concern over safety issues extends to management system implementation, and ensuring health and safety in the workplace and is indicated in DP, MBNQA and EFQM models. The SP (2010) goes beyond that, and, based on lean ideas, refers to the health and safety of all the organization`s stakeholders and to the implementation of OHSAS reporting.

All these awards mentioned the importance of supply chains. EFQM (2009) award mentioned the business` need to achieve higher performance of its supply chain, achieving mutual benefits with their partners. DP award mentioned the development of a quality supply chain management (JUSE, 2011). SP (2010) refers that its framework is used to implement countermeasures face organizational and supply chains challenges. MBNQA (2011) mentioned that supply chain requirements might include: on-time or just-in-time delivery, research and design capability, process and product innovation, customized manufacturing or services, or data information. The work system performance can be achieved through supply chain performance improvement namely, reductions in inventory and incoming inspections, increases in quality and productivity, improvements in electronic data exchange or reductions in costs (MBNQA, 2011).

3.1.2. Standards

A standard is a document that provides requirements and guidelines that can be used consistently to ensure good business management practice so that materials, products, processes and services are fit for their purpose (ISO, 2011a).

A standard based on quality management, created in 1994, is the Standard ISO 9001, which provides the requirements for a quality management system (QMS) and its focus is on delivery of quality products and meet customer requirements. With ISO 9001 the organization demonstrates its ability to consistently provide products (which include services) that enhance customer satisfaction and meet the regulatory requirements (ISO, 2009). Moreover, this standard has a meaning in the supply chain context (ISO, 2011b): to provide the organization

with the necessary degree of confidence on the supply of products from their suppliers (i.e. they have to meet the organization`s needs and comply with applicable regulations).

The framework has four main processes that along with the "quality management system" represent the five most important ISO 9001 requirements (Chiarini, 2011): i) quality management system; ii) management responsibility; iii) management of the resources; iv) measurement, analysis and improvement; and v) product realization; The first four are applicable to all organizations and the product realization section may be adapted to meet the needs of the organization. Figure 3.5 shows the foundation of establishment of ISO quality management system.

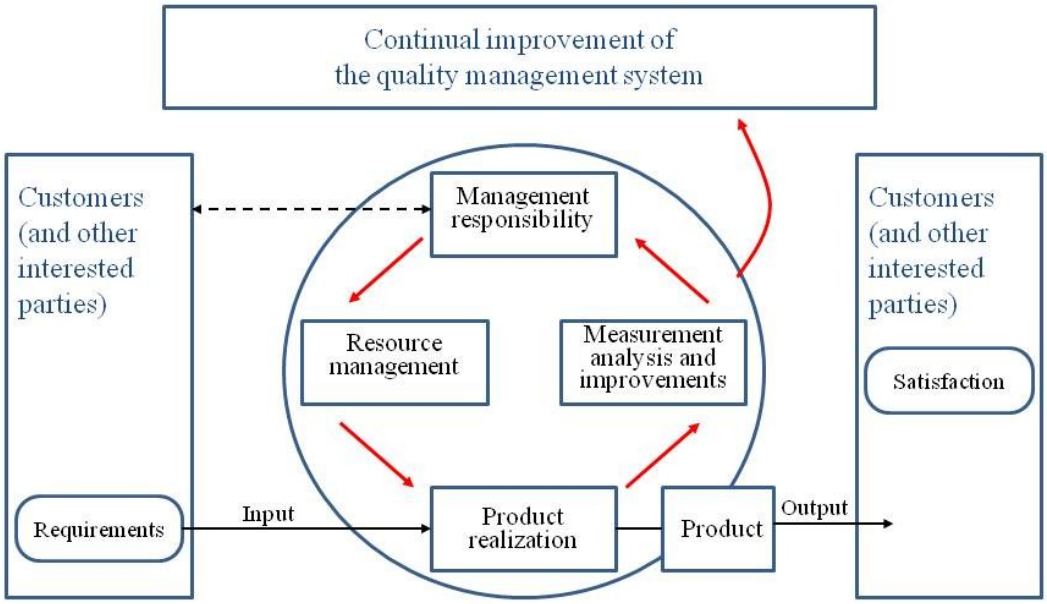

Figure 3. 5 - ISO QMS Framework

(Source: ISO, 2009)

According to Chiarini (2011) the most common benefits of implementing an ISO 9001 quality system include:

- standardization and repeatability of processes;
- improvement of customer satisfaction; and
- reduction of costs of poor quality.

The Six Sigma approach is also based on quality management and the scope is to manage continuous improvement based on controlling the variability of processes (ISO/CD 13053-1, 2009). According to Christopher and Rutherford (2004) "Six Sigma is a data-driven, continuous improvement methodology that seeks to bring processes under control and to improve process capability"; and it "offers a route to creating more robust supply chain processes that reduce the risk of non-conformance and hence produce a more reliable and consistent output." International Six Sigma Standard ISO/CD 13053 relates to managing business improvement processes. The Six Sigma trains experts who work on solving important problems at the same time as they teach others in the organization. It offers a structured training framework with different levels namely Yellow, Green and Black belt program training. Although this is a certification standard produced by ISO, it has a different structure consisting of two parts: the part 1 with the DMAIC (Define-measure-analyze-improve-control) methodology (ISO/CD 13053-1, 2009) and the part 2 with the tools and techniques (ISO/CD 13053-2, 2009).

The ISO 14001 is one of the most widely utilized environment management systems (EMS). The ISO 14001 defines an organized approach to reduce the impact of environmental aspects. It describes a system to help an organization achieve its own environmental objectives (Makower, 2009). However, it does not specify an optimum environmental performance level (Melnyk *et al.*, 2003). The ISO 14001 is modeled in the same management system structure as ISO 9001. This standard contains the following components (AME, 2008): i) identify environmental impacts within manufacturing and other activities; ii) set environmental goals, measuring performance, and reviewing progress; iii) establish procedures for reducing and controlling risks and impacts of its activities, responding to emergencies, and training employees, contractors and others at company sites; iv) maintain records and documentation; and v) audit compliance with regulations and performance of the management system. According to Nawrocka *et al.* (2009) the ISO 14001 is "a useful tool in the management of environmental supply chain issues".

Another certifications that aligns with the standard ISO 9001 and ISO 14001 is the OHSAS 18001. This is an internationally recognized standard that deals with all aspects of health and safety in the workplace (AME, 2008). It aims to provide organizations with elements of an effective occupational health and safety (OH&S) management system such as OH&S hazards and OH&S risks associated. This standard works on the same principle as the ISO 9001 and ISO14001.

The norm NP 4457 defines the requirements of an efficient management system of research, development and innovation (RDI). This norm can be used in any kind of organization in the

management of their innovation process, in areas such new products, services or processes, new method of marketing or organizational, and technological (NP 4457, 2007). The main objective is to enable an organization to develop and implement an RDI policy and in the end increase the effectiveness of their performance in relation to innovation. All requirements of the standard apply to organizations with RDI, regardless of their size and complexity and the nature of its activities. This standard is applicable to any kind of innovation: product, process, organizational, marketing or a combination of these (NP 4457, 2007). The innovation can be applied on the synchronization of the flows of materials and information across the supply chain. There are other standards already published in other countries, but with different scope, as for example the British standard.

The ISO 26000 provides guidance on social responsibility and is an international standard released in 2010. This standard contains guidelines, not requirements, and therefore cannot be used for certification, like the more well-known ISO 9001 and ISO 14001 (ISO, 2011a). It is intended to help organizations to achieve benefits of socially responsible behavior, ensure healthy ecosystems, social equity and good organizational governance (ISO, 2011a). Addressing these issues is a way for organizations to fulfill their own responsibility throughout the supply chain.

This standard is based on seven core subjects of social responsibility: organizational governance, human rights, labor practices, the environment, fair operating practices, consumer issues, community involvement and development (ISO, 2011a). In respect of the environment it identifies the following issues: i) environmental responsibility; ii) sustainable resource use; iii) climate change mitigation and adaptation; and iv) protection of the environment, biodiversity and restoration of natural habitats.

The structural and organizational requirements of ISO management system standards are designed to be compatible (ISO, 2009; Melnyk *et al.*, 2003). The management system ISO 9001 corresponds to environment management system ISO 14001, to occupational health and safety management system OHSAS 18001 and is used to assist in gaining recognition through national awards (ISO, 2011a). All these standards mention:

- the management system policy;
- the planning of management aspects, legal and other requirements, objectives, targets and programs;

- implementation and operation which take into consideration resources, roles, responsibilities and authorities, as well as competence, training and awareness, and communication, documentation, control of documents and operational control;
- measurement, analysis and improvement; and
- review.

3.1.3. Tools

A tool helps to support organizations with various features to follow when it tries to implement a change in the current way of operating. There are industry specific tools designed for processes or for measuring (Hitchcock and Willard, 2006).

A management tool that contributes on the field of the supply chain is the Supply Chain Operation Reference (SCOR) model. This tool was developed by the Supply Chain Council (SCC) in 1996, which provides a framework to measure and benchmark supply chain performance. It characterizes supply chain processes and for each process it considers the activities, the performance measures, the practices that produce best-in-class performance and the skills required for the employees performing the process (SCC, 2010). The business process framework describes the process in way that makes sense to key stakeholders (SCC, 2010). According to SCC (2013) "SCOR helps manage a common set of business problems through a standardized language, standardized metrics, and common business practices which accelerate business change and improve performance." It provides an opportunity to include measures which can capture the performance of activities within the organization and eventually of the various entities in supply chain (Lambert *et al.*, 2005).

According to SCC (2010) it "does not describe every business process or activity. It does not address sales and marketing, research and technology development, or product development. SCOR assumes but does not specifically address quality, information technology, or administration." SCOR helps on (SCC, 2010):

- cost control;
- superior customer service;
- planning and risk management;
- supplier/partner relationship management;
- talent.

Furthermore, it can considers the environmentally management a concern in industry, providing a structure for measuring environmental performance, the GreenSCOR.

A management tool based on environment management system, available since 1995, is the Eco-Management and Audit Scheme (EMAS). EMAS Regulation is an EU scheme implemented by the European Commission (Iraldo *et al.*, 2009). The EMAS assists organization to measure, evaluate, report and improve their environmental performance. This framework is based on ISO 14001 but goes further with additional issues (linked to a number of elements of section 4 of the standard ISO 14001): i) environmental review; ii) legal compliance; iii) environmental performance; iv) employee involvement; and v) communication (EMAS, 2009). The benefits of EMAS registration are (EMAS, 2011a):

- cost reduction;
- risk minimisation;
- regulatory compliance;
- relation with internal and external stakeholders;
- competitive advantage.

It helps organizations to optimize their production processes, reducing environmental impact and making more effective the use of resources and can inform their stakeholders about the main organization`s environmental priorities (EMAS; 2009).

Another tool that evolved from its origins, in strictly an environmental reporting (Nikolaeva and Bicho, 2011) is the Global Reporting Initiative (GRI). GRI was established in 1999, and became a framework related to sustainability. It enables all organizations to measure and report their sustainability performance. This management tool is quite different because it provides standards how organizations should report their information. It supports an organization with reporting guidelines and with a list of performance measures (i.e. including sustainable performance organized by economic, environmental and social categories). In respect to environment it identifies the following environmental aspects: i) materials; ii) energy; iii) water; iv) biodiversity; v) emissions, effluents, and waste; vi) products and services; vii) compliance; viii) transport; and ix) overall. It is intended to ensure a balanced and reasonable presentation of the organization`s performance and to provide consistency across organizations, achieving sustainable supply chains (Hitchcock and Willard, 2006; GRI, 2011).

These three management tools mentioned similar features such as the performance, the transparency and the credibility (EMAS, 2011a; GRI, 2011; SCC, 2010).

3.2. Comparison Between Frameworks

The frameworks change in structure and scope and are based on different principles. However, the principles are based on the foundation for organizational behavior and consequently to their supply chain. All the management frameworks indicate a continuous improvement culture. The methodology most applied is the Plan-Do-Check-Act (PDCA) methodology used by the award DP, ISO 9001, ISO 14001 and OHSAS 18001, NP 4457 and EMAS. The SP, MBNQA and EFQM awards considered as a methodology, among many, that may be applied. Other models do not describe which methodology to use, as ISO 26000. Moreover, the standard ISO 26000 draws on the GRI guidelines (Nikolaeva and Bicho, 2011). The Six Sigma ISO/CD 13053 follows and explains the six sigma specific approach, referred as Define-Measure-Analyze-Improve-Control (DMAIC) methodology. Furthermore, the awards and SCOR mentioned the compatibility of implementation with ISO 9001. The management frameworks MBNQA, SP and SCOR refer a variety of applications management philosophies as Six Sigma and Lean. Table 3.3 presents the relevant characteristics that can be extracted from these models. Four different fields are proposed where different topics can be grouped: i) an organization`s key categories, selected as the "near-common" characteristics considered in almost all management frameworks, ii) strategic issues reflected the principles of each framework; iii) management philosophies regards to approaches exercised in the application of the management framework; and iv) methodology (Mtgh) for development of the frameworks.

Some research has been conducted in this area. Kumar (2007) made a qualitative comparison between DP and MBNQA which tried to understand the differences and similarities between them. Khoo and Tan (2003) compare the MBNQA, the DP, and the Japan quality award with regards to concepts and criteria. Dror (2008) prepared in his work a comparison of organizational performance management frameworks between MBNQA, EFQM and Balanced Scorecard. Talwar (2011) made a comparative study of framework, criteria and criterion weighting of twenty excellence models/national quality awards identifying their common features, contradictions and suggestions. Politis and Siskos (2010) proposed a methodology that consists of an integrated framework of evaluation criteria based on international self-assessment models. Cruz-Machado (2004) made a comparative study between the requisites of ISO 9000 and a lean manufacturing system. Chiarini (2011) drew up guidelines for integrating ISO 9001 requirements with lean principles and tools.

Table 3. 3 - Topics referred to in awards, standards and tools

Topics \ Management Frameworks		Awards				Standards						Tools		
		Deming Prize	Shingo Prize	MBNQA	EFQM	ISO 9001	ISO 14001	OHSAS 18001	NP 4457	ISO 26000	ISO/CD 13053	SCOR	EMAS	GRI
Organization`s key categories	Leadership	•	•	•	•	•	•	•	•	•		•	•	•
	People	•	•	•	•	•	•	•	•	•		•	•	•
	Strategic planning	•	•	•	•	•	•	•	•	•		•	•	•
	Stakeholders	•	•	•	•	•	•	•	•	•		•	•	•
	Processes	•	•	•	•	•	•	•	•	•	•	•	•	•
	Results	•	•	•	•	•	•	•	•	•		•	•	•
Strategic issues	Continuous improvement	•	•	•	•	•	•	•	•	•	•	•	•	•
	Focus on customer	•	•	•	•	•					•	•		
	Focus on future	•	•	•	•					•				
	Education and training	•	•	•	•	•	•	•	•	•	•	•	•	•
	Legal requirements	•	•	•	•	•	•	•	•	•	•		•	•
	Performance indicators	•	•	•	•							•	•	•
Management philosophies	Quality	•	•	•	•	•					•			
	Lean		•	•								•		
	Green	•	•	•	•		•			•		•	•	•
	Social	•	•	•	•					•				•
	Economic	•	•	•	•									•
	Health and safety	•	•	•	•			•		•				•
	Innovation	•	•	•	•				•					
	Six Sigma		•	•							•	•		
Mthg	PDCA	•	•	•	•	•	•	•	•				•	
	DMAIC		•								•			

All these management frameworks provide requirements and guidelines to improve the business performance. However, the analysis of these requirements and guidelines are important to identify which contributions they may provide. Regarding to the principles guidelines and features in awards, standards and tools it was selected a set of "near-common" characteristics, considered as key categories. The organization`s key categories are represented by leadership, people, strategic planning, stakeholders, processes and results. The contributions from these management frameworks under study for each category are important to identify similarities or contradictions between them. To identify the distinctiveness of each management framework, to help in their comparison, it was created a table for each framework. Since, it is wide information a more detailed analysis is presented in Annex 1 where each specific management framework is reviewed by subject: i) objectives; ii) focus; iii) principles; iv) continuous improvement; v) supportive techniques and tools; vi) leadership; vii) people; viii) strategic planning; ix) stakeholders; x) processes; and xii) results. The last six subjects are the organization`s key categories mentioned above (Table 3.3) and is intended to study in more detail these categories; to understand which issues in each category is mentioned by each management framework is the next step of this study.

3.2.1. Leadership

This category is mentioned by all models except the ISO Six Sigma (ISO/CD 13053-1, 2009). According to the ISO 9001 (2008) framework, one requirement is management responsibility. This is also mentioned in ISO 14001 (2004), OHSAS 18001 (2007) and NP 4457 (2007). According to SP (2010), leaders must have a philosophical and cultural commitment to organization, must be able to lead others with integrity and must define a strategic direction that provides a unifying vision, assuring a safe environment. MBNQA (2011) states that leaders must assure their personal actions guide and sustain the organization, to meet its legal, ethical and societal responsibilities. In addition, EFQM (2011a) mentions that leaders act upon future requirements, acting has role models for organizational values and ethics and inspiring trust at all times. Leaders must share the values of the vision and must establish business strategies (JUSE, 2011). As it is possible to analyze in Annex 1, the standards mentioned that leaders or top management must demonstrate their commitment in their communications and their actions. SCOR point out that supply chain leaders are responsible for align the skills of their people and organizational structure with strategic objectives (SCC, 2010).

The leader must develop the vision, mission, goals and values of the organization, promoting a business culture that takes into consideration practices that improve operations and, according to ISO 9001 (2008) establish a quality policy, according to ISO 14001 (2004) and EMAS (2009) an environment policy such as pollution prevention and waste minimization, and according to OHSAS 18001 (2007) a health and safety policy in the workplace. The management of knowledge, ideas and creativeness mentioned by NP 4457 (2007) and by the award EFQM (2009); and the social and ethical behavior towards the local community and society are establish by the standard ISO 26000 (2010), the tool GRI (2011) and the award SP (2010). All awards mention that leadership must be engage with the organization and its supply chain.

3.2.2. People

People are an organization`s key asset, because they are an essential part of every value stream, process and system (SP, 2010). SCOR (SCC, 2010) mention that, "talented people are at the heart of supply chains that effectively respond to and exploit the opportunities." For MBNQA (2011), people are actively involved in accomplishing the work of any organization. People development, empowerment, creativeness and learning are among the important issues mentioned and it is possible to evaluate in Annex 1. SP (2010) states that the organization`s culture must be dictated by respect for each individual. Respect for every individual supports the development of employees and creates an environment for empowerment, associated with the improvement of processes. This principle includes education, training and coaching.

The model ISO/CD 13053-1 (2009) specifies a system, which ensures that every employee has an identified key role and can respond to the requirements of six sigma. According to EMAS (2011b) and SP (2010), the employees that take training get new skills which make it possible for them to recognize their roles and understand why their actions matter. EMAS (2011b) suggests that employees should respond to what the leader communicates and should work as a team.

In addition, the employee’s contribution must be recognized by the organization (ISO 9001, 2008) through communication and rewards. These are ways to motivate employees (EFQM, 2011a). When employees feel that are treated with dignity, fairness and equity (EFQM, 2011a; ISO 26000, 2010; GRI, 2011) and feel that their work is a mean to solving major issues of concern to them, a powerful source of commitment and loyalty is developed (SP, 2010). MBNQA (2011) indicates that empowering employees to take action and give solutions to

problems concerning their work increases employees' commitment and involvement. These cause a deep engagement with the organization (GRI, 2011).

3.2.3. Strategic Planning

Strategy is a proactive customer-oriented business objective (JUSE, 2011; ISO 9001, 2008) with policies, plans, objectives, and processes which are developed and deployed in order to deliver the strategy (EFQM, 2011a). The MBNQA (2011) examines how to convert strategic objectives into action plans. The SCOR (SCC, 2010) mentioned the importance to define realistic targets that support strategic objectives. As it is possible to see in Annex 1, the strategic planning may be defined as quality objectives (ISO 9001, 2008), environment objectives (ISO 14001, 2004; EMAS, 2009) or health and safety objectives (OHSAS 18001, 2007) and also in innovation objectives (NP 4457, 2007). According to ISO/CD 13053-1 (2009), the six sigma project must be linked to an organization`s business strategy.

To the award EFQM (2011a), social responsibility is considered in developing strategy that promotes social and cultural activities. In addition, ISO 26000 (2010) mentions that social responsibility may be an integral part of the core organizational strategy, with assigned responsibilities to all appropriate levels of the organization. The models ISO 9001 (2008), ISO 14001 (2004), OHSAS 18001 (2007) and MBNQA (2011) mentioned that legal and others requirements must be taken into consideration.

Strategy and policy must be reviewed periodically to ensure that they remain relevant and appropriate to the organization (ISO 9001, 2008; ISO 14001, 2004; EFQM, 2011a).

3.2.4. Stakeholders

Stakeholder can be defined as a group or a person such as employees, customers, suppliers, shareholders, investors or beneficiaries, special interest group or community members (JUSE, 2011; SP, 2010; MBNQA, 2011).

The MBNQA (2011) mentions that an organization must take into account all stakeholders in the value chain, because stakeholders can place constraints on the organization`s business. The EFQM (2011a) model mentions that the relationship between an organization and its stakeholders must be planned and managed. SCOR (SCC, 2010) refers to the importance of an

easier coordination with customers, suppliers and others stakeholders. According to SP (2010) and EFQM (2009), the leaders must define the organization`s responsibilities in protecting the environment, the health and safety of all the organization`s stakeholders, and also they should be personally involved with stakeholders.

The standards ISO 9001 (2008), ISO 14001 (2004), OHSAS 18001 (2007) and the NP 4457 (2007) refer to the communication of the procedures and requirements so as to allow for a better understanding of the value chain. GRI (2011) and SP (2010) mention that transparency can be defined as a complete revelation of information that allows stakeholders to make decisions. SP (2010) also mentions to the importance of nurturing a proactive and a long-term relationship. As indicate in Annex 1, GRI (2011) and ISO 26000 (2010) refer to the stakeholder engagement process as a tool for understanding the expectations and interests of stakeholders.

3.2.5. Processes

Processes are related with the creation of value for the customer (MBNQA, 2011; JUSE, 2011; SP, 2011; ISO 9001, 2008; SCC, 2010) and other stakeholders (EFQM, 2011a) through continuous improvement (SP, 2010). According to MBNQA (2011) a process refers to linked activities with the purpose of producing a product or service for a customer and involves combinations of people, machines, tools, techniques, materials and improvements in a defined series of steps or actions. It is important to manage the processes, doing the right things, as defined by customer (SSC, 2010).

According to the awards of the MBNQA (2011) and EFQM (2011a), organizations must design, manage and improve their processes. For these two awards, processes are one of the criteria. To the standards, each process should be documented (OHSAS 18001, 2007; ISO 14001, 2004; ISO 9001, 2008) and controlled (ISO/CD 13053-1, 2009). Another technique that must be used is the standardization of processes. Standardization represents control of the process, constructing the process as simply as possible (SP, 2010). According to the award of SP (2010), processes are related to continuous improvement. Continuous improvement is a principle underpinning most of the models under consideration (Annex 1).

3.2.6. Results

Performance may influence the decisions to be made at different organizational levels, i.e., at the strategic, tactical, and operational levels. It is important to measure progress accurately, because good feedback of results makes it possible to adjust activities, practices, processes and plans.

Some management frameworks provide performance indicators, such as GRI in sustainable performance, SP in business performance or SCOR in supply chain performance. The award SP mentioned that the results must be represented by quality, cost/productivity, delivery, customer satisfaction and morale (SP, 2010). MBNQA (2011) asserts that the results are a composite of outcomes, including product and process, customer-focused, workforce-focused, leadership and governance, and financial and market performance. The award EFQM (2011a) refers to results as people, customers, society, and other key financial and non-financial results. SCOR (SCC, 2010) mentioned that performance is focused on reliability, responsiveness, agility, cost and asset. The others models do not specify which performance indicators to apply. They only refer to which information should be analyzed (ISO 9001, 2008; ISO 14001, 2004; OHSAS 18001, 2007; NP 4457, 2007). The MBNQA (2011) states that measuring, monitoring, and analysis of the progress on a regular basis are the prerequisites of evaluating the performance. This performance can be measured by a performance measurement system. This system can monitor all organization and its supply chains.

In this perspective, SP (2010) states that the balanced scorecard may be applied to evaluate all aspects of performance. MBNQA (2011) indicates the Balanced Scorecard as a tool to be used by the organizations. Moreover, the EFQM model uses the balanced scorecard as an approach to achieving balanced results (EFQM, 2011b). However, the balanced scorecard`s four standard perspectives are different from the four different result areas of the EFQM. Nevertheless, any measures can be included in the balanced scorecard perspective (EFQM, 2011b).

3.3. Management Frameworks Monitoring

To develop an efficient and effective SC it is necessary to monitor and measure all aspects of value. Performance measures should provide to the organization a current overview of how they and their SC are. The performance measurement system is essentially to give managers the

information they need to manage the organizations, because applying a performance measurement systems that works well will take many organizations well into the future (Morgan, 2007). The feedback given by the performance results go to influence all business aspects. Therefore, it is essential to identify which performance measures really matter to the business, since those measures influence the decisions to be made at different organizational levels (Gunasakaran *et al.*, 2001; Morgan, 2007). In addition, it is not the number of measures that counts to get a better performance results; the performance measurements can be better addressed using only a few good measures that represent the important aspects of value (Gunasakaran *et al.*, 2001).

Therefore, the need for performance measurement systems at different levels of decision-making is certainly not something new (Sharma and Bhagwat, 2007). Performance measurement and measures have an important role to play in setting objectives, evaluating performance, and determining future courses of actions (Gunasekaran *et al.*, 2004), and also can be defined as the process of quantifying the efficiency and effectiveness of action (Folan and Browne, 2005). The focus is also on measures that take the SC point of view: the financial measures are used on a strategic level instead of non-financial measures that are used on tactical and operational level of an organization (Gunasekaran *et al.*, 2001). Cai *et al.* (2009) mentioned that "since many measurement systems lacked strategy alignment, a balanced approach and systemic thinking, they had difficulty in systematically identifying the most appropriate metrics". For these authors to address this difficulty, some researchers have used a well-known performance measurement approach the Balanced Scorecard (BSC) to evaluate supply chain performance.

Since Kaplan and Norton (1996) proposed a balanced scorecard (BSC) structure, many organizations have tried to implement it for strategy management. The BSC is a powerful balanced strategic management system that facilitates the implementation of strategy, using measures to ensure that corporate vision and strategy are implemented and achieved (Chia *et al.*, 2009). According to Kaplan and Norton (1996) "the balanced scorecard translates mission strategy into objectives and measures organized into four different perspectives: financial, customer, internal business process and learning and growth". Combining these four perspectives on a chain of cause-and-effect, managers can understand their interrelationships and help to clarify and operationalize the vision and strategy of the organization achieving strategic success (Duarte *et al.*, 2011a). Figure 3.6 outlined the BSC framework proposed by Kaplan and Norton (1996), which translates a strategy into operational terms.

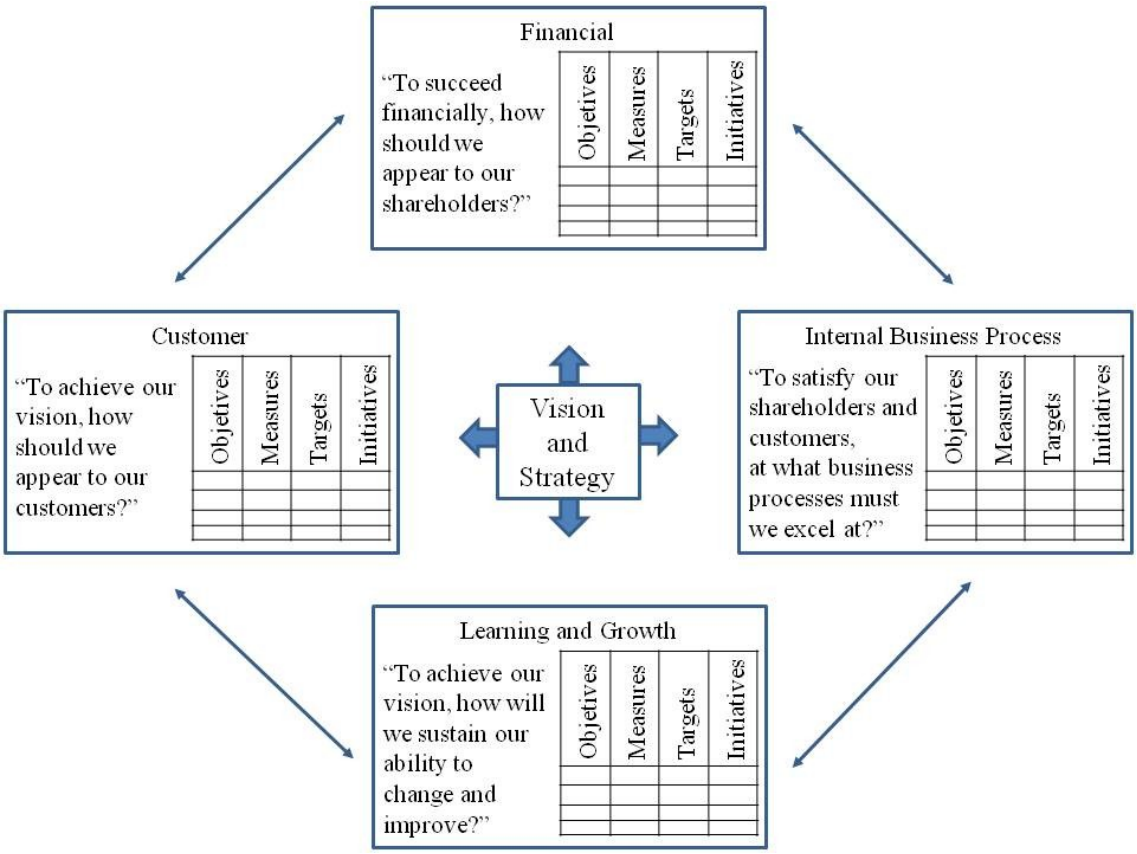

Figure 3. 6 - BSC Framework

(Source: Kaplan and Norton, 1996)

The BSC could give insights on how performance measurement is perceived by supply chain stakeholders (Carvalho *et al.*, 2011b). To the authors Sharma and Bhagwat (2007) it is clear that for effective SCM, measurement goals must consider the overall scenario and the metrics to be used, and should be represented as a balanced approach. This balanced approach could be fundamental to understand SCM measures in a way that the BSC prescribes (Duarte *et al.*, 2011a). According to Chia *et al.* (2009) the BSC allows to examine what is measured and how performance measurement is perceived by entities on supply chain. Table 3.4 summarizes a list of performance measures categorized by the four BSC perspectives.

Table 3. 4 - List of performance measures for the BSC perspectives

BSC	Performance measures	References
Financial perspective	Sales growth Return on sales Return on equity	Hubbard, 2009
	Return on assets	Brewer and Speh, 2000; Hubbard, 2009
	Return on investment	Chia *et al.*, 2009; Sidiropoulos *et al.*, 2004
	Gross revenue; Cost	Chia *et al.*, 2009
	Profit before tax	Chia *et al.*, 2009; Brewer and Speh, 2000
	Economic Value Added	Sidiropoulos *et al.*, 2004
	Cash-to-cash cycle Customer growth & profitability	Brewer and Speh, 2000
	Operating earnings Operating costs Operating efficiency	Xiaoping and Chen, 2008
Customer perspective	Market share	Chia *et al.*, 2009; Sidiropoulos *et al.*, 2004; Hubbard, 2009
	Customer satisfaction	Chia *et al.*, 2009; Sidiropoulos *et al.*, 2004; Xiaoping and Chen, 2008
	Perception of flexible response No. customer contact point	Brewer and Speh, 2000
	No. of customers retained	Chia *et al.*, 2009; Brewer and Speh, 2000
	Product/service quality	Xiaoping and Chen, 2008; Chia *et al.*, 2009
	Customer value	Xiaoping and Chen, 2008
	Order response time	Brewer and Speh, 2000; Xiaoping and Chen, 2008
	Order cycle time; No. new customers; Defects; Product return rate	Hubbard, 2009
Internal Business Process Perspective	Productivity; Capacity utilization; Labour turnover; Av. unit production; Working capital/sales	Hubbard, 2009
	Production and sales	Xiaoping and Chen, 2008
	Response time; Quality	Brewer and Speh, 2000; Xiaoping and Chen, 2008
	Cycle efficiency; Cost ownership; Target cost achieved	Brewer and Speh, 2000
	Lead-time; New products per year	Sidiropoulos *et al.*, 2004
	New services implemented per year; Quality of services; On time delivery; Waste reduction;	Chia *et al.*, 2009
Learning and Growth perspective	Employee satisfaction	Chia *et al.*, 2009; Sidiropoulos *et al.*, 2004; Hubbard, 2009
	Product finalization point Product category commitment ratio	Brewer and Speh, 2000
	New products; Training spend/sale; New market entered; R&D spend/sale; Invest./total assets	Hubbard, 2009
	New customers; Level of information; Development of new products; Capital investment	Xiaoping and Chen, 2008
	Employee turnover per year No. of suggestions implemented yearly Money invested in employee training yearly	Chia *et al.*, 2009
	Information diffusion	Sidiropoulos *et al.*, 2004

Many organizations have its own unique conditions in a way that the BSC may be customized (Hubbard, 2009). The important is that the main principles of the model remain the same (Hubbard, 2009); it means that measures should be linked across the four perspectives to give information about strategic themes. The set of measures must be part of management system in all levels of the organization and represent a balance between (Kaplan and Norten, 1996; Bhagwat and Sharma, 2007): i) short-term and long-term objectives; ii) financial and non-financial measures; iii) leading indicators and lagging indicators; and iv) external and internal performance perspectives.

The BSC has been recognized as a tool to drive improvements (Stenzel, 2007). It is possible to integrate this tool within different systems wherein the focus is on managing and improving organizational performance (MBNQA, 2011; EFQM 2011b). The important is to be clear about how it fits with systems to help to achieve the strategic objectives (EFQM, 2011b). Their combination can be applied on business by selecting the appropriate performance measures according to organization` supply chain situation (*i.e.* strategy, mission and business processes). Those who understand the linkage between the BSC and SC will have a greater chance to put their SC into a source of competitive advantage.

3.4. Chapter Overview

In this chapter a characterization of each management frameworks, namely awards, standards and tools is presented, followed by a comparison between them. Studies on issues related to the environment, social, health and safety benefits, quality and innovation were taken into consideration. Almost all the management frameworks refer to the supply chain business processes, and the need for leadership, people, strategic planning, stakeholders, processes and results as important issues for organization transformation. These concepts are dependent on the beliefs and behaviors in the organization`s supply chain.

The management frameworks mentioned the focus on results to create value. Therefore organizations must evaluate their supply chain performance. Monitor the actual performance gives the suggestions where the supply chain needs to be developed, controlled and improved. In this context, a study on performance measurement systems was performed specific on SC. The SC performance evaluation will benefit with a BSC approach to align with business objectives.

4. Conceptual Framework for Lean-Green Supply Chain

Organizations are aware that they must continue to change and improve their SC processes; this lead to a transformation in processes and procedures. This chapter proposed a conceptual framework to assist organizations in a lean-green supply chain modelling. The conceptual framework describes what should be a lean and green supply chain providing the elements and respective guidelines to implement a lean-green organization`s supply chain. Using the information collected in the literature review, a number of relationships between the lean approach and the green approach were established. The objective of this chapter is to develop a lean-green supply chain framework, considering the key criteria and relating them with lean and green elements and guidelines. A scoring method is proposed to evaluate a lean-green transformation.

4.1. Modelling Fundamentals

The LARG_SCM is an acronym for "lean, agile, resilient and green supply chain management". In the Chapter 2 of these dissertation, SCM paradigms were presented and a justification to include them in this research was given: the lean paradigm focus on continuous processes improvement, searching for simplification, reducing activities that do not add value and, at the same time, reduce waste; the agile paradigm intends to create the ability to answer efficient and effectively to unpredictable changes in the markets; the resilient paradigm provides the ability of the supply chain to react efficiently to the unexpected disturbances; the green paradigm aims to minimize the environmental impact through environmental consciousness while eliminating environmental waste in organizations.

Neither paradigm is better or worst then other; simply have different purposes and act in different situations. Lean and green paradigms are developed in way to identify new business opportunities for organizational improvements and, consequently, have a strong impact on the supply chain. Businesses that apply the lean paradigm report significant improvements in their operations (Ryder, 2011). Businesses are changing in ways that improve the environment through the application of green paradigm (Broek, 2010). The objective of agile and resilient is to have the ability to triumph over innumerous changes. Figure 4.1 illustrates what can occur in an organization`s supply chain: lean and green are focus on the organization`s activities which leave to a stability in SC processes and agile and resilience responds if something different happens.

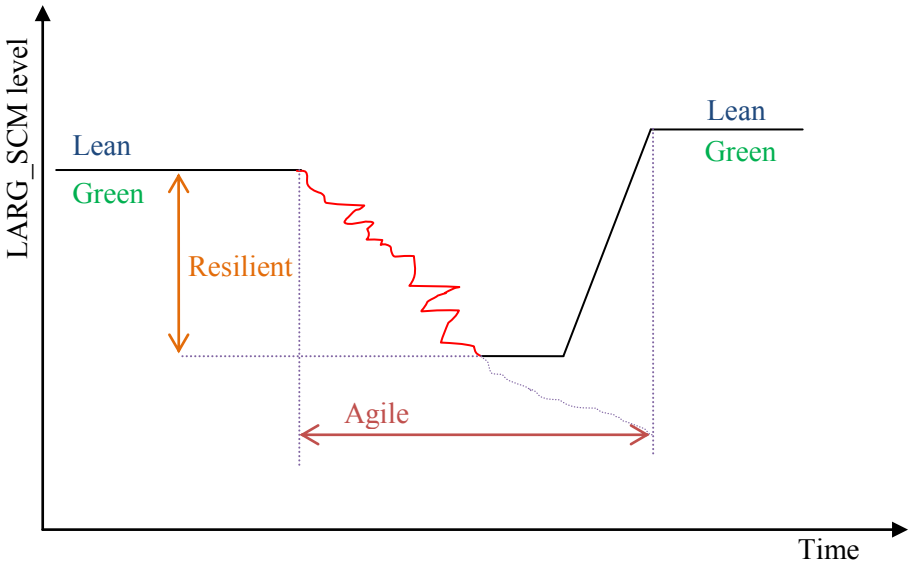

Figure 4. 1 - The LARG_SCM

From this point of view it is possible to understand that lean and green are the support for the organizational business solidity. In addition and according to Azevedo *et al.* (2012), the deployment of lean and green SCM practices influences the sustainable development of businesses in an SC context. There is a set of lean and green practices that influence positively not only the economic but also social and environmental measures (Azevedo *et al.*, 2012). In compliance, the Broek (2010) cites that "today's economic, social and regulatory dynamics are putting real pressures on companies to be both lean and green in their product sourcing, logistics, distribution and operational practices". Moreover, the lean and green have the same global purpose: to satisfy customer needs at the lowest possible cost to all members in the SC (Carvalho *et al.*, 2010), reducing or eliminating all kind of waste (Mollenkopf *et al.*, 2010) making an efficient use of resources (Torielli *et al.*, 2011).

Additionally, the most popular frameworks used by organizations for business performance improvements are relative to the lean (e.g. SP or MBNQA) and green (e.g. ISO 14001, EMAS or SCOR) paradigms. This had an impact on restricting the study to these two paradigms since those have applicability guidelines through management frameworks and organizational culture. An example is that some companies give potential importance to lean and green having specific departments to manage these paradigms. Therefore, it is important to assess their integration at the supply chain business level.

Another base that supports this idea is the structured literature review carried out on Chapter 2 which gave indications of what should be modeled. Analyzing in depth the library database

"ISI Web of Knowledge", the green, followed by the agile and subsequent the lean are extensively studied. Figure 4.2 has been developed to assist in the visualization of the number of papers available in this library database (from 2000 to 2009).

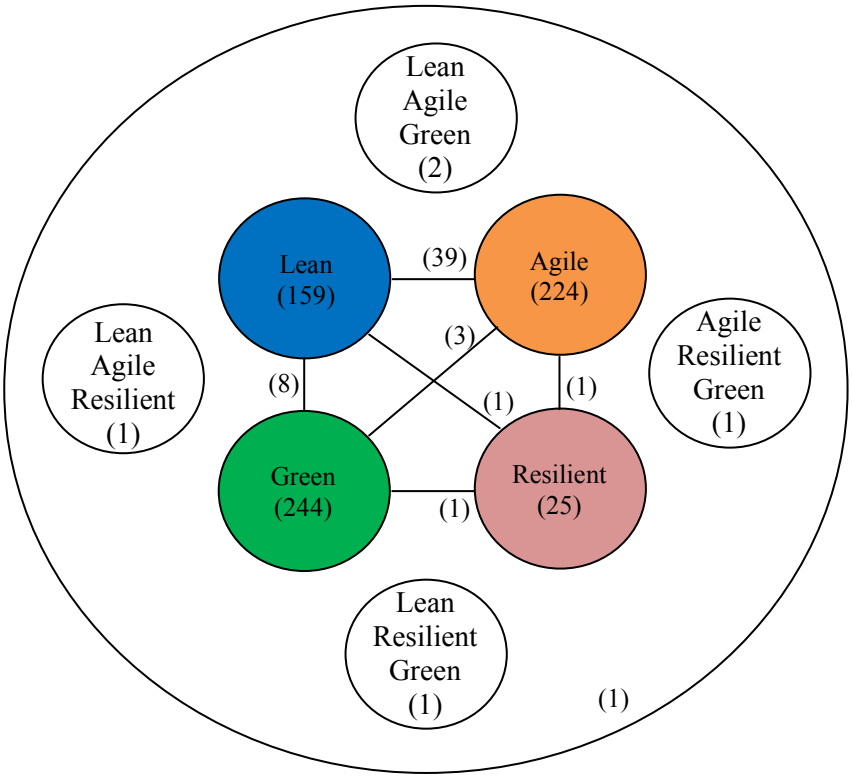

Figure 4. 2 - Number of publications by paradigms under study

The number of papers in each combination of paradigms is indicated in brackets. From the combination "Lean & Agile & Supply chain" 39 papers were considered, followed by "Lean & Green & Supply chain" with 8 papers. Therefore the lean and green begin to have some relevance among academicians but its study is not well developed yet. It is possible to assume that their study is of major importance and their application in industry is possible but is not yet expanded. If these two paradigms are very important peculiarly for supply chain it is of a significant importance their combination` study.

In this line of ideas, the conceptual framework will be based on lean and green paradigms searching for the best way of implementation and defining as a framework to help organizations to manage their SCs.

4.2. The Lean-Green Supply Chain Framework

The lean and green approach, defined as a management framework, can be seen as a new opportunity for supply chain environment improvement. Both concepts require a change in attitude and establishment of organizational cultures supporting the philosophy underlying each concept (Johansson and Winroth, 2009). The lean and green approaches have impact throughout the supply chain, therefore a conceptual framework to assist in modelling a lean-green supply chain is proposed.

The impact of lean and green implementation in supply chain is important in order to identify which of them are relevant for the operations and which require improvements. It is necessary to use the correct window of implementation (Dües *et al.*, 2013). The compatibility between these two approaches can be defined as a new form of strategy and can also be a better form of management (Carvalho *et al.*, 2011b; Mollenkopf *et al.*, 2010).

In this research the definition "lean-green" is chosen to represent the new approach that will be developed and represents a way of working in the organization and its supply chain. The "lean-green" represents a hybrid supply chain. The lean-green transformation and its links to management frameworks should be important in the way to model a lean-green approach, with their specific principles, practices, techniques and tools. The study developed on previous chapters provides some inspirations to model a lean-green supply chain.

The lean-green supply chain management framework has been designed in 3 stages of data:

- the definition of the key criteria;
- the identification of the lean-green SC elements;
- the development of the lean-green SC guidelines.

Figure 4.3 shows the stages of a lean-green supply chain transformation. These stages will help the organizations in a lean-green supply chain transformation. An assessment method will be established to assist in the evaluation of the organization`s supply chain in terms of a lean-green implementation.

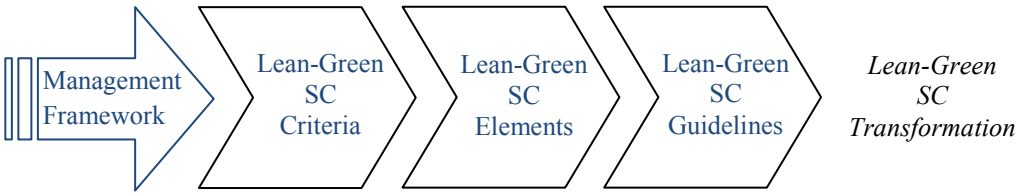

Figure 4. 3 - Stages of data for lean-green supply chain transformation

The conceptual framework to support this study is presented in Figure 4.4; it outlines the key criteria to model a lean-green organization`s supply chain. Based on management frameworks analysis presented in the previous chapter, some "near-common" characteristics mentioned in almost all the frameworks are identified namely, leadership, people, strategic planning, stakeholders, processes and results. This conceptual framework considered these characteristics as the key criteria to achieve a lean-green approach.

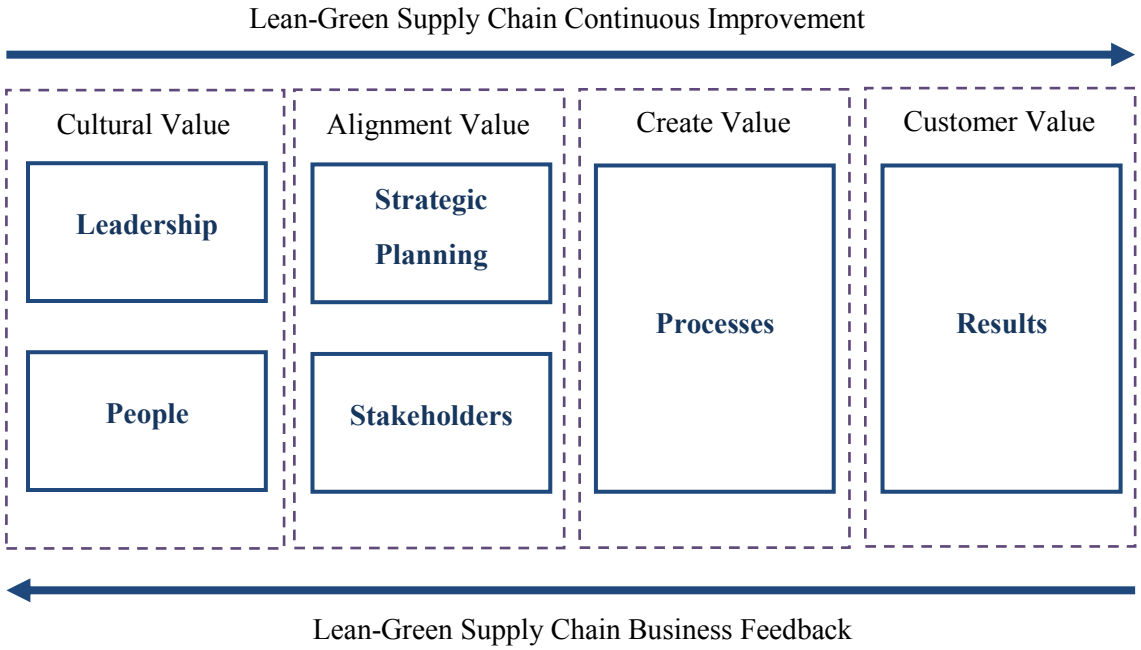

Figure 4. 4 - The lean-green supply chain conceptual framework

This research addresses a lean-green approach in the SCM with these six criteria. The criteria leadership, people, strategic planning, stakeholders and processes represent the organization`s supply chain activities and behaviors to implement the lean-green approach.

These five criteria act together and give important information to results. The results represent what an organization`s supply chain achieve. The results give feedback to develop and improve the SC activities. With the results information, the SC can be improved. The lean-green considerations must be part of every decision that is made and must be align with supply chain priorities.

This framework is sub-divided into four different dimensions on a lean-green implementation and is represented as follows:

- Cultural value: participative leadership to gain the commitment and involvement of all the stakeholders, who transmit security on a cultural change across all entities of the SC. They must transmit involvement and commitment to ensure the ongoing success of the organization and its supply chain in the application of a lean-green approach. Employee empowerment to demonstrate that they can change their work culture and attitudes (Anand and Kodali, 2008). The communication of the principles of a lean-green transformation and the integrity towards this new vision allows employees understand the direction of the organization and of its supply chain, and its strategy and vision is adapted into their daily decision-making.
- Alignment value: strategy focuses on customer and others stakeholders since they can place constraints on the organization`s supply chain and consequently their relationship must be planned and managed. The strategy should always be aligned with the stakeholders and always updated so that the whole SC can stay into compliance. Therefore, stakeholders should adjust their way of work to achieve the objectives of lean-green approach.
- Create value: processes must be simplified in way to add value to customer. For that, SC processes should be well organized, applying continuous improvement through eliminating of non-value activities, focusing on the elimination of all forms of waste. Coordinate internal and external processes and resources in the organization to improve SC. The critical activities should be oriented in way to optimize the value and the tools provide the necessary support for the progress of the SC processes.
- Customer value: the results show how the organization and its supply chain are providing value to the customer. It is important that the organization understand the cause-and-effect of their actions through performance measures. It is necessary to identify the best performance measures that indicate the value to the customer.

The ability to measure and understand what each performance measure represents is important, in order to manage in line with the results. This will allow choosing which necessary

elements must be implemented or improved. Thus the continuous improvement should always be present. The lean-green SC transformation through the applicability of this conceptual framework will give value to business (*i.e.* something that is of great importance for customers and other stakeholders). Stenzel (2007) define value as an activity that contributes to transforming a product or information into customer requirements.

4.3. Lean-Green Supply Chain Criteria and Elements

A lean-green approach can be implemented in all organizational areas with the application of various principles, practices, techniques and tools (Bergmiller and McCright, 2009; Cruz-Machado and Leitner, 2010). Similarly to the description of the authors Gurumurthy and Kodali (2009) and Anand and Kodali (2008) that defined tools, techniques, practices and procedures as "elements", this research considers the term "element" to define principles, practices, techniques and tools. Considering the six criteria of the conceptual framework and based on lean supply chain and green supply chain literature review, as well as data given in management frameworks, the lean-green elements for a lean-green supply chain transformation are presented in Table 4.1; these elements are indexed by key criteria.

Table 4. 1 - Elements for a lean-green supply chain

Criteria index	**Lean-Green Elements**	
Leadership	• Company culture • Long-term thinking • Flat organizational structure • Management commitment • Vision and mission • Management communication • Top-down leadership endorsement • Legal and govern requirements	• Management systems: – Six Sigma – Innovation tools – ISO standards (ISO 9001 & ISO 14001) – Social responsibility • Long-term employment • Investment opportunities
People	• Education and training • Employee involvement • Employee empowerment • Cross functional teams • Skills and core competences • Employee evaluation	• Ideas and suggestion schemes • Rewards and recognition • Communication between employees • Job rotation or flexible job responsibilities

Table 4. 1 - Elements for a lean-green supply chain (cont.)

Criteria index	**Lean-Green Elements**	
Strategic Planning	• Clear lean-green strategy • Shared by all levels of the organization and other stakeholders • Establish lean-green plans and objectives	• Strategy with focus on the customer and other stakeholders • Strategy communication • Strategy deployment
Stakeholders	• Creating value for customers • Strategic alliances • Long-term relationship • Close cooperation • Information share • Risk share	• Supplier selection • Supplier` ISO 9001 and ISO 14001 • Supplier evaluation • Customer satisfaction • Customer demand • Takt time
Processes	• Process and product focus • SC operations: – Delivery strategy – Transportation strategy – Lot size option – Inventory level strategy – Resource capacity – Packaging strategy – Product design – 3R`s (reduce, reuse, recycle) – Remanufacturing – Rework	• SC continuous improvement • Waste elimination • SC Toolkit: – Value stream mapping – A3 report – Kaizen event – Housekeeping (5S+S) – Standardization and work instruction – Life cycle assessment (LCA) – 5Why`s – Analytical tools
Results	• Monitor all aspects of value • Lean and Green measures • Measures up-to-date	• Data analysis • Cause-and-effect • Mix of short and long-term results • Balanced Scorecard framework

4.3.1. Leadership

4.3.1.1. Organizational structure

The culture of an organization must have into consideration an analysis of lean-green organizational situation. The culture is highlighted as a driver in lean-green approach (Mollenkopf *et al.*, 2010). Leadership must guide the organization in way to define how organization operates. Not only the lean thinking but the green thinking influences an increasing number of SC business decisions (EPA, 2009). An organization must create a continual improvement-focused waste elimination culture and should engage with the supply chain to improve all organizational performance (EPA, 2009).

The lean approach should be established as a long-term thinking. The green approach also advocates a long-term thinking since environmental impacts originating from industrial

activities affect the natural environment for many years (Johansson and Winroth, 2009). This basic principle is shared on lean-green approach.

The flat organizational structure refers to minimizing the number of organization levels for decision-making and approvals (Gurumurthy and Kodali, 2009). Few levels of hierarchy allow a better employee involvement and employee empowerment (Dües *et al.*, 2013). It also refers to minimizing the number of stages in the supply chain as it increases the customer lead time, apart from increasing the supply chain cost and the controlling the environment risk (Anand and Kodali, 2008). The lean approach uses an organizational structure with few levels in the hierarchy (Vonderembse *et al.*, 2006). The green approach integrates environmental thinking where few levels of hierarchy will help to develop better the green issues (Srivastava, 2007; Sarkis, 2002). Thus, a flat organizational structure is important for a lean-green supply chain implementation.

Another principle connected is the long-term employment. Top management must ensure a long-term employment (Gurumurthy and Kodali, 2009) to drive the perspective that people are an essential part of every value stream, process, or system (SP, 2010). Therefore, a lean-green implementation gains in having a long-term employment in its structure.

Top management must ensure that the organization fulfils legal requirements and regulations (Zhu and Sarkis, 2006; MBNQA, 2011). According to Mudgal *et al.* (2009) legislation and regulation are the essential instruments for the proper governance of business organizations including the environment in which they operate. Legal requirements are considered as the most significant external influence on the strategy formulations in organizations and in their supply chains. Compliance with environmental regulation is the most important stimuli for the encouragement of green improvement (Mudgal *et al.*, 2009). That is, regulations are becoming integral in an organization reputation and corporate image (Mollenkopf *et al.*, 2010). Furthermore, Torielli *et al.* (2010) suggest that properly designed regulations would trigger innovation that would improve cost, improve value, and, at the same time, reduce environmental impacts. In summary, even if it is not specific from the approaches, this is important in a lean-green SC implementation.

To assist in the lean-green transformation and similar to what the business awards indicate, some management systems can be integrated in processes and will be helpful in the development of lean-green approach. Management systems that are compatible with the lean-green framework are as follows:

- The Six Sigma Management System. The "six sigma" is a method that organizations can use to identify and eliminate causes of errors, defects or failures in business processes; it focuses on outputs that are important to customers (Antony, 2004). Integrating six sigma with lean characterize the well-known "lean six sigma" methodology. The "lean six sigma" use lean to reduce and eliminate waste and "six sigma" to reduce process variation. The Lean and the Six Sigma efforts can expand their traditional scope, and can be integrated with a green approach; better control of hidden wastes and, at the same time, it improves environmental and operational results (EPA, 2009; IBM, 2007). The "lean six sigma" projects can control the green issues as for example the carbon dioxide emissions, energy or water (IBM, 2007; EPA, 2009). This can create an organizational culture with focus on continuous improvement, in waste elimination and pollution control (EPA, 2009). Thus, the lean-green implementation can apply the "six sigma" system. The "lean-green six sigma" can be an effective method to achieve a product with high quality. Some issues are associated to this such as: reduction of lean-green wastes, process optimization, zero defects, rework reduction, and reduction on environmental impacts.
- The Innovation management system helps to develop creativeness in the organization and assist in a continuous improvement lean-green transformation. Develop new schemes which can improve supply chain activities. The lean-green is based on product and process innovation (Johansson and Winroth, 2009). Therefore, management should develop a mindset for innovation and change.
- The use of ISO standards, such as ISO 9001 and ISO 14001 also assist in a lean-green improvement (Vais *et al.*, 2006). Torielli *et al.* (2010) mentioned that lean, ISO 9001 and ISO 14001 are not separate activities, but mutually supportive. The implementation of ISO 9001 for quality management and the ISO 14001 for environment management is important on a lean-green approach.
- The social responsibility is an important issue in the organization`s recognition. Businesses are increasingly experiment in incorporating social responsibility into the core of business strategy and operations (EPA, 2009). The management must ensure a social responsibility behaviour, ethical behaviour and community support (MBNQA, 2010). These are issues to assist organization in managing the differences within the supply chains. One of the elements of lean concerns to organizations and its employees are being socially responsible (SP, 2010): "lean" could include the cooperative community, as company or supply chain (SP, 2010); "green" makes part of social responsibility by the principle of environmental responsibility (ISO 26000, 2010). The

lean-green implementation advocates organization`s responsibilities such as social and ethical behaviour and consider as an objective in SCM.

4.3.1.2. Nature of management

The lean-green approach must be versed from the management executives (Hitchcock and Willard, 2006). The management must also explore the concept as the most central trends that could affect their business. A successful implementation must have a plan to fit their particular organization`s circumstances. The management must integrate the lean thinking (Johansson and Winroth, 2009) as well as the environmental consciousness into the organizational culture (Zhu *et al.*, 2008). Thus management is a very important factor for the development of a lean-green approach. Lean and green initiatives are both driven top-down within organizations (Mollenkopf *et al.*, 2010). Top-down leadership endorsement is one requirement for a lean-green SC transformation.

The commitment of top-level managers and the support of mid-level managers are very important to the dissemination of a lean-green approach. A true commitment and involvement from the top management is important because transmits security in the application of a lean and green thinking in all entities of SC (Zhu and Sarkis, 2004). The lean management requires a large commitment (Ryder, 2011), as well as green management (Mudgal *et al.*, 2009). The manager has been shown to be one of the most influential factors in determining the pro-activeness of the organization. Mollenkopf *et al.* (2010) reports the possibility of the lack of awareness among managers of the benefits of green initiatives. Thus, the management must create and communicate the vision and mission for a lean-green transformation and communicate to employees and to other stakeholders what is needed from them in order to be aligned with the supply chain. The lean-green implementation needs that top management communicate the importance of the transformation for the organization and its SC.

In addition, the investment is very important for both lean and green. The investment made is important in a lean approach (Anand and Kodali, 2008). To Mudgal *et al.* (2009) the environmental investments inevitably rely on the top management's attitude. Therefore the investment is an issue of a great importance that top management must have in mind when adopt a lean-green SC transformation.

4.3.2. People

In a lean-green implementation employees may resist to change (Hitchcock and Willard, 2006). Usually much more may be expected from them. The education and training may support the establishment of a new mindset emphasizing the importance of lean and green considerations (Johansson and Winroth, 2009). It has long been recognized that education and training are essential ingredients of effective lean management (Ryder, 2011) and green management (Mudgal *et al.*, 2009).

Sawhney *et al.* (2007) mentioned that a positive employee involvement and empowerment depends on the culture of the organization. According to Johansson and Winroth (2009) the involvement and empowerment of the employees to these concepts are vital. Both lean and green need a high level of employee involvement in order to be successful (Gordon, 2001; Puvanasvaran *et al.*, 2011; EPA, 2007; Johansson and Winroth, 2009). The involvement of every employee at every level of the organization is crucial (Torielli *et al.* 2010). According to Dües *et al.* (2013), lean approach encourages the involvement of employees and gives them responsibility which also simplifies the implementation of a green approach. This will make that employees explore and resolve opportunities concerned to elimination of all kind of waste (Zhu and Sarkis, 2004; Hitchcock and Willard, 2006).

The employees must be encouraged to develop creativity and innovative initiatives. Innovation corresponds to the implementation of the new improved solutions or the identification of opportunity to change and improvement. Therefore, they can transport their creativity through giving ideas and suggestion schemes. The stimulus for the employee's initiative, their capacity for innovation and adopting proactive attitudes (*i.e.* empowerment) is an important principle in a lean-green implementation. Celebrating success is the way to motivate employees to keep doing their best (Ryder, 2011). The recognition and rewards of individual or group initiatives in way to improve organizational performance or save money is a principle of lean (Gurumuthy and Kodali, 2009; Anand and Kodali, 2008) and can be easily transported to a green approach. All employees must know how they can effectively protect the green environment from damage that may potentially be caused by supply chain processes into their areas of responsibility.

In addition, it can help develop a cross-functional team working not only within each stage of the SC, but also between different stages of SC (Anand and Kodali, 2008). The cross-functional teams may consist of members from different functional areas such as, operations, purchasing, production planning and control, quality and apart from the members from key

suppliers (Anand and Kodaly, 2008); it involves people from all levels of the organization (Shah and Ward, 2007). The aim is to integrate all functional aspects and resolve all problems regarding all areas, trying to find the best way to implement and improve the performance of the organization. With this team, the environmental conscious of the employees increase, and contributes to knowledge and skills to solve complex problems (Johansson and Winroth, 2009). The cross-functional teams are important for both lean and green approaches considering the best way of implementation. It is important that the cross-functional team have evolved the lean-green SC transformation into a formal situation.

One of the requirements to become lean is to ensure that their employees own multiple skills. They should provide them the necessary training, apart from rotating them across other departments and jobs (Anand and Kodali, 2008). These skills can also be regarded as having considerations for green approach (Hitchcock and Willard, 2006). The employee's skills must be formal defined for every employee regarding lean-green skills. Employees who are continually learning new skills and move throughout jobs stay motivated and enthusiastic (Ryder, 2011). People who do several jobs understand how those jobs fit together. Thus, job rotation as well the communication between employees is important for the understanding of the SC activities that influence their job and how to achieve a lean-green transformation.

Employee must demonstrate its commitment in the change process accepting constructive criticism and suggestions to improve the SC. They must have tools and information to facilitate the development of employees` initiatives and to accomplish their jobs. In addition to this principle, the encouraging of delegation of competencies and responsibilities (empowerment) is an element shared by lean-green approach. In the end it's the people that make the difference and make the organization and its supply chains works (Torielli *et al.*, 2010).

A formal evaluation system is good for the employee because it is one a way to help the employees to understand, achieve and improve their way of working. Performance evaluation is one of the tools used either in order to promote the communication around the work and improvement activities, with the purpose of measuring the degree of satisfaction and employees adhesion to the strategic objectives and challenges.

Therefore, "People" is a criterion which drives the organization and its supply chain operations: for the organization`s supply chain success the employees must have a detailed education and training in way to be well skilled for the work process and to achieve its goals; employees must be encouraged to use creativity to solve problems; involvement, empowerment and commitment of employees are key factors for the success of the lean-green transformation.

4.3.3. Strategic Planning

The plan of the lean-green supply chain transformation must be put in place at the time where the probability of the success is high. The strategy planning defines the objectives and plans for the organizational business and for the supply chain. The supply chain strategy must be aligned with business strategy. The strategy must be clear, with the rules, plans and objectives well established and be executed artfully by all (from employees, to mid-manager or to top manager) (Hitchcock and Willard, 2006).

The lean strategy is focusing on create value to customer, continuous improvement through elimination of waste and cost reduction (Anand and Kodali, 2008). The green strategy is being established to respond to critical issues that arise from environmental impact, natural resource conservation, industrial waste reduction (i.e. reduction of energy, water, air emissions and noise) (EPA, 2009; Gordon, 2001; SP, 2010). Then it should consider that the strategy for lean should take into account the green thinking and the green strategy must take into account the lean thinking. The strategy must be relative to reducing or eliminating all kind of wastes and non-value added activities.

The lean-green SC strategy should be aligned with the other entities of supply chain. It should take into consideration the stakeholders. The management should communicate the strategy towards their employees and other key stakeholders. There are different forms to communicate the strategy namely, throughout meetings, awareness sessions, and forums or through specific booklets and e-mails. Centikaya (2011) mentioned to be a collaboration strategy. The whole SC must stay into compliance where all stakeholders adjust the necessary strategy in way to achieve the objectives of a lean-green supply chain.

The deployment of the objectives of the lean-green approach must be based on a systematic way. This can be carried out with the help of a Balanced Scorecard. In addition, the strategy must be reviewed periodically through an analysis of an entire set of key performance measures. It is important to define the results to achieve, as part of the strategy. Therefore, in a lean-green SC implementation it is important to define the strategy with the action plan, objectives well defined and performance measures well selected.

4.3.4. Stakeholders

"Stakeholders" are related with all the processes involved in the supply chain. The supply chain management not only depends of the leadership and people of the organization but also depends on all other stakeholders that are involved in the extended chain such as suppliers, customers and local community or shareholders (Anand and Kodali, 2008; Wu, 2003).

One of the elements of the lean approach, concerning to the extended chain of partners, is challenging them and helping them with improvements (Johansson and Winroth, 2009; Anand and Kodali, 2008). Thus, close cooperation with all stakeholders in the supply chain is an essential ingredient of the lean approach (Johansson and Winroth, 2009). Furthermore, the green impacts are not only an organization concern but it is a concern of all stakeholders on their processes in supply chain (Broek, 2010). For example environmental risk is an example of risk share that must be shared by the organization and its stakeholders (González-Benito and González-Benito, 2006).

Organizations must identify their strategic alliances. Nurturing a proactive and long-term relationship with their key stakeholders in an interdependency partnership is a crucial ingredient. Information sharing among key stakeholders is an important instrument in building trust with the manufacturer, the suppliers and the customers and should be made using information technology tools such as the internet, e-mail system or electronic data interchange (EDI) (Anand and Kodali, 2008). This may help in the elimination of waste (for example paper used and energy consumption) and may lead to improvements in the performance (e.g. inventory levels or cost savings) (Mollenkopf *et al.*, 2010). EDI deployment by manufacturers, suppliers and customers allow better information sharing of production planning and scheduling to improve operational efficiency and increase materials flows and information flows precision and reduces the paper consumption which leads to fewer disposal or recycling paper (Anand and Kodali, 2008).

Both lean and green advocate stakeholders` involvement in order to achieve business success (Johansson and Winroth, 2009). A lean-green approach should be based in the establishment of cooperative relationships with suppliers and customers for better undertaking of joint lean and green SC activities.

4.3.4.1. Suppliers

The lean-green implementation linking to suppliers is very important. Suppliers have an important role in supply chain activities. However, among the available suppliers, it is necessary to develop loyal suppliers, who can supply products/parts any time in any quantity with perfect quality.

One of the important elements of lean approach is also the close proximity with the manufacturer to increase the trust between manufacturers and suppliers improving supply chain performance (Azevedo *et al.*, 2012). Reduce the number of suppliers is another associated element (Anand and Kodali, 2008), as well as the delivery of material with more durability and easier to recycle. To a green approach this will help to control the environmental impacts (EPA, 2007). Therefore, this makes the whole system easier to control and it is dependent on mutual trust (Anand and Kodali, 2008). Provide training, resources and supports to continuous improvement are elements in a lean-green implementation that must be integrated with the communication about lean-green expectations to suppliers.

Manufacturers normally require their suppliers to have quality certification (e.g. the ISO 9001) and environmental certification (e.g. the ISO 14001). With these certifications it is possible to confirm their clear quality and environmental practices. According to Azevedo *et al.* (2012) the ISO 14001 standards works like a snow ball, influencing all supply chain partners to adopt more environmental friendly practices.

It is very important to evaluate the suppliers (Doolen and Hacker, 2005) in way to understand which suppliers are the best in supply chain processes namely in product quality, in delivery time, cost (Carvalho *et al.*, 2011b), pollution prevention and compliance with regulatory requirements (Simpson and Samson, 2010). The lean-green implementation asks for specific suppliers and those should be selected by lean and green criteria.

In sum, the goal of engaging with suppliers is to develop a shared mindset about lean-green issues, working more closely with suppliers sharing lean-green priorities and strategy and control better their supply chain performance.

4.3.4.2. Customers

Organizations know that customers are their primary goal to strive to innovate and create value for them by understanding and anticipating their expectations and needs (EFQM, 2011a).

The customer satisfaction is the more important driver for an organization. However, products exceeding the customers` expectations are the objective that should always be the most important and require greater innovation and creativity. According to EPA (2009) it is important to let customers pull value through the organization by understanding what the customer wants and producing to meet real demand. Products, processes and strategy should be focused on customer needs. The mission must identify the really needs of customers (Gurumurthy and Kodali, 2009). If the organizations in a supply chain are not being well coordinated between them the supply chain can fail and cannot supply the right product, at the right quantity and quality and at the right time and price. Consequently, the stabilization of the demand is very important (Doolen and Hacker, 2005), as it can control better the value streams and the prevention of pollution. When the customer demand is well-known, it is easier to simplify all processes and product (Gurumuthy and Kodali, 2009) controlling better the productivity and the source of wastes without adversely affecting performance requirements of products (Mudgal *et al.*, 2009). With the aim of enhancing customer satisfaction, the takt time or rhythm of the sales should be meet, introducing a real pull system and improving on-time delivery as well as quality (Chiarini, 2011).

Customers can cooperate with the manufacturer in the design of the product establishing materials and components that are better for environment and change on specifications (Carvalho *et al.*, 2010). The customers must be the first to know all the product information. Organizations in all the supply chain should be aware that understanding customer preferences, including those related to environment are important to increase competitive advantages.

In addition, customers are more aware that the products can be recycled, reused or disposed by environmentally safer methods. These customers may represent a kind of market more demanding: they not only want quality products at low prices but also pretend that this quality is reflected in the quality of the environment.

4.3.5. Processes

The implementation of a lean-green supply chain approach impacts functional processes throughout the supply chain (Mollenkopf *et al.*, 2010). The lean approach is mainly focused on improving the processes; the product development is linked, since de product design sets conditions for manufacturing, affecting the process efficiency (Johansson and Winroth, 2009). The simplification of product and processes are key in a lean approach. The green approach clearly acknowledges the need of improvements related to both processes and products

(Johansson and Winroth, 2009). The purpose is reducing the environmental impacts along the entire product life cycle (Johansson and Winroth, 2009). The lean approach also should consider the product life cycle (Torielli *et al.*, 2011). The product design is an important element: it must considered the kind of materials applicable to product; the use of customized materials and; how easy it is to disassemble, recycle or dispose old products (Gordon, 2001).

Organizations should promote continuous improvement in all the supply chain. Lean operations add competitive advantage through implementation of green approach (Mollenkopf *et al.*, 2010). Better processes results in better products with better quality and so with less rework and remanufacturing, less disposal and less environmental impacts, reducing cost and time. In summary, the lean-green implementation involves a process and product focus.

4.3.5.1. SC operations

The SC operations improvement is a necessary trend and possible to obtain through productivity improvement. It is understandable that management must have a good "formula" to control the SC processes. In a lean-green strategy normally is not necessary highlighting the need to access strategic tradeoffs (Mollenkopf *et al.*, 2010); however some tradeoffs may be occur during the implementation.

The impact of lean-green implementation in supply chain is important in order to identify which of them are relevant for the operations and which require improvements, identifying the best combinations between lean and green paradigms in the supply chain. The manager must find a way to balance the conflicting objectives and tradeoffs. In the context of organization`s supply chain, it is necessary to analyze which tradeoffs are considered important to them. The lean-green approach must pass through optimizing the whole system against multiple objectives. This framework mentioned the organization`s supply chain processes that can be subject to conflicts between both approaches.

One of the most referred tradeoffs between both approaches is the relationship between replenishment frequency and additional air emissions (Zhu and Sarkis, 2004; Venkat and Wakeland, 2006; Sawhney et al., 2007). Frequent deliveries will raise fuel consumption and may cause a negative impact on environment relative to air emissions, and can happen through the following:

- The small lot production which is a lean element, involve frequent deliveries (Sawhney *et al.*, 2007; Toke *et al.*, 2010). To minimize this impact it can adapt the lot-size and

optimizes the space utilization on transportation, to be a full load. (Mollenkopf *et al.*, 2010; Anand and Kodali, 2008). However, waiting for a full load may lead to longer lead-times (Toke *et al.*, 2010). The lean-green implementation prescribes the optimization of a small lot production connected to a delivery transport fully loaded.

- The same is verified with reduction on inventory level (Venkat and Wakeland, 2006), involving frequent delivery. It is possible to optimize through the close proximity with suppliers which reduce the distance of the route (Azevedo *et al.*, 2012).

Optimizing replenishment frequency is one issue that allows lean-green SC implementation more effective.

The decentralized inventory management, which is an element of the lean approach and is more frequent when suppliers can be closer to manufacturers, may cause an increased inventory across the supply chain, increasing the possibilities of green waste (Zhu and Sarkis, 2004). Thus, the lean-green implementation prescribe a reduction in the supply chain capacity buffers, in order to reduce unnecessary waste and promote the efficiency of resource consumption (Carvalho *et al.*, 2011a).

Connected to this, are the standard packaging or containers during transportation as a means to achieve both lean and green objectives minimizing the negative environment impact caused by just-in-time deliveries (Mollenkopf *et al.*, 2010). The returned packaging and containers involves designing customized containers for handling materials. The use of reusable/returned packages to delivery materials requires cooperation with suppliers (Toke *et al.*, 2010) but helps to control the inventory (Mollenkopf *et al.*, 2010) and to reduce storage and recovery delays which represent operational cost savings and environment impacts (Rao and Holt, 2005). The use of standard packaging or containers must be an element of a lean-green implementation.

The efficiency of SC process was determined by the good use of resources (Puvanasvaran *et al.*, 2011). Both approaches contribute for the reduction of the supply chain excess capacity: the lean paradigm is characterized by a higher level of the supply chain resources utilization; and green paradigm requires usefulness of natural resource consumption (Carvalho *et al.*, 2011a). The activities should be carried out with minimum resources and should provide maximum benefits (Gurumurthy and Kodali, 2009). The lean and green implementation must be based on optimized resource utilization (Puvanasvaran *et al.*, 2011). This can be achieved through the use of alternative sources, different employee skills, and the use of new technology or tools.

Transportation is another important issue in a lean-green implementation. The transport can generate more waste and environment impacts if it is not well studied and strategically applied. According to Toke *et al.* (2010) some transport modes like rail and ship, use less energy or use energy more efficiently than other modes like by road or air. However, it is not always possible to use the ideal transport. It is possible to develop the use of optimized and standardized routes (Anand and Kodali, 2008).

One of the cornerstones for lean and green paradigms is the 3R`s - reduce, reuse and recycle (Vais *et al.*, 2006). This element help in the optimization of the SC processes achieving products with higher quality with less rework and remanufacturing, less disposal and less environmental impacts, reducing cost and time (González-Benito and González-Benito, 2006). To know how to reduce or recycle solid and liquid waste (EPA, 2007) or recovery material is a practice of the 3R`s.

All process improvement is directed to have less or no waste in the processes. According to EPA (2007), green waste is "an unnecessary or excess use of resources or a substance released to the air, water, or land that could harm human health or the environment". Similar to lean wastes, the green wastes represent costs to organization (EPA, 2007). The reduction or elimination of all kind of waste is a core objective of a lean-green supply chain approach.

4.3.5.2. SC toolkit

The selection of the appropriate tools is important because tools must support the systems (SP, 2010). The lean tools can be adapted through a lean-green transformation process. The most tools boarded in the academic and practitioner literature are:

- The Value Stream Map (VSM) is used to see the material and information flows (Chiarini, 2011), process steps that are value-added to customer (ISO/CD 13053-2, 2009) and also non-value added steps and bottlenecks (Cruz-Machado and Leitner, 2010). Some authors (Venkat and Wakeland, 2006; Sidiropoulos, *et al.*, 2004; EPA, 2007, AME, 2008, Torielli *et al.*, 2011) refer as green value stream mapping for decreasing environment impact adding the right metrics, such as hazardous materials used, water used, energy used and transportation carbon dioxide emissions. This tool comprises two maps: the current state and the future state map and uses standardized symbols for mapping the process and follows the entire flow of a product, service or product family from the suppliers to the customers (Chiarini, 2011).

- The Kaizen event may conduct lean events on processes with environmental opportunities and has in consideration environment impacts (EPA, 2007; AME, 2008). This is an event for solving a problem or reduces waste (Chiarini, 2011) that represents a continuous incremental improvement through low-cost optimizations (Vais *et al.*, 2006). The continuous improvement efforts of operations (process improvement) as team projects, can constitute a key source to green improvements (Johansson and Winroth, 2009; Mollenkopf *et al.*, 2010). The Kaizen event team is usually composed by a cross functional team with personnel at all levels (Chiarini, 2011) which by their configuration take an exclusive viewpoint and that can increased the level of success of lean-green supply chain improvements.
- The A3 report (Chiarini, 2011; SP, 2010) is a quick problem solving method based on the lean approach. The A3 report is registered and displayed in a page with landscape orientation. This report can be used to get an analysis, a corrective action or an action plan, providing information in a succinct manner. This report can be applied to a green problem. A lean-green A3 reporting could be obtained relative to a SC problem.
- The Housekeeping or the 5S (Cruz-Machado and Leitner, 2010; EPA, 2007; AME, 2008; Torielli *et al.*, 2011) that consists in Sort, Straighten, Shine, Standardize, and Sustain (Chiarini, 2011; Vais *et al.*, 2006) may add a sixth S that represent the Safety (5S + safety). This means the continuously check for hazards and defects (Cruz-Machado and Leitner, 2010) and its importance to the employees and to the community (EPA, 2007; Torielli *et al.*, 2011). This tool generally cost very little or nothing but it helps in improving employees' morale, workplace safety and the product quality to a large extent (Mudgal *et al.*, 2009). The green approach in a business and industrial context is based upon philosophy that relates strongly to the 5S (Mudgal *et al.*, 2009). Normally the lean-green implementation starts with this tool.
- Standardization is a rule for a lean implementation where employees have the instructions and tools they need to meet customer expectations (Ryder, 2011) and where green environment activities and procedures relevant to the work area are integrated into standard work (EPA, 2007). The lean and green paradigms become embedded in the people jobs and this should be reflected in a job description. This tool can define different roles and can be used on different hierarchical levels of organization to help in streamline the SC activities.
- The 5 whys (AME, 2008) is a question-asking method and is used to investigate the root cause of a particular problem (Cruz-Machado and Leitner, 2010). The problem may

be a green difficulty. The analytical tools such as Pareto charts and Ishikawa diagrams (AME, 2008) can also reflect a lean-green analysis.

- In addition to these tools it is possible to consider others related to the processes. The most well-known green tool is the life-cycle assessment (LCA). This tool tries to capture the true environment impacts over the entire life-cycle of the product (Srivastava, 2007; Johansson and Winroth, 2009). According to Srivastava (2007), the scope of this tool is to track all material and energy flows of a product from the retrieval of its raw materials out of the environment to the disposal of the product back into the environment." The lean approach does not concern for the impact of product use (Dües *et al.*, 2013) but, if this tool help to expose hidden wastes, it is important its use in a lean-green SC transformation.

4.3.6. Results

The results should always be monitored. The results must be considered by the use of measures that represent customer value. To improve real-time decision-making and problem-solving it is important to use the right measures and rapid performance feedback (EPA, 2009). For an organization to be successful, the lean and green measurements must be integrated at every level of the organization. The five criteria (leadership, people, strategic planning, stakeholders and processes) must be mirrored in the results, to which all SC transformations must lead. The results will lead to new targets and recommendations for lean-green improvement. This is important for understanding how the lean and green paradigms must fit together and how it helps to achieve the strategic objectives.

The Balanced Scorecard is mentioned as a management tool to assess the performance of a lean-green supply chain. The lean and green approaches require similar ongoing reviews (Mollenkopf *et al.*, 2010). This tool may be an approach to achieving a balanced set of results that meet both the short and long term needs (SP, 2010; EFQM, 2011b). It must consist in a lean and green measure (Sidiropoulos *et al.*, 2004). This framework should be defined with a specific lean-green supply chain measures considering the four BSC perspectives.

4.4. Lean-Green Supply Chain Guidelines

The lean and green implementation must pass through areas of an organization and consequently in SC activities. For definition of the based guidelines for lean-green transformation, the six criterions of the conceptual framework were considered, namely leadership, people, strategic planning, stakeholders, processes and results. The guidelines for a lean-green supply chain transformation are structured into Table 4.2. Based on considered key criteria and on the elements proposed for each criterion, specific guidelines are characterized for a lean-green SC transformation.

Table 4. 2 - Guidelines for lean-green supply chain transformation

	Lean-Green Guidelines
Leadership	• Management should demonstrate its commitment and involvement to a lean-green approach. They should communicate the importance of lean-green for the organization. They should establish strategic, measurable lean and green objectives. • Management should ensure the principles of the lean and green approach such as waste reduction and efficiency. • Management must define the commitments with stakeholders and the communications between them, as a way to reduce the environmental risk, cost and time. • Management must ensure investment in way to help in lean-green SC transformation. • Management should guarantee a hierarchical structure with few levels in way to reduce the decision information. • Management should ensure the legal requirements and govern norms. • Management should ensure the application of management system to assist in the implementation of lean-green approach.
People	• Engaging every employee to root out lean and green waste, eliminate problems and make improvements. Defining a kaizen event with a lean-green team leader. • Should provide training and education in order to increase employees' skills. Apply principles such as cross-functional training, job enlargement and enrichment and flexible job responsibilities. • Organizations should encourage the employees to keep exploring new ways and suggest innovative ideas. • Organizations should ensure rewards and recognition for the employees. • Organizations should determine the necessary competences for employees.

Table 4. 2 - Guidelines for lean-green supply chain transformation (cont.)

	Lean-Green Guidelines
Strategic Planning	• Management should ensure a clear lean-green strategy which should be shared by all levels of the organization. SC strategy should be aligned with business objectives. • Management should establish lean-green plans and objectives. • Strategy with focus on the customer and others considered key stakeholders. Lean-green SC strategy should take into consideration the stakeholders. • Strategy should be communicated to stakeholders (through meetings or reports). • The deployment of the lean-green SC strategy must be on a systematic way.
Stakeholders	• Organizations should be focused on creating value for customers, investors, employees and communities. • Organizations should nurture a proactive and long-term relationship. • Organizations should promote commitment and communication between their stakeholders (e.g. suppliers or customers). Information sharing using information technology tools. • Organizations should define strategic alliances nurturing a close cooperation between them. • Organizations should ensure supplier selection according to lean and green criteria; should have the ISO 9001 and ISO 14001 certifications. • Organizations should encourage their suppliers to integrate lean-green into their business through setting strategy, continuing monitoring their SC performance in way to overcome barriers to improvement. • Management should guarantee the customer demand assuring their satisfaction.
Processes	• Management should focus on process and products; improve the SC activities in way to have product with quality. • Organizations should promote continuous improvement in all SC in way to bring SC processes under control. • Organizations should identify the best combination between lean and green approaches in SC. Conflicts between both approaches should be minimized. SC operations such as transportation system, inventory strategy or resources capacity are examples that should be addressed. • Management must focus on tools to enhance the success of lean-green SC activities. Some tools can be used for lean-green continuous improvement such as Kaizen event, A3 report, or analytical tools. • Organizations should promote a better work environment applying the 6S methodology. • Organizations should use VSM to determine better processes taking into consideration the resources, information and waste in a current state and in a future state. • Standardization and work instruction should be defined, documenting best practices and making sure that they are followed.

Table 4. 2 - Guidelines for lean-green supply chain transformation (cont.)

	Lean-Green Guidelines
Results	• Management should select a performance measurement system and select measures that help to see how the organization and its supply chain is providing value to the customer. • Management must analyze the data to understand the short and long term needs. • Management should evaluate the cause-and-effect to understand the SC behaviors.

4.5. Lean-Green Supply Chain Criteria Scoring

The scoring method makes possible to evaluate criteria (Dror, 2008). To characterize the weighting to each defined criteria, the scoring weight technique was based on the three most well-known awards. The decisive factor to select only the three awards namely SP, MBNQA and EFQM was because all have a total score of 1000 points on their assessment scheme. In a tentative to compare and contrast the three assessment criteria of quality awards, Table 4.3 was developed to find linkages between the three awards.

Table 4. 3 - Linkages between criteria score of quality awards

SP (SP, 2010)	**MBNQA** (MBNQA, 2010)	**EFQM** (EFQM, 2009; EFQM, 2011a)
• Cultural Enablers…….....150 15%	• Leadership…….120 • Workforce Focus…….85 20.5%	• Leadership…….100 • People……100 • People Results……...100 30%
• Continuous Improvement .400 40%	• Measurement, Analysis and Knowledge Management….90 • Operations Focus…….85 17.5%	• Partnership and Resources.100 • Processes, Products and services……..100 20%
• Enterprise alignment……..200 20%	• Strategic Planning……85 8.5%	• Strategy……..100 10%
	• Customer Focus……...85 8.5%	• Customer Results……...150 • Society Results.....100 25%
• Results……...250 25%	• Results……...450 45%	• Key Results……150 15%
Points: 1000	Points: 1000	Points: 1000

The analysis illustrates the following:

- The human side has more importance in EFQM (30% of the total number of points) and MBNQA (20.5%) awards;
- SP award (20%) is more concerned with strategy issues;
- The concerns with the customer (and external stakeholders) are more evident in EFQM award (25%);
- The concerns with internal operations are more evident in SP award (40%);
- The models have different scores for results SP (25%), MBNQA (45%) and EFQM (15% or 50% if other external results are considered).

The conceptual framework proposes a scoring based on a 1000 points score, similar to the adopted by the awards under study. With the data from the awards scoring it is possible to propose a criteria score for the lean-green approach. Through a basic formula, the values of each line were calculated (see Table 4.3), getting a final score for each criterion proposed. Equation (1) demonstrates the basic formula for calculating each score as:

$$\text{Lean-Green criteria score} = \frac{[\text{Score (SP)} + \text{Score (MBNQA)} + \text{Score (EFQM)}]}{3} \qquad (1)$$

For example, the line in Table 4.3 that consists in "enterprise alignment" (20%) from SP, "strategic planning" (8.5%) from MBNQA and "strategy" (10%) from EFQM gives a total of 128 out of 1000 points. Thus, the strategic planning criterion score was adapted to 130 points. The leadership and people criteria were considered in the same line and so it was calculated together and given the same score with 110 points each. Another example is the results criterion a total of 283 points, was adjusted for 280 points. The processes criterion had a score of 260 points and the stakeholders 110 points. The calculus of stakeholder`s criterion was the last to be considered. Their calculation was only based on a customer perspective ("customer focus" from MBNQA and "customer results" and "society results" from EFQM). Table 4.4 shows the calculation made to achieve lean-green criterion weighting. Figure 4.5 shows the criteria and respective scores to model and evaluate a lean-green organization`s supply chain.

Table 4. 4 - Lean-Green criterion weighting calculation

SP Score	MBNQA Score	EFQM Score	Equation (1) Results	Lean-Green Criteria Score	
150	205	300	218.3 ≅ 220	Leadership….110 People……110	
400	175	200	258.3 ≅ 260	Processes…...260	
200	85	100	128.3 ≅ 130	Strategic Planning…….130	
-	85	250	111.6 ≅ 110	Stakeholders..110	
250	450	150	283.3 ≅ 280	Results…….. 280	

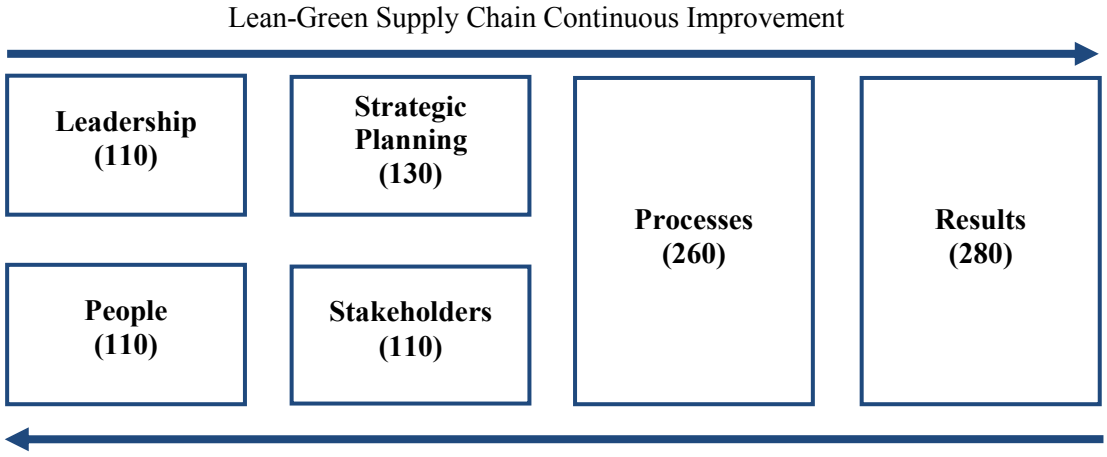

Figure 4. 5 - Lean-Green weighting between criteria

With the lean-green criteria guidelines and elements and the weighting between criteria, it is proposed an assessment method for lean-green organization`s supply chain. The organization`s supply chain total score results from a process that involves two phases:

- Score of each lean-green criterion part guidelines and elements; and
- Overall score

The approach should be evaluated based on the level of lean-green implementation, analyzing if the integration of both approaches is evident. The criterion scale and calculation method was based on EFQM evaluation (IPQ, 2005). Table 4.5 shows the different levels of score. The scale includes the following levels:

- No evidence: there is no evidence of lean-green implementation.
- Some evidence: there is some evidence of the beginning of lean-green approach. This evidence may be related to the lean approach and to the green approach.
- Evidence: there is evidence of lean-green implementation. Change became visible; this may be related to the deployment of lean approach and green approach.
- Clear evidence: there is evidence of lean-green implementation, applying both approaches.
- Total evidence: there is total evidence of lean-green implementation, applying a lean-green approach.

Table 4. 5 - Lean-Green scale

0%					25%					50%					75%					100%				
No Evidence					Some Evidence					Evidence					Clear Evidence					Total Evidence				
		0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100		

The organization`s supply chain total score is calculated through the completion the tables 4.6 and 4.7. Table 4.6 indicates the criterion part that represents each part considered in lean-green guidelines (Table 4.2). Table 4.7 indicates the "weighting score" calculated above in this chapter.

The calculation method should be executed as follows:

- introduced the score for each criterion part;
- obtained the arithmetic mean of each criterion, considered the "assign score";
- multiplied each "assigned score" by "weighting factor" to calculate the total "weight score" obtained.

Table 4. 6 - Lean-Green criterion calculation

Leadership		People		Strategic Planning		Stakeholders		Processes		Results	
Criterion part	%	Criterion part	%	Criterion part	%	Criterion part	%	Criterion part	%	Criterion part	%
1		1		1		1		1		1	
2		2		2		2		2		2	
3		3		3		3		3		3	
4		4		4		4		4			
5		5		5		5		5			
6						6		6			
7						7		7			
Total		Total		Total		Total		Total		Total	
÷7x100		÷5x100		÷5x100		÷7x100		÷7x100		÷3x100	
Assign Score		Assign Score		Assign Score		Assign Score		Assign Score		Assign Score	

The lean-green overall score is the weighted sum of the scores related to all elements and guidelines. The overall score is between the minimum value of zero (total = 0) and the maximum value of 1000 points. The lean-green score system will help organizations to evaluate their level of lean-green organization` supply chain implementation.

Table 4. 7 - Calculation of the overall score

Lean-Green Criteria	Assigned Score	Weighting	Weighted Score
Leadership		x 110	=
People		x 110	=
Strategic Planning		x 130	=
Stakeholders		x 110	=
Processes		x 260	=
Results		x 280	=
		Overall Score	

4.6. Lean-Green Supply Chain Monitoring System

4.6.1. BSC for Evaluation Lean-Green Supply Chain

The BSC is developed based on the organization strategy. Objectives, measures, targets, and action program are developed for each of the identified perspectives. Kaplan and Norton (1996) refer that the BSC four perspectives should be viewed as a template. For them, depending on the organization strategy one or more perspective can be introduced or in other hand, to use fewer that the four perspectives, measuring the factors that create competitive advantage and innovation for the organization.

BSC with its four perspectives is a good starting point to developing a performance system that incorporates issues in way to study the lean-green supply chain performance. For Stenzel (2007), lean management does not require adopting the BSC, however this seems to be compatible with lean thinking. This compatibility is supported by four perspectives: (i) the financial perspective, by delivering value to stakeholders; (ii) the customer perspective, supporting lean focus on final customers; (iii) the internal business process perspective, which highlights the importance of organizations to adopt a continuous improvement culture; and (iv) the innovation and learning perspective, which intends to promote organizational culture changes and respect for people. Stenzel (2007) mentioned that it is important to deploy measures that drive lean behavior by the BSC. Organizations already using the BSC prior to embarking on lean transformation should find the BSC a useful tool for promoting lean (Stenzel, 2007).

Kaplan and Norton (1996) mentioned that "for organizations environmental clean is a competitive advantage". Sidiropoulos *et al.* (2004) refer that there are three possibilities to integrate green aspects in BSC: i) environmental and social metrics can be integrated in the existing four standard perspectives, ii) an additional perspective can be added to take environmental and social aspects into account and iii) a specific environmental and social scorecard can be formulated. In their research Sidiropoulos *et al.* (2004) add a fifth environmental perspective to the BSC; these authors defined an Eco-Balanced Scorecard, with respect to a lean and green operations strategy. Hsu and Liu (2010) have adopting BSC in environmental strategy management, using a specific environmental BSC. Table 4.8 summarizes the lean-green performance measures classified by the four BSC perspectives. This can be used as a template to evaluate lean-green SCM performance.

Table 4. 8 - List of performance measures identified for lean-green BSC supply chain

BSC	Performance measures	References
Financial	Profit after interest and tax; Profit from recycle and resource consumption products	Sidiropoulos *et al.*, 2004; Hsu and Liu, 2010; Bhasin, 2008; Ray *et al.*, 2006
	Gross revenue	Gurumurthy and Kodaly, 2008
	Revenue of green products; Return rate of green investment	Hsu and Liu, 2010
	Return on investment	Chia *et al.*, 2009; Ray *et al.*,2006; Sidiropoulos *et al.*, 2004
	Return on assets	Kainuma and Tawara, 2006; Gurumurthy and Kodali, 2008
	Disposal costs; Pollution treatment costs	Hsu and Liu, 2010; Zhu *et al.*, 2007; Hervani *et al.*, 2005
	Operational costs	Zhu *et al.*, 2007; Hervani *et al.*, 2005
	Scrap and rework cost	Zhu *et al.*, 2008
Customer	Market share by product group	Hubbard, 2009; Bhasin, 2008; Sidiropoulos *et al.*, 2004
	Customer returns Responsiveness On-time delivery	Sidiropoulos *et al.*, 2004; Bhasin, 2008; Hsu and Liu, 2010; Hervani *et al.*, 2005
	Product safety	Hervani *et al.*, 2005
	Quality improvement due to greener products Green image	Hsu and Liu, 2010
	Customer satisfaction index Service quality	Bhasin, 2008
Internal Business Process	Process efficiency Operational efficiency Capacity utilization	Hubbard, 2009; Hsu and Liu, 2010; Hervani *et al.*, 2005; Zhu *et al.*, 2008; Gurumurthy and Kodali, 2008
	Material waste; Hazardous waste; Water waste; Energy waste; Scrap/non-product output; Air emissions	EPA, 2007; Zhu *et al.*, 2007; Sidiropoulos *et al.*, 2004
	Materials use; Water use; Energy use	EPA, 2007; Sidiropoulos *et al.*, 2004; Kainuma and Tawara, 2006
	Percentage of recyclable components	Sidiropoulos *et al.*, 2004
	Lead-time Value added time Non-value added time	Gurumurthy and Kodali, 2008; Ray *et al.*, 2006
	Inventory level Raw material inventory WIP inventory Finished goods inventory	Zhu *et al.*, 2008; Ray *et al.*, 2006; Bhasin, 2008
Learning and Growth	Number of accidents Absenteeism Labor turnover	Gurumurthy and Kodali, 2008; Bhasin, 2008
	Quality of professional/technical development Environmental education and training Employee`s initiative Understanding to related policy and laws	Hsu and Liu, 2010
	Rewards and recognition; Suggestion schemes; Communication between employees	Gurumurthy and Kodali, 2009
	Quality of leadership development Retention of top employees	Bhasin, 2008

A conceptual linkage between the lean-green supply chain performance measures within BSC structure is shown in Figure 4.6 and it contains performance measures proposed on Table 4.5. This conceptual linkage is based on work published by Duarte *et al*. (2011a) and Carvalho *et al.* (2011b); it integrates the lean-green measures through the four traditional BSC perspectives to reach the benefits on supply chain performance.

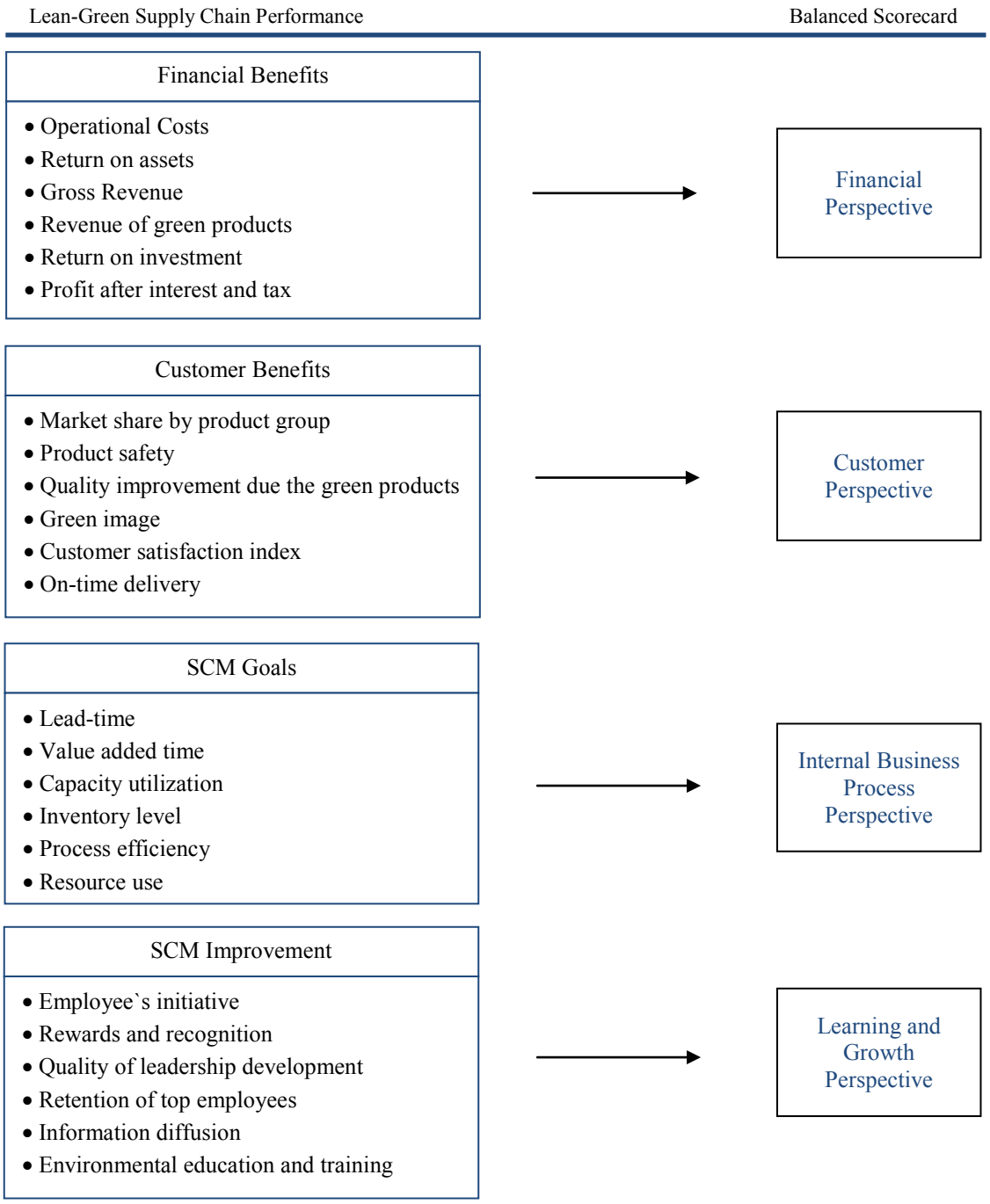

Figure 4. 6 - Linking lean-green supply chain performance and the BSC

If organizations take actions by linking the performance measurement system to their lean-green elements, then they should be better positioned to succeed in their supply chain initiatives.

4.6.2. Lean-Green BSC Cause-and-Effect Framework

The supply chain managers should identify the performance measures. Usually, they identify the measures according to their objective requirements and practical experiences (Cai *et al.*, 2009). To get a balanced performance measurement they often decide to use the BSC. Several authors categorized a number of measures by the different BSC perspectives (Kaplan and Norton, 1996; Chia *et al.*, 2009; Hubbard, 2009; Sidiropoulos *et al.*, 2004; Hsu and Liu, 2010; Brewer and Speh, 2000; Bhasin, 2008). To develop a BSC as a strategic and dynamic performance measurement system, Bhagwat and Sharma (2007) point out three principles:

- built in cause-and-effect relationships;
- include sufficient performance drivers;
- provide a linkage to financial measures.

Cai *et al.* (2009) refer that most of the indicators/measures in a supply chain are correlated and have complicated cause-and-effect relationships. These cause-and-effect relationships can make the connections among objectives and measures in the various perspectives.

According to Hsu and Liu (2010) "there are strong relations among performance measures covering multiple dimensional but balanced aspects for a delicate strategy control. For example, measures of learning and growth perspective could strongly affect internal process perspective and therefore affect financial perspective". Another example is supplied by Bhagwat and Sharma (2007): "flexibility of service systems to meet particular customer needs (internal business process perspective) will be more likely to meet customer expectations (customer perspective). Higher level of customer expectations will lead companies to supply more innovative products and services (learning and growth perspective). This in turn will increase the market share and profitability (financial perspective)". The cause-and-effect relationship can involve some, the four or more perspectives in the BSC and may evaluate lean and green supply chain management.

This approach creates a BSC framework for evaluating lean and green supply chain performance. The four standard perspectives were used where the lean-green measures are selected. These measures were based on literature review and they intend to lead into the

meaning of strategy: they were selected as important features taking into account the following purposes:

- for financial measures two core measures were selected: i) "profitability and revenues" which is based on profit after interest and tax, profit from recycle and resource consumption products, revenue and revenue of green products, return rate of environmental investment and return of investment (Chia *et al.*, 2009; Sidiropoulos *et al.*, 2004; Hsu and Liu, 2010; Bhasin, 2008); and ii) the measure "cost" based on operational costs, disposal and pollution treatment costs (Hsu and Liu, 2010; Zhu *et al.*, 2007; Hervani *et al.*, 2005);
- for customer measures were selected the "market share" as market share by product group (Chia *et al.*, 2009; Hubbard, 2009; Sidiropoulos *et al.*, 2004; Bhasin, 2008) and "customer satisfaction" that can be measured as customer returns, responsiveness and on-time delivery (Sidiropoulos *et al.*, 2004; Hsu and Liu, 2010; Bhasin, 2008; Hervani *et al.*, 2005);
- for internal business process measures was used "waste reduction" (Chia *et al.*, 2009; Zhu *et al.*, 2007), as it is based on traditional lean wastes and green wastes (EPA, 2007); and "productivity" was used, as well, as it is based on process and operational efficiency and capacity utilization (Hubbard, 2009; Hsu and Liu, 2010; Hervani *et al.*, 2005);
- for learning and growth measures, "employee morale and satisfaction" can be expressed by the number of accidents, absenteeism and labour turnover (Chia *et al.*, 2009, Sidiropoulos *et al.*, 2004; Hsu and Liu, 2010; Bhasin, 2008; Gurumurthy and Kodali, 2008); and "employee's education and training" based on quality of professional/technical development and environmental education and training (Hsu and Liu, 2010; Bhasin, 2008; Hervani *et al.*, 2005).

It is possible to recognize that supply chain business practices and actions influence the performance measures and they are related with each others. The "employee morale and satisfaction" measure may be justified with the following Kaplan and Norton (1996) statement: "the most satisfied customers were the ones served by the employees who scored highest in morale". Gordon (2001) state about the lean and green implementation that employee morale increases through the pride of working for a lean-green organization and report fewer illnesses and accidents. In addition, EPA (2007) refers that "when employees take pride in their work there can be a substantial positive effect on organizational morale and that can empower employees and promote an improvement in productivity". Financial benefits may be reached due to improvements in operational efficiency or productivity (Nawrocka *et al.*, 2009).

According to Pettersen (2009) improve productivity and make products with fewer defects to precise customer satisfaction, are some of the goals using lean characteristics as for example continuous improvements and just-in-time philosophy. Gordon (2001) states that introducing efficiencies will contribute to earn more market share. EPA (2007) refers that the benefits of coordinating lean and green approach pass through cost reduction, improve process flow, meet customer expectations and improve employee morale and commitment.

Employee education and training are main issues on waste reduction. The education of employees has a relation with product conformity (Hsu and Liu, 2010) reducing waste. Besides, it is possible to get financial benefits from a waste reduction (Nawrocka *et al.*, 2009). Learning to see and eliminate waste is the basis of lean approach (EPA, 2007). Thus eliminating production wastes and environmental wastes indicate opportunities for saving cost (EPA, 2007; Pettersen, 2009). Another result from lean and green implementation stated by Gordon (2001) was "paying less for disposal because much less is wasted; earning revenues trough recycling". Figure 4.7 illustrates the cause-and-effect relationships between measures that were developed in the BSC perspectives approach.

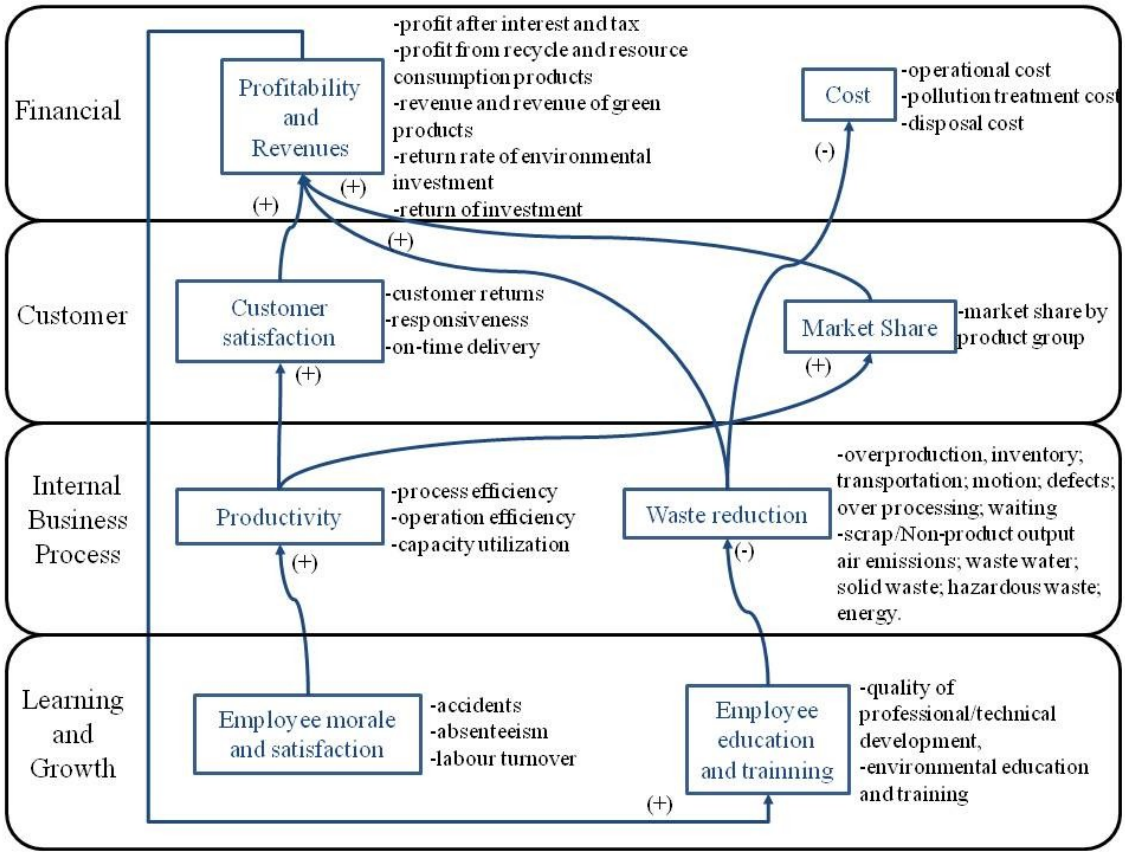

Figure 4. 7 - Cause-and-effect lean-green BSC

With this diagram, it is possible to visualize how lean and green measures are related and it is possible to find out an entire sequence of linkages:

- A growth on "employee's education and training" (learning and growth), drive to "waste reduction" (internal business process), which increase "profitability and revenues" and decrease "cost" (financial).
- An increase on "employee morale and satisfaction" supports an improvement in "productivity" measure, driving to a rise in "customer satisfaction" and "market share". These last measures (in customer perspective) increment "profitability and revenues" (in financial perspective), which provides a possibility to make more investment in "employee's education and training" (in learning and growth perspective).

These linkages in the scorecard are an example of how to evaluate the organization and its supply chain performance and allow to analyze the relationships between the measures. The elements adopted to work in the lean-green approach may influence the performance results. These results must be monitored and analyzed to provide feedback, as it will influence how organization improves the business and its supply chain.

4.7. Chapter Overview

This study suggests that management frameworks studied in Chapter 3 can be a good starting point for modeling a lean-green supply chain business. This chapter attempts to describe the different steps of a lean-green transformation, developing a lean-green supply chain management framework. The proposed conceptual framework consisted in the definition of the criteria with corresponding elements, guidelines and scoring system. It is possible to conclude that there are elements that support both, a lean approach and a green approach.

Connected is the lean-green monitoring system that is very important to give feedback to management. With this information managers can take actions, establish new strategic objectives and improve processes. For a lean-green transformation the BSC can be considered a useful tool to evaluate SC performance.

With this conceptual framework it is possible to reinforce the idea that lean-green is a good structure for organization`s supply chain. Organizations must develop their supply chain management framework to stay correctly positioned and aligned with the market.

5. Case Study Research

A SC model is an important way of interpreting the industrial environment being a starting point for achieving the lean-green transformation. From a SC perspective it is possible to understand the structure and elements used in industry. The central objective of this chapter is through a case study analysis, to check how lean-green supply chains could be implemented. The case study intends to confirm which lean-green elements may be applied to companies to achieve a lean-green supply chain. It pretends to determine the organizations attitudes about lean-green implementation. This allows a more depth understanding of a lean-green supply chain.

5.1. Methodology

The purpose of this study is to confirm the research questions which pretend to understand the basic mechanisms for a lean-green supply chain implementation. For that, it is important examine how lean-green elements (defined in conceptual framework) are being implemented in the real world; therefore, a case study approach was considered the best method for this research. The key advantage of this approach is to interact with the organizations to carry out an in-depth investigation and immediate validation of the findings, which a large-scale survey cannot provide.

According to Voss *et al.* (2002) "case research has been one of the most powerful research methods in the development of new theory". To develop new theory, randomized sampling is not appropriate (Eisenhardt and Graebner, 2007). Case studies allow the development of a valuable theoretical framework (Yin, 2003), as they can be focused on a specific topic or organization (Boyer and Swink, 2008) or supply chain (Seuring, 2005). According to Seuring (2005), a case study research is an empirical analysis that examines a phenomenon within its real life context, particularly when the limits between phenomenon and context are not clear. They may offer insights that might not be achieved with other approaches (Rowley, 2002). Boyer and Swink (2008) further mentioned that the great benefits of case studies include the ability to examine a topic in great depth, particularly poorly understood or emerging phenomena, allowing a thorough examination of numerous factors and nuances. This research pretends to clarify where their boundaries for lean-green are drawn and falls in interest of understanding the process rather than outcomes. Furthermore, this methodology is preferred in examining contemporary events in which the extent of control of the investigator over the

events studies is limited (Yin, 2003), which is the case in this analysis. Yin (2003) mentioned that the case studies can be exploratory, descriptive or explanatory (Yin, 2003):

- an exploratory case study is intending in defining the questions and propositions of a subsequent study or at determining the practicability of the desired research procedures;
- a descriptive case study presents a complete description of a phenomenon within its context; or
- an explanatory case study presents data bearing on cause-and-effect relationships explaining how events happened.

The case studies are useful in providing answers to "How" and "Why" questions, and in this role can be used for exploratory, descriptive or explanatory research (Rowley, 2002). Eisenhardt (1989) mentioned that case studies can be used to provide description, to test theory or to generate theory. According to this profile the research is an exploratory case study, since it pretends determine the practicability of the desired research procedures by the organization and their attitudes about lean-green implementation. This research is based on observations, exploring the reality to develop a cumulative knowledge of the organizational modeling processes ensuring that the current research is relevant. The choice of this methodology seems appropriate for study as it provides a better understanding of the modelling process for the integration between lean and green approaches.

Furthermore the case study can be based on a single or multiple case studies (Yin, 2003). A single case study only can provide a wealth of description and direct observation of phenomena in natural scenery (Boyer and Swink, 2008). Multiple cases can be developed on various organizations or can be developed on the same organization studying different issues (Voss *et al.*, 2002). A multiple case study may reduce the depth of study when resources are constrained, but can both augment external validity, and help guard against observer bias (Voss *et al.*, 2002). Multiple cases typically yield more robust, generalizable, and testable theory than single-case research (Eisenhardt and Graebner, 2007). The methodology chosen to answer the research question is a multiple case study. The intention of this research is not to select an unusual case, but to cover more cases to identify the various elements within a chosen supply chain to improve the research methodology.

The case studies must be conducted in the same manner, enabling cross case analysis. The cross case analysis is concerned with identifying patterns across the various organizations (Pagell and Wu, 2009) and should seek to increase the internal validity of the findings (Voss *et al.*, 2002). In his study Pagell (2004) defined their data analyses as having two main

components: within and across case analysis. According to this author, within case analysis helps the researcher to examine the characteristics in a single context, while the across case analysis serves as a form of replication. Consequently this research tried to develop this approach of investigation.

The research process proposed to this research use a qualitative study using case study research because it has been effectively employed in a large variety of situations (Boyer and Swink, 2008) and it is excellent as guide for conducting research in organizational businesses and in its supply chains. According to Yin (2003) defining unit of analysis is the more important issue. The study`s unit analysis can be an event such as a decision, a program, an implementation process or organizational change (Rowley, 2002). In this research the unit of analysis is the lean-green implementation in the organization`s supply chain.

In sum, to assist further development of the conceptual framework, the multiple case study provide a depth understanding of the research developing a more complete understanding of the compatibilities between lean and green in the areas of organization`s supply chain.

5.1.1. Case Study Design

The setting for this study is the automotive industry which seems an appropriate choice for reasons concerning both the lean and green approaches. Their implementation is a specific issue that is not always applied by the organizations in all their departments or areas. A selection of research places is shaped by the choice of research topics (Pettigrew, 1990). This industry sector has high levels of lean and green implementation (Azevedo *et al.*, 2012) which allow a better understanding of the role of the integration between them. In addition, it is also expected that automotive multinational companies play an active role in developing sustainable supply chain contributing for the successful development of business (Carvalho *et al.*, 2011b).

The selection of this sector was also because of its importance to the Portuguese economy (Carvalho *et al.*, 2011b). The Portuguese automotive sector, in 2011 sold 80% of the production to foreign markets, representing 4.3% of the country's Gross Domestic Product (AFIA, 2012). The principal strengths for the development of this sector in Portugal are the technique skills, presence of multinationals, history as exporter and low wage costs (AFIA, 2012).

The process of choosing where the research was carry out, was based on "planned opportunism" (Pettigrew, 1990). This research used an automaker that is partner in an

international research project, the LARG_SCM project mentioned in previous chapters.

The case study was developed in a single automotive supply chain. This research work was created through a study on the automaker and their suppliers in the region center of Portugal. This sector has established itself as one of the most important centers of regional development. The supply chain consists in downstream linkages where the automaker produces according to the final customer needs; in the opposite direction, the upstream linkages consist in partnerships with their suppliers. The automaker is the leader partner in the supply chain and is the company that pulls the business.

The pull flow was extended beyond the boundary of the automaker factory to include the upstream supply chain. The study falls in upstream supply chain specifically in automaker and their suppliers located in an Industrial Park close to the automaker. The focus of the investigation centers on the companies and the processes that influence the supply chain. The study was limited to companies located in the Industrial Park being the only option available by the automaker. Therefore the possibility of applying this research to other companies of the group outside the country was excluded from the beginning. The automaker can rule the upstream SC processes and can influence the SC in terms of lean-green management. How lean-green elements defined in conceptual framework are developed is the question that wants to respond.

The universe considered for this study consists of different organizations in terms of the development of activities. According to Eisenhardt and Graebner (2007) "adding three cases to a single-case study is modest in terms of numbers, but offers four times the analytic power". The cases have been selected to offer contrasting in some situation is terms of lean and green applicable.

In a first phase of this research nine companies, considering focal company, first-tier suppliers and logistic service providers (LSPs), have been contacted. Relative to the suppliers, six were first-tier suppliers of materials and components parts and the other two LSPs. In all cases, it was made a first interview with leading experts and it was made a visit to the plant site to get an overview of the business of the organization. By a matter of time management of the organization in query, only four suppliers have accepted to continue the process of case study. Therefore it was considered a universe with three different research groups: i) the automaker; ii) second group consists of three first-tier supplier and one LSP which give a deepened data and; iii) the third group where it was made a less profound study. Table 5.1 summarizes the profiles according to, position in the supply chain, company type, and product type and organization size

(number of employees). Almost all the companies are in the Industrial Park since its beginning. In all cases organization names are withheld in accordance with the general request for organizational confidentiality (Wong and Boon-itt, 2008).

Table 5. 1 - Details of the case companies

Case study	Position in SC	Product type	Company size (n. of employees)
Company 1	Focal company	Vehicles	3600
Company 2	First-tier supplier	Exhaust system	70
Company 3	First-tier supplier	Front /rear suspension and Front/rear axle	100
Company 4	First-tier supplier	Interior doors and panels modules	320
Company 5	LSP	Steel coils	50
Company 6	First-tier supplier	Cockpit	115
Company 7	First-tier supplier	Paints	*
Company 8	First-tier supplier	Hard top	255
Company 9	LSP	-	50

Legend: * Without information

The company 1 manufactures passenger and multi-purpose vehicles. Company 2 is in the metalomechanics area of business and is a multinational company leader in the production of exhaust systems and catalytic converters. The product delivery to automaker is the exhaust systems. The Company 3 is a multinational company and is in the metalomechanics area of business. Today the company is a component assembly chassis module, suspension components and welding of metal parts for the automotive industry. The product delivery to automaker is front/rear axle and front/rear suspension. Another fist-tier supplier is the company 4 and is in the Interior Systems area of business and the product delivery to automaker is doors and panels modules. Company 5 is a logistic service provider and is in the area of services with the objective of supporting some distant first-tier suppliers. This company has the responsibility to receive, storage and deliver the steel coils to automaker. Company 6 is a joint venture of two other suppliers that provides the cockpit. Company 7 is a multinational company and is in the coating car area. The company supports the sourcing and management of the automaker paint area. The company 8 makes part of multinational company. It supplies the hard top of one vehicle model. Company 9 supplies the transport and logistics services. This company provides the transport services of automaker covering full loads and mixed cargo.

Some of these companies are also second-tier suppliers from other suppliers in the Industrial Park. For example, company 3 supplies the skeleton of cockpit to company 6. The company 7 supplies with paints to company 4 for their paint area.

5.1.2. Data Sources

To conduct the case studies a data collection tool was developed. A structured interview protocol was designed to limit the expert bias in the study results, data that drew on personal judgment of the participants (Azevedo *et al.*, 2012). The data collection tool was founded on the literature review and on conceptual framework proposed. It was defined a set of semi-structured interview questions. This protocol was considered a guide to help on interviews.

Before starting the field work it was advisable to test the protocol. According to Yin (2003) this phase help to understand and define better some issues because initially the uncertain to about major aspects of a real case study may appear as the questions to be asked, the prepositions of study or the access to the data. A pilot study was carried out. The pilot phase was made to a manager of another automotive company who did not make part of the companies included in the case study. The respondent was interviewed to provide comments that helped to validate the relevance of the protocol.

Additionally, the participation in several International Meetings and Conferences helped to disseminate and discuss the research getting feedback and exchange comments and opinions with other researchers experienced in this area of research. These events provided access to a level of relevant information and knowledge, which helped improvements in current and future research setting. After this process, the protocol suffered some adjustments and changes. This pre-test helped to understand where it could be improved considering the clarity and the applicability of the protocol.

Typically case studies draw on multiple sources of evidence (Rowley, 2002) as interviews, documents, archival documents or direct observation and all pointed in the same direction (Yin, 2003; Rowley, 2002). This kind of data collection is defined as the concept of triangulation (Yin, 2003).

In this research, different sources of data were used to enrich the study and to obtain correct data since it is possible to happen that the interviewees may make effort to protect the image and reputation of their organizations. The case study research was conducted as shown in Figure

5.1. Therefore, the interview data were further triangulated with available internal documents, archival documents, direct observations, internet sites and inclusive news published about companies in local and national newspapers to confirm and enlarge evidences. The direct observation through field visits help to understand some procedures, obtaining additional information. To attain the most reliable results this study was supported through the most time consuming face-to-face interviews.

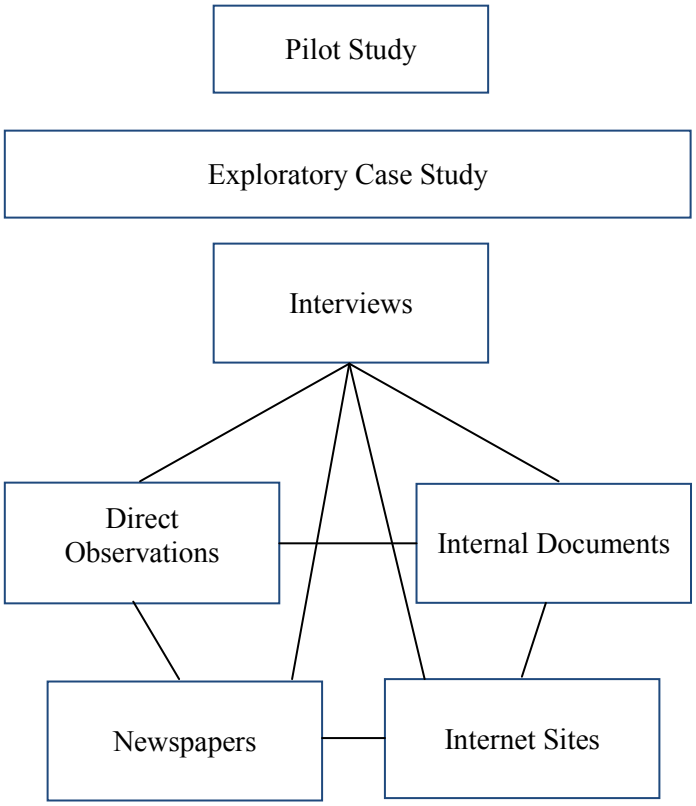

Figure 5. 1 - Case study research

The Annex 2 gives a set of semi-structured interview questions grouped in three sections. The first section is concerned with the understanding of organization characterization; the second section the perception that the respondent has about the integration between lean and green initiatives; and the third section is the body of the interview which is divided in the six principal criterion considered in the conceptual framework namely, leadership, people, strategic planning, stakeholders, processes and results. The questions are made in way that respondent could give their opinion and examples.

As the focus of the study was on the supply chain, the research focused more on the automaker which have more interviews and more direct observations than in the suppliers to understand the way of doing business. The interviews are conducted at the company facility. Although the interviewees seem to have different titles they were the best qualified and were selected as the most appropriate to answer to questions within the organization since they were related to supply chain and because of their experience.

According to Rowley (2002) "in complex case studies it is important to differentiate between the questions asked of specific interviewees and used to interrogate documents, questions asked of the individual case, and questions to be asked across multiple cases". Some questions were made to have an overview as single case study and specific questions asked for cross-cases. It was not possible to get all the answers in all companies, but interesting findings emerged from the interviews. Table 5.2 reports the number of interviews conducted and the titles of the interviewees.

Table 5. 2 - Overview of interviews

Case study	No. of Interviews	Title of interviewees
Company 1	8	Supply & Logistics manager
	1	Supply Chain executive
	2	Environmental coordinator
	2	Lean coordinator
	1	Lean calculator
Company 2	2	Lean manager
Company 3	3	Logistics manager
Company 4	2	Logistics manager
	1	Environmental coordinator
Company 5	2	Operations manager
Company 6	1	Logistics responsible
	1	Environmental coordinator
Company 7	1	Logistics manager
Company 8	1	Logistics responsible
Company 9	1	Project manager

This research started with the automaker. Afterwards, much more interviews were made to understand the organization`s supply chain in terms of interactions between lean and green and the relationship with their suppliers. In addition, direct observations were made without interfering in the employees work to complement data to those interviews. This direct observation undergoes by for example the participation in logistic meetings with all first-tier suppliers in just-in-time system.

The lean and green approaches have impact throughout the supply chain. Being a production company or logistic service provider may have differences in the concept of implementing lean and green elements. The six criteria defined in the conceptual framework are the starting point for an evaluation of companies, regarding the implementation of lean and green.

5.2. Automotive Supply Chain

5.2.1. Focal Company

The automaker is a large company with intense supply chain operations. The automaker is the leader partner in supply chain. The organization is producing in Portugal since 1995 and constitutes one of the most modern industrial units. It produces passenger and multi-purpose motor vehicles and components. The automaker is responsible for the production of four different models of familiar vehicles. In 2011 the company was selling mainly to, as the first market the Europe followed by China. Table 5.3 gives a representative automaker data relative to the year 2011.

The organization`s vision is to be the plant most attractive of the group. The automaker competes with the others plants of the brand. The company considered five different criteria as the goals of the plant: i) cost reduction; ii) productivity; iii) defects; iv) continuous improvement and v) organization and quality. In this sense, the automaker aims to achieve maximum productivity and quality of products based on employees and infrastructure. The organization`s mission is to produce high quality vehicles. The mission reflects the challenge of the automaker for integrity, respect for people and their skills, excellent teamwork, responsibility and autonomy, skills and core competences, and commitment to achieve the common goal.

Table 5. 3 - General data of focal company

(Source: Automaker internet company site)

Data	The numbers of 2011
Production per day	625 vehicles per day in two shift
Total Production (vehicles)	133,100
Maximum production capacity (per year)	180,000 vehicles in 3 shifts
Number of employees	3603
Impact on national exports (%)	4.6
Production for exportation (%)	98.9
Production for the domestic market (%)	1.1
Sales turnover (million €)	2246
Investment (millions €)	58.6
Impact in Gross Domestic Product (%)	1.4

The strategy goals are defined by the group to be an objective to achieve until 2018. These are the long-term objectives to being developed in ten years. The group aims to be the most successful and fascinating automaker in the world. They define four different topics to be achieved: i) intends to become a world leader by using intelligent innovations and technologies, while at the same time delivering customer satisfaction and quality; ii) over the long term, aims to be the major producer, sharing as the major growth markets develop; iii) intends to increase its return on sales before tax at least 8% and, iv) becomes the top employer across all brands. To do so the automaker must have a leadership team, must have an approach of commitment with suppliers, must be a quality organization and also focus on social responsibility by good environment practices and improving the employees` quality of life. Thus, the priorities are the people, cost reduction and wellness.

Another goal related is to reduce the environmental impact per vehicle or component produced through a production process more efficient and sustainable, with an innovation culture, rigor and responsible management. The brand has the commitment to reduce 25% of the environmental impact by reducing emissions and disposal, and saving energy and water. The automaker proposes to maintain the environmental effectiveness superior to the expectations of customers and to the legal requirements. The company reveals a proactive approach towards to green in order to be prepared for future changes in legislation and regulations. This purpose goes back to the creation of the plant that was built with standards that were beyond legal requirements for this type of industry.

For the focal company - the automaker - the best way to reduce the environment impacts is to minimize the resource consumptions as water, energy and raw materials, reducing and controlling the environment wastes namely, air emissions, sewage, noise, and water, energy and gas consumption. Other features connected to environment aspects are the protection of soil, the transportation, materials approval and influence on suppliers.

The organization achieved the quality management system according to ISO 9001 without the clause of product design because that is a responsibility of the headquarters. This standard is in compliance with a quality specification for the automotive industry the ISO/TS 16949. Partially integrated with ISO 9001 is the environmental management system ISO 14001. According to the Environmental coordinator, the organization is not certified by EMAS due to the bureaucracy inherent to the process: it would represent an increase of costs and it would not translate a significant improvement in the environment performance.

These management systems help the synchronization of the supply chain process. The manufacturing process of a vehicle is sequential, having four different areas: the press, body construction, paint and assembly. The assembly line is a single line to produce the four different models, leaving a car in every 73 seconds. Therefore, it is necessary that the flow of materials and information are well coordinated along all the supply chain to assure the automaker has the right material at the right time for the right customized vehicle.

The innovation in the automaker is directed to improvements of the plant, which leaves room for productivity improvement, namely in lean and green issues. The innovation and creativeness can be managed by the continuous improvement process. The company has a customized system that manages the ideas of employees. Different types of ideas can be registry on different areas: i) environment; ii) quality; iii) ergonomics; iv) safety; v) cost prevention and vi) reduction of cycle time. An implemented idea in an area can improve other areas. The employee`s ideas can be developed by a team with employees from different areas in order to develop the idea and put into practice the improvement. The top manager, area manager and controller follow the development. Before being approved the implementation, the idea must be financially validated. After approval of the idea`s implementation, the payment of the reward to employee is made. In 2011 the automaker predicts to reach in 4.1 million Euros in savings. The innovation and creativity is connected to the investment and their return.

5.2.2. Upstream SC

The automaker has about 671 suppliers distributed all over the world, which about 27 in just-in-time system. These 27 suppliers represent 50 percent of the car final value. They manufacture specific components for automaker in a single sourcing policy ensuring a just-in-sequence delivery. Only 10 percent of all suppliers` company (component part suppliers, raw material suppliers and primer service suppliers) are established in Portugal. Table 5.4 indicates the number of supplier by geographic distribution.

Table 5. 4 - Suppliers by geographical distribution
(Source: Automaker internet company site)

Region	Number of Suppliers
Portugal (Industrial Park)	12
Portugal (Elsewhere)	67
Rest of Europe	581
Rest of World	11

The first-tier suppliers must fulfill strictly the requirements imposed by the brand. The headquarters are the responsible to select the first-tier suppliers, the second-tier suppliers and some third-tier suppliers. The result is that the first-tier suppliers must buy specifically to second-tier suppliers imposed without possibility to have alternative suppliers. Normally the second-tier suppliers are from all over the Word.

Another imposition is the product design. Product design ensures that materials used in vehicle do not result in damage to the environment and takes into consideration the disassembly at the end of its life cycle. The product design is the responsibility of the automaker`s headquarters. Neither the automaker nor the first-tier suppliers have influence on the development and design of the vehicles. The purchasing guidelines and contract with suppliers are made with automaker` headquarters. The supplier`s commitment is to deliver on time without defects with advanced green materials.

Suppliers must meet all automaker requirements, satisfying all technique requirements to avoid product defects and negative environmental aspects. The automaker considers the activity of their first-tier supplier as an extension of its own activity and one of the results is that the

automaker develops a long-term relationship with suppliers. A cooperative culture is vital to this supply chain.

The suppliers are committed to deliver all requested material in the correct quantities and sequence, as the automaker must always respect the original production sequence which is at least 98% of the pre-established sequence for the day. To make this happen, the suppliers must communicate potential problems as soon as they are identified and they cooperate in their resolution, because, if the supply is compromised in order to stop the automaker´s production line, the supplier must have to pay a fine to the automaker. This fact affects the entire supply chain. To prevent these situations the automaker has a weekly meeting with all just-in-time suppliers, to report all potential problems detected; as single source suppliers, they must guarantee that the delivery of components will be well performed. Another meeting is conducted every day with the problematic suppliers pertaining to parts shipment. This is very important because: if one supplier does not deliver the material, all the supply chain will be affected. Therefore, the suppliers take a leadership role in communicating with the automaker. In addition, the automaker has logistics employees that are during the production time, in contact with suppliers. Even so, some problems can happen.

The industrial park (IP) is composed by 12 suppliers who provide material and components parts and LSPs that make the final procedure of distant suppliers, that is, dispatch the components or storage material from others suppliers. The core of these first-tier suppliers plant is to produce for the automaker. They focus entirely on the focal company. The selection for being a component supplier implies to be located in the IP. This supplier`s concentration, where the distance between suppliers and automaker is reduced will contribute to reduce the carbon dioxide emissions relative to the transport of components.

The automaker nominees one LSP to be responsible for the transport of components parts between suppliers and automaker. The LSP gets the component part in the supplier plant and delivers in automaker`s canopy/unloading trucks. The delivery of components parts directly to the point of use is delegated to another LSP which offers a synchronized delivery system. This will reduce the inventory in the plant. An example is the component part that can be delivery to automaker assembly line every two hours. Another specification is relative to the delivery of other raw materials that must respect pre-set delivery times to warehouse.

The industrial park land is rented by the automaker to suppliers and so they are responsible for any environment hazard that occurs (e.g. spills). The automaker imposes to suppliers located in the IP and others (by its relevance) to have a valid ISO 14001 or EMAS certification. This

applies not only to component part supplier but also service providers. Table 5.5 indicates the year of obtaining the environmental certification by each case company; it reveals that almost all the companies have the environmental certification for over a decade and that they would ensure environmental best practices.

Table 5. 5 - Environmental certification date

(Source: Automaker 2005 Environmental Report)

Companies	Year
Company 1	1998
Company 2	2001
Company 3	1999
Company 4	2000
Company 5	2004
Company 6	2003
Company 7	2002

Furthermore, they have a process to influence and monitoring the suppliers, which involves carrying out periodic visits resulting in an evaluation. This evaluation makes part of the supplier`s evaluation rating system which is a standard ISO 9001 document. This audit is conducted annually, but if the automaker considers the supplier environmentally correct, those suppliers are awarded without auditing in the following year. This work is developed in jointly by the automaker`s environmental control and logistics control, and a supplier representative. The IP suppliers can be seen as an environmental community since they share the same sewage treatment plant and the same pluvial wire. Thus, the concept of industrial ecology exists as a result of the geographic concentration with a short distance supply, more environmentally responsible and more attractive in terms of cost.

5.2.3. Downstream SC

Compliance with the customer expectations is very important to the automaker; surveys are developed to evaluate the products acceptance by the end customer, and; market research is carried out to know the customers` needs and the preferences relative to vehicles.

The automaker does not commercialize the vehicles. Dealers are dedicated to their trade and are the point of contact with final customers. The production planning for four weeks is made with the dealerships orders and some are based on forecast. The customers have different preferences and can choose the vehicle specification (e.g. color options, engine sizes, or seat types) in a total of eighty different combinations for the same model. The customer demanding is highly customized which results in a high demanding production. The automaker production plan is not uniform; it produces according to the needs of each model.

The year 2011 was a good year for sales and for to automaker production. However, due the present situation, that Europe can fall into recession, a reduction on sales is predictable and a reduction on production as well. This situation not only affects the automaker production but also the production of suppliers. The automaker tries to diversify markets to other regions as for China which is its second best customer, after Germany. Normally the manufactured vehicles went to the distribution centre located in Germany and hence for each country for dealership that will reach the end customer. However, to optimize the transport, nowadays ships are leaving directly from Portugal to China. This new kind of transport reduces from nine to five weeks the arrival time of vehicles to Chinese customers.

An objective of the automaker is the systematically adaptation of the processes to achieve top quality, environmental sustainability and, consequently customer satisfaction. An initiative that can influence the manufacture of the vehicle is customer country regulations. For example vehicle`s carbon dioxide emissions take into consideration the legal requirements of the country (e.g. for China is different from Europe) and over that, applying the requirement with less cost.

5.2.4. Reverse SC

Customers and manufacturers are aware of the problems derived from the end-of-life of the vehicles. Therefore, at the end of their service life, the vehicles go to dismantling companies that break up into their constituent components parts and materials. The brand is one of the 69 vehicle brand that is present on International Dismantling Information System (IDIS). Almost all the components, parts and materials have documentation for the dismantling, recovery and recycle of end-of-life vehicle. The vehicle reaches a 95% of recovery rate and with this avoids an irresponsible disposal.

5.3. Findings and Discussion

The purpose of this section is to explore the lean-green supply chain elements implementation. This study is designed to validate the conceptual framework in order to answer to the research question. A thematic qualitative analysis of the interviews and documents has been performed. The interview questions and the citations extracted from the transcribed interviews related to these themes, internal documents and information available on company sites have been reviewed. The individual criterions of the conceptual framework are applied to the subsequent case analysis to determine if they facilitate or inhibit the success of lean-green SC. In the case study, companies manage its operations according to a lean approach in a just-in-time system and apply the green approach to their activities to minimize the environmental impacts. The research findings of how the case study views and incorporates these criteria are discussed below.

5.3.1. Lean-Green General Overview

The level of integration of lean and green in different businesses are managed in a different manner. In the focal company the lean and green approaches were implemented at the same time, in the launching of the plant. This was derived from the fact that the plant was built to standards in advance of Portuguese legal requirements and it was considered a benchmarking plant to others of the group in terms of green environment. Usually the first-tier suppliers were implemented primary the lean system due the implementation of manufacturing and logistics processes; in a following phase they had to implement a green system. However, the opposite was also verified. The company starting to implement a green approach and then began to adjust the way of work with lean initiatives.

All the five companies have different strategies as regards to the deployment of lean and green elements in the different departments. However the lean-green initiatives are disseminated to all departments with necessary practices; the companies have taken an ongoing implementation. However, the deployment of green is not considered as important as lean.

Another finding is that in these kinds of companies, the lean environment represents how they really work, especially on the manufacturing and logistics departments; the green side is usually developed as specific improvements. All companies have a responsible manager or even a department specifically to manage the green issues. Companies have to address a number of environment legal regulations which requires specific support from responsible experts. In all

situations it could be verified that green issues are not a responsibility of an outsider specialist; but is a responsibility inside the company so that the know-how remains in company.

This is very important for the development of both approaches and their integration; if the knowledge of both approaches keep up on company, it represents that the company can be autonomous in terms of lean-green implementation. Normally, they only need external consulting due to the legal requirements.

The automaker, as a large company, has a lean department and a green department with different managers. However, there is evidence, in a supplier, of the opposite where the responsibility of the implementation of both approaches falls on the same person existing only one department for their management. This is an important fact because it reveals that it is possible to work both ways. With the same manager for both approaches it would be possible that the dissemination it could use the same terms and glossary and the understanding by all the people could be more easy and quick. The automaker does not have a single department managing both approaches which may be due to its size (i.e. number of employees); by having different managers, the information of each approach arrives at different times to each employee allowing that employee to understand better each approach and what it may represent for his workplace. Another possibility is to have different departments: it can help the communication process with the other companies of the group which should have a similar company structure. So, a number of factors may influence the decision to have different departments, and this must be taken into consideration.

Other evidence encountered is that all the companies meet the quality standards requirements ISO 9001 certified. The manufacturing companies are, additionally, in compliance with the automotive standard certification ISO/TS 16949. In addition, the German quality standard VDA 6.3 is implemented in two of these companies. The companies, in this case study, have implemented environmental standard requirements and are ISO 14001 certified; they have implemented practices to improve environmental performance and promote environmental practices related to pollution prevention and control. The focal company has the ISO 14001 partially integrated with ISO 9001 and have implemented the OHSAS 18001 standard management. It is possible to conclude that all companies have a management system to help to control their supply chain activities in respect to quality and environmental processes.

All the manufacturing companies belong to multinational corporations which are aware of their social responsibility tracing the responsibilities for the company. Another issue is the legislation that all companies must ensure compliance with the legal requirements of their

activity and others subscribed by the company.

The study reveals that companies are prepared to react to emergency situations that may cause negative environment impacts. An example of this is the focal company that has a private fire brigade that treats fire fighting and similar situations. Another example is in the pluvial wire with eventual entrance of hazardous substances; as an example in the case of extreme pluvial wire, a shut off value allows retention of any hazardous substances and contaminated water.

From a general point of view, the companies believe that green inhibits the lean activities more at operational level due the legal requirements but after the implementation of those requirements lean overlaps the green in all situations. An example given by the automaker is the packaging of airbags that have specific conditions of storage but having this in accordance to requirements, lean approach can be applied. There was only a specific point of view that considered the lean approach is good for the development of green approach and vice versa.

5.3.2. Lean-Green Leadership

It is evident that top management has the most important role for companies to act accordingly a lean approach and a green approach. Top management must stay aligned with those approaches and their way of working. The manufacturing companies have a strong top-down leadership endorsement. Although the manufacturing companies work in a lean environment, the elements have been implemented by phases; the same happened for green approach. The power of that endorsement has been sustained and has grown since its initial implementation.

A case study finding is that all management communicates their intentions. Different ways to transmit their intention are used, through meetings, workshops, company`s newspaper or flyers. It was possible to observe that two case companies have an informative monthly newspaper available for all employees; other mentioned to have information sessions for all employees with management.

This is a good way to disseminate the companies` information: the objectives (the small-, medium- and even long-term objectives), information regarding the company productivity and efficacy, or information relative to lean and green improvement and simplification (otherwise, employees would not know important occurrences, as they normally only know information about their department).

One case company commented that SC manager has every day a department meeting with their employees in the beginning of the shift and another once a week; a monthly meeting to define operational strategies is carried out, as well. Connected to this observation is that generally the companies have a structure with few levels having a horizontal hierarchy which allows helping in problem solving.

Another finding is that innovation is linked to investment and its return. Companies considered investment to improve lean and green practices. Three companies mentioned that the investment must have a return in 1 year. However, the respondents mentioned that there are some changes in the plant that are long-term returns and others are not accounted for your return. Everything has to do with strategy: an example, given by manufacturing companies, was the painting process improvements to reduce emissions and reduce hazardous materials. Another example given by the supplier, mentioned a change made in the roof of the plant to provide better daylight. With this investment, a long-term savings is expected by decreasing artificial light. Indirectly, this could influence the work environment in the plant and consequently improve the SC activities.

These ideas were a result of increased leadership capability allowing an increased organizational responsiveness and improvement through lean and green approaches. It is believed that leadership is a strong factor for the development of the lean and green approach.

5.3.3. Lean-Green People

The people are the key piece in the lean and green supply chain. The automaker tries to preserve their good employees. Therefore, the company is committed to its employees investing in continuous improvement of the conditions of employment, evaluation processes and recognition of employee performance.

A finding is that the employees participate in the education and training programs. All employees have access to lean and green approaches through program learning, brochures, specific meetings or awareness sessions. Necessary competences are determined for each role; however, not all of them have specifically lean and green responsibilities defined by role.

It should be set which responsibilities each employee must have toward a lean-green approach. If employees know what their lean and green responsibilities are and the means to achieve them, it is presumed that they will know how to proceed in all predictable situations.

This should assist to have a department or workplace well organized in terms of a lean-green implementation.

The register of the ideas and suggestions by employees differ from company to company. Three companies have a software to register the employees lean and green ideas and for all areas of supply chain, referring to either a single stage or multiple SC stages. Another company has a manual register and another one do not register ideas or suggestions. The companies promote the employee involvement by celebrating and rewarding the success. It was found in one case, that the register of the ideas makes part of the employee`s objectives.

People are engaged to eliminate problems and wastes, normally associated with their workplace, but it can consider all types of improvement. An example of an automaker employee that works in production line gives the suggestion concerning to the road without lighting between the Plant and Industrial Park. The idea was to design a lighting project with photovoltaic panels and luminaries with LED technology on the pillar. This idea, not only improved the safety of persons and vehicles in the just-in-time lane, but will also avoid consumption about 1 MWh/year and carbon dioxide emissions equivalent of 259 kg/year; recognition was given to this employee with a monetary prize, an award and the recognition registered in the company newspaper.

In this element different situations with regard to the registration of ideas and suggestions made by employees were observed. It is believed that the best option is to record the ideas; all employees should be enabled to record a lean-green idea. This stimulates the creativity of each employee and if the idea is implemented, the employee should feel more confidence and satisfaction; associated with the implementation of the idea should be the recognition by the company. The lean-green ideas will lead to improvements and to simplification of activities in SC processes.

Connected to employee`s ideas are the cross-functional teams that are used by all manufacturing companies to implement a suggestion. According to the automaker the company`s objectives can be achieved by team work and continuous education and training.

It is worth mentioning that companies stress out the education and training and the employee innovative ideas and suggestion schemes in a lean-green environment.

5.3.4. Lean-Green Strategic Planning

All companies have defined their strategy, plans and budgets. All of them have defined their visions and missions and try to respond to customer needs. The companies have established their objectives and converted them in performance measures. The company`s strategies are aligned with their corporate strategies. In a general view of the case study, it was observed that lean and green approaches are considered important to business to achieve customer requirements. All the companies are aware of the lean and green initiatives to improve the SC processes.

In this supply chain the operational strategy of the first-tier suppliers is based on a six month forecast sending by the automaker. Having receiving this forecast they can plan the production and allocate time to buying materials and components to their suppliers (second-tier supplier). The lean-green strategy is normally applicable as an operational plan. Usually the automaker strategy will end up to influence the way of working of the first-tier suppliers.

The automaker considered the processes of their first-tier suppliers as an extension of their processes especially of the manufacturing stream. As an example, suppliers adjust their processes to the automaker processes; it was verified that the automaker has only one production line with capacity to produce mixed vehicles models (in this case four different models); one supplier has designed and changed its production line to have a mixed production line, producing different components models for specific automaker vehicles.

Adjusting the way people/company work, based on its principal customer, will help to reduce waste, time and costs (*i.e.* storage components, transport or energy). It is important that suppliers understand the customer` s strategy and be able to respond to customer requests even if their initial strategy had to be changed.

Strategic Planning criterion is important for organizations and for their supply chains. A lean-green approach must have a strategy well developed and disseminated to align value with all the stakeholders.

5.3.5. Lean-Green Stakeholders

In this supply chain there is a strong partnership between the automaker and the first-tier-suppliers, especially the just-in-time suppliers and those who are geographically closer. In

addition, the time duration to produce the same model can cover a period of 10 years, which may assure conditions for the creation of a long-term relationship with suppliers.

One of the supplier`s selection criteria are is based on the lowest price. The green criterion could be applied in case of tiebreak. The suppliers` selection for a new vehicle can be a vital decision for the suppliers to make decisions regarding the continued investment in their company. In this supply chain the first-tier suppliers cannot select their own suppliers. However, it was observed that for other supply chains with other products, the companies can choose their own suppliers. This selection is also based on lower cost and quality standards.

Another associated finding was the suppliers of this case study, are almost all multinational companies which help to easily answer to all premises intended by the automaker. A rule established to the first-tier suppliers is to fulfill with quality and environmental systems, namely ISO 9001 and ISO 14001 or EMAS. For the second tier-suppliers the automaker only advises but the pressure imposed to first-tier suppliers entails for a follow up action to influence their suppliers not certified in order to obtain quality and environmental certification. However, a finding is that case companies have the awareness to select suppliers with certification on ISO 9001 and ISO 14001.

This supports the implementation of the best practices, either in terms of quality or environment; all operate in a similar manner based on the same requisites, which may allow better flows of materials and information.

Another issue is the supplier`s evaluation. Manufacturing companies evaluate their suppliers. The automaker considers very important the on time delivery of materials, having designed their own supplier evaluation rating system. There are different criteria depending of the type of supplier. For geographically closer suppliers within 50 kilometers radius, they must fulfill the requirements consisting of six delivery criteria relative to supply chain performance including environmental performance. The criteria are:

- utilization of supplier communication system;
- up-to-schedule shipping performance;
- reaction to problems;
- overshipment;
- record maintenance; and
- environment management system.

The purpose is to rate suppliers on their delivery performance with greater visibility and give base for future decisions. This research shows that the supplier`s monitoring helps to improve their processes in terms of lean and green which in turn helps to create efficiencies and to control better lean and green wastes connected to the supply chain.

Another important issue in stakeholders category is information sharing. The information flow is supported by ERP (enterprise resource planning) technology to manage the internal processes. Other technology used by all first-tier suppliers is EDI (electronic data interchange) to share business data between the automaker and supplier. The first-tier suppliers know exactly what they need to produce the exact quantities and the exact time, avoiding data errors as missed deliveries or wrong components, as well as reduce consuming of natural resources, by optimizing the delivery. Different messages are sent by the automaker to suppliers at different times. For example, all first-tier suppliers receive a six month forecast, so they can prepare their own production and sourcing plans. For the just-in-time suppliers they receive at different times, different EDI messages. The first is a fifteen days forecast that serves to plan the production; at this time the sequence of production line can be changed. The other message is sent six days in advance, giving information about the part number and the car number. Afterwards, the suppliers receive a message pointing out that the vehicle body is starting in production line and the daily message specify with the sequence of the vehicle in the assembly line. From the receipt of the message at the supplier, until the component has being launched in the automaker assembly line, may take less than 12 hours. The information between first-tier suppliers and second-tier supplier can be made by EDI or only by e-mail. According to case companies this practice helps the flow of information, align the process and can reduce processing time (as well as paper and toner).

The Stakeholders criterion is vital in a lean-green supply chain; strong alliances and partnerships allow better material and information flows which lead to better lean and green processes. Some initiatives could be improved, namely, the automaker could have a supplier` representative on plant; currently only company 7 has a representative because of the specificity of the materials. The suppliers would be more aware of what the automaker` s problems are and what they should involve. This kind of organization would allow to simplify and to improve control of a number of SC activities.

5.3.6. Lean-Green Operations

All suppliers in the IP have a politics of continuous improvement in their processes. All the case companies are focused on reducing costs and therefore try to improve supply chain processes. One of the enhancements will be in delivery of materials, because it can result in a tradeoff situation.

All companies interviewed have a clear view towards to transport modes and transport routes; they try to reduce costs, and even by being an indirect source of pollution (carbon dioxide emissions) they try to reduce resources (energy consumption). In IP, the transport of components, parts and materials are made by truck. This transportation is in charge of a LSP contracted by the automaker. The truck must carry full capacity and takes the components from only one supplier. However, it is possible that the truck can carry material from two different suppliers (no more than two, because of the transport time of charge and discharge). Even so, the replenishment frequency is very high where the components parts have an average delivery of two hours. The Company 5 is the only that made its own delivery of steel coils due the need of special vehicles.

Outside of the IP may be used other transportation modes. The automaker is developing studies relative to different transport modes. One of the studies is directed to find new opportunities to perform more multimodal transportation because the cost by road is going to increase over the rail (where the price of fuel, the level of air emissions and energy consumption are lower). The automaker uses, once a week, the train as a transportation mode to receive material from their headquarters` reconciliation center. Moreover, uses the ship to send vehicles to China. Another example is given by Company 3 which receives by ship, raw materials that come from China.

Awareness from other company is that, for long distances, is better to have recent trucks since they are cleaner and consume less fuel. All companies mentioned that trucks must have a full load. In addition to this subject, the optimization of the transport routes is a concern to reduce costs. Company 3 mentioned that, being part of Multinational Corporation, it is possible that the truck make a specific route delivering parts and materials for several factories of the group.

Additionally, a finding is that companies are aware of the procedures that must be followed to be more lean and green. One company mentioned that a requisite for the selection of a supplier, (responsible for the transport) is to be ISO 14001 certified, because the company itself already has an environmental concern.

All companies are trying to optimize the transport mode and the transport routes through a minor cost. This is not surprising since this subject is much referred to by companies and even by academics; it is believed that this subject can be considered one of the first issues to be regarded by companies in order their supply chain become leaner and greener.

Other point connected to this is the re-utilization of packages to deliver materials. All companies adopted re-used standard packaging and containers. The Companies 1 and 3 mentioned that it is a high investment to purchase the packaging but it is a good return of investment in the long-term contributing to cost reduction. However, for distant suppliers, all companies have similar strategies: in Europe they apply re-used packaging but for the rest of the word they utilize cardboard packaging.

In the IP the deliveries to the automaker are made using re-usable packaging. These are returned to the suppliers or LSPs closing the loop with reverse logistics. The re-usable packages are specific racks and fixtures that transport the components from first-tier supplier to the automaker`s production line; the return from automaker to first-tier supplier may go empty or bring damaged components in order to be re-used or be reworked. The packaging is designed to minimize damage to components during the transportation, reducing the amount of scrap. In addition, the available packages in the IP are limited by the automaker to avoid stock on hold, improving the internal supply chain process through a reduction of inventory levels and reduce solid waste since it reduces the disposal of packaging.

The rework or remanufacture is a responsibility of the first-tier supplier. The suppliers are responsible for rework of their components parts. All manufacturing suppliers try to have "zero defects" in way to not increase the costs and not increase natural resources. The "Six Sigma" is being used, as a tool to help to reduce defects. Company 2 was the only one that indicated how they work with "Six Sigma" but they don`t establish any relationship with green. Company 3 mentioned that it a priority improves the process in way to have "zero defects". The research shows that the goal of having "zero defects" is a lean and green goal due reduces activities as rework, recycle or reuse.

The resource optimization is also a very important issue for the companies. Companies develop small project in way to improve the plant. Two companies mentioned the optimization of light in the plant by changing the layout of the plant to use natural light. It is possible to conclude that companies investigate ways to reduce cost improving the plant layout.

Another evidence is that all manufacturing companies have a concern with stock levels, as they represent costs in terms of material, warehouse and energy consumption. Strategies are

adapted to try to reduce inventory. A finding is that companies try to reduce as much as possible the size of the material batches coming from their suppliers. The second-tier suppliers are selected by the automaker`s headquarter and typically make deliveries of large batches. One example given by one manufacturing company revealed that, although they only need 280 pieces, their supplier delivery only in batches of 1000. To address this problem the supplier has a LSP also hosted in IP which stores their material. Company 3 mentioned that in some cases it is not possible to reduce stock because the materials come from China. Company 4 mentioned that they could reduce the suppliers` batch sizes. The case study revealed that suppliers use to have an average of 3 days stocks.

One discovery from case studies was related to the product design. The suppliers or even the automaker have no responsibility or collaboration in its conception. The automaker`s headquarters is the responsible for the product development.

A finding resulted from the SC processes analysis, where it was verified that the continuous improvement is promoted between automaker and organizations hosted on IP. This is a crucial point for the implementation of a lean-green supply chain. Strong evidences are in the implementation of the lean-green SC processes; the Processes criterion has an important role in the value creation.

5.3.7. Lean-Green Tools

The case study gives evidences of the use a number of tools to help in the daily work. Having that in mind, the research intends to determine which tools are used by companies to assist a lean-green supply chain implementation.

Several tools, namely value stream mapping, kaizen event, A3 report, 5/6S methodology and standardization, are used by the organizations. It is possible to conclude that there is an implementation pattern for the tools under study. The application of different tools, to help in the activities, is visible in the different companies.

Value stream mapping is used by three case companies but only as a lean tool for the analysis of the most important products of the production. One of the organizations, have implemented it only in two product references which represent about 40% of production. No one used in the green aspects or in the integration of both.

It is believed that companies can still streamline the value and, using the VSM, as a tool, is

a good solution. The evaluation of measures as energy or hazardous materials or carbon dioxide emissions linked to time or cost and connected to material flows, is important; new wastes can be discovered. Companies using the GVSM can improve several aspects that may still being ignored. It would be important to offer to these companies a more strategic use of this tool.

From the interviews it was noticed that continuous improvement, namely, Kaizen event is applied by all organizations to lean issues. Only two companies used it also to improve green issues or both at the same time. One of them stressed the idea that to make an improvement in lean also try to improve the green part; however, it was registered that one company considered that it is not always possible to make continuous improvement events; they justified it with the kind of organizational structure and time consumed. The organizational structure of this company is reduced which results to be difficult to allocate people to these events. However, these events result in an improvement which normally represents earnings to company. Therefore, the time consumed is justified by these earnings not only in operational terms but financial, as well. To allocate different people, with different skills, is important for these events to become successful; these should be made in a routine and scheduled basis. The lean-green approach can be better implemented and improved using this element.

Standardization is commonly in all case companies. For the LSP, is very important to standardize processes and their record, because of their fluent employee turnover (*i.e.* in leaving the company). With the high turnover of employees, if the activity is registered with their specifications and instructions, all employees that came to work in that activity can execute in the same manner; this may reduce the variation from differences in work methods and helps new employees to have a faster learning process on how to perform their work. Standardization is a convenient element to register the lean and green issues which help the employee to execute its work. Another idea connected to this was given by the automaker: they are trying to integrate those documents (official documents) with the documents resulting from ISO 9001 and ISO 14001.

The manufacturing companies have implemented 5S in almost all departments, although some of them are still in development. Generally, the 5S methodology is considered quite relevant. Safety is a core issue for all the companies, but the sixth S is not evaluated at the same time. When automaker makes 5S audit do not considers at the same time the sixth S (safety). This methodology is applied as a lean tool and not as a lean-green tool, even though the 5S help to improve green issues.

The A3 report is used to evaluate lean and green issues, but only three companies used the

A3 report for lean issues; two of them used to contemplate the lean and green initiatives. It is important to mention that this tool will help to visualize how to improve an activity or a process based on lean-green approach. It is important that companies use this tool for the process improvement, and easy development; all employees should have access and training in this report.

Another aspect that was found relevant with this case study in a lean-green transformation is the Total Productive Maintenance (TPM). This initiative consists in a maintenance program that combines predictive and preventive maintenance, the improvement of the equipment and the manufactured products. The purpose is to have "zero wastes" in equipment availability. All manufacturing companies applied TPM initiatives. For the automaker, TPM is a foundation for the lean system and it is connected to the green issues; indirectly it helps to raise the levels of environmental awareness in the workstation.

Not all the tools considered as the most important to assist a lean and green supply chain implementation by academics, are used in the case study companies. The application of these tools is not vital to achieve a lean-green implementation. However, they assist in the improvement of the SC processes; it is important to register that it is possible to apply these tools as lean-green implementation tools. Companies should be aware that the lean-green toolkit can facilitate the achievement of an efficient SC.

5.3.8. Lean-Green Monitoring

Monitoring the evolution of the lean-green transformation is vital to understand the impact of the counter measures adopted. All companies have performance measurement systems and assess the performance through key performance indicators all over the company. However, no one use a Balanced Scorecard approach for the evaluation of lean and green supply chain. The Balanced Scorecard is considered a tool for the evaluation of all aspects of supply chain business performance. If the companies of this case study do not use this tool maybe it is because: the BSC is quite difficult to develop, or; the people with the responsibility to select the performance measurement system don`t know the BSC potentials, or; they use, as a corporative company, the same performance measure system as the other companies in the group. Even so, it is the tool that a number of worldwide recognized awards (SP, MBNQA and EFQM) mentioned to evaluate and monitor the performance. This tool allows to make a cause-and-effect relationship evaluation which let the companies to understand better their supply chain performance and allows to understand their strengths and weakness. It is a strong conviction

that the BSC is a good, if not the best tool, which companies, in the case study should implement. This research purposes to companies the use of this tool.

Company 1 created its own performance measurement system in order to monitor performance indicators that consider important to achieve the strategic objectives for 2018. Based on it, a diagram was created to define the "Key performance indicators tree"; they considered it as a tree consisting in four different dimensions: profit, customer, people and growth. Fourteen trees were designed (one for each department and another one for the entire organization). There is a daily meeting to analyze the performance measures since each have their objective. If the value is not within the parameters considered to be acceptable for the objective, it is mandatory to analyze the problem, and try to amend. Every month they have a meeting to analyze the entire tree. The objective is to reduce cost and to get a high continuous improvement process with no failures. A plant award was implemented; the performance measures for the plant award were defined as production time by vehicle and vehicles by employee. For supply chain department the most important measures are the number of missing parts in the vehicle and the inventory level.

The green performance is not important for the principal diagram, since it is well controlled by the environmental department. The only environment performance measures integrated in the principal diagram is the "resource consumption" representing the indicators "water", "energy" and "gas" consumption. The diagram have other indicators that will have effect on environment, namely, "scrap level", "make right at first time" and "without failure". The company developed reports, available to all stakeholders that register the consumption of water and energy, air emissions and scrap, all by company. The research shows that the carbon dioxide emissions from the transport activity are not registered (only the transport cost). Accounting the carbon dioxide emissions will be important for future analysis as the company run their supply chains. This may be defined as a criterion on the selection of new routing, new truck or even a new supplier. In addition, it is predictable that, at the medium-term, companies will be charged by their supply chain`s carbon dioxide emissions, as it already happens with the volatile organic compounds emissions considered to the plant emissions where the legal limit is 60 g/m^2.

In all case companies, the manager of each department is the responsible for its objectives and key performance indicators. The evaluation is made by business areas. All of them mentioned that performance measures may help to see the evolution of the business performance and the need for eventual action. That is, to obtain feedback for improvement. In all the cases, "cost" is the most important performance measure.

Another finding is that one company case study accounts the lean-green as a hybrid approach; for them the "cost savings" performance measure is relative to savings of lean and green activities. This is an evidence that it is possible to consider and develop lean-green measures in a hybrid approach.

5.4. Lean-Green Assessment and Scoring

For the implementation of a lean-green supply chain management framework, a scoring and assessment method was developed and tested with the case companies. The assessment was based on case study results under a data triangulation derived from observations, interviews, and internal documents, information collected on national newspapers and internet. The assessment was based on the conceptual framework proposed in Chapter 4. The model has a total scoring based on 1000 points. The assessments were made at five companies that integrated the case study where a deepener study was carried out. Table 5.6 indicates the total score obtained by each company. For the model proposed, criterion score was based on lean-green elements and lean-green guidelines. These totals derived from the evaluation carried out in company under the researcher supervision.

Table 5. 6 - Assessment method applied to companies

Case study / Criteria Score	Company 1	Company 2	Company 3	Company 4	Company 5
Leadership	103	101	97	91	88
People	101	69	97	94	63
Strategic Planning	109	118	105	103	107
Stakeholders	101	96	91	88	86
Processes	234	228	199	208	175
Results	210	233	182	183	187
Total	858	846	771	765	704

All companies obtained quite high scores. The multinational character of these companies has to respond to high standards set by their headquarters, should be considered for this success. In addition, a number of experts (AME, 2008; Corbett and Klassen, 2006; Carvalho *et al.*, 2011a; Dües *et al.*, 2013) claim that lean and green are synergetic approaches (for instance Dües

et al. (2013) argue that "a synergy is often described with the equation 1 + 1 = 3 meaning that combined elements have greater results than the sum of the separate performances"). There is a strong conviction that these high scores are derived from a good interaction between lean and green implementation in these companies. This exercise proved that, as a general overview, they are heavily armed with actions of a lean approach and a green approach. Company 2 is more capable to obtain lean-green results than the other companies. Company 5 is less developed in comparison with other companies. The conceptual framework draws a supply chain that focuses on adopting the best of both environments. It is possible to say that these companies, through this management framework, need to drive more continuous improvements to achieve the "best-in-class" status. This assessment confirms that the companies in the automotive industry have high levels of lean and green implementation; an additional confirmation is that the elements considered in the conceptual framework were well selected to represent the lean-green supply chain management framework.

5.5. Chapter Overview

All the companies in this study demonstrated to have implemented a policy of continuous improvement in their processes, being focused on reducing costs and therefore trying to improve SC processes. Consistent with the research questions and the conceptual framework, specific subjects were asked concerning to each criterion. The case study was used as illustrations that come to confirm and support the conceptual framework. Although not all lean-green elements are implemented, there are evidences that the six key criteria are important for a lean-green supply chain transformation. All criteria were considered vital to improve SC performance. In addition, multinational companies are receptive and prepared to implement lean-green elements due the internal requirements of their headquarters.

All companies have not yet reached the "ideal state" of a lean-green approach. As expected the automaker influence the suppliers with their SC activities. It was realized that the automaker brings the lean-green issues into the SC: with the close relationship and partnership with their suppliers, the on-going continuous improvement processes, the takt time definition, people empowerment and cost reduction. Consequently, all the SC entities want to minimize waste in all areas of the SC.

The lean strategy and the green strategy were defined as a corporate strategy and a supply chain strategy. Supply chain manager are often mainly focused on measures that appear to lie within their natural scope of responsibility. The lean and green paradigms are already something

that is routinely done. Nowadays the lean and green are implemented as improvements for supply chain, in general representing cost savings.

It is possible to conclude that lean and green can be integrated and the organizations will have to work to adjust their processes. If the leader partner in the supply chain (the automaker), has a strong lean and green culture this will be transferred across the supply chain, especially to their first-tier suppliers. The case study revealed that it is possible to make a synchronized lean-green implementation to achieve a hybrid supply chain.

6. Lean-Green Supply Chain Roadmap

A roadmap is a guide that indicates where we are and where we should be. This roadmap intends to be an oriented-tool for the deployment of lean-green approach. Kotnour (2011) state that "during a transformation, the organization determines what is the right work completed the right way with the right capabilities (e.g., people, processes, and tools) in order for the organization to bring value to its customers". In this chapter, the lean-green SC transformation will be defined in the shape of a roadmap. Based on what was retained from the case study, presented in the previous chapter, it intends to consider this roadmap as a proposal for lean-green integrated implementation.

6.1. Lean-Green Roadmap Elements

The case study provides important lessons and insights that contribute to design a roadmap for other companies planning to implement a lean-green approach. It is designed as a proposal, based on the automotive sector, giving the views of what can be done in other industry sectors. It pretends to define the roadmap to follow if a company wants to achieve "best-in-class" lean-green requirements. According to Kotnour (2011), a transformation is an intentional change of a company business over time. This roadmap is a tool that provides how to guidance the business and supply chain activities taking into account the improvement of their performance. With this research it is possible to state that modelling lean-green is not a destination but a journey over long-term. Modelling lean-green must be built around values that help to achieve the "ideal state".

Some research has been conducted in this area. Rouse (2011) indicate ten steps to transforming a company. For a lean approach, LAI@MIT (2005) developed a company transition to a lean roadmap. Leanhouse (2012) shows a lean roadmap with a general lean transformation. For a green approach, Strandberg (2009) shows a roadmap consisting of ten different sections and identifying the benefits of each. The information provided by these authors helped to understand how to define a roadmap.

This roadmap considers eight stages; it starts with the "current state" where the company is and ends with the "future state" where the company should be after the transformation. This roadmap pretends to answer to the research question; it gives the sequence of implementation of a number of lean-green elements. The lean-green SC roadmap is presented in Figure 6.1.

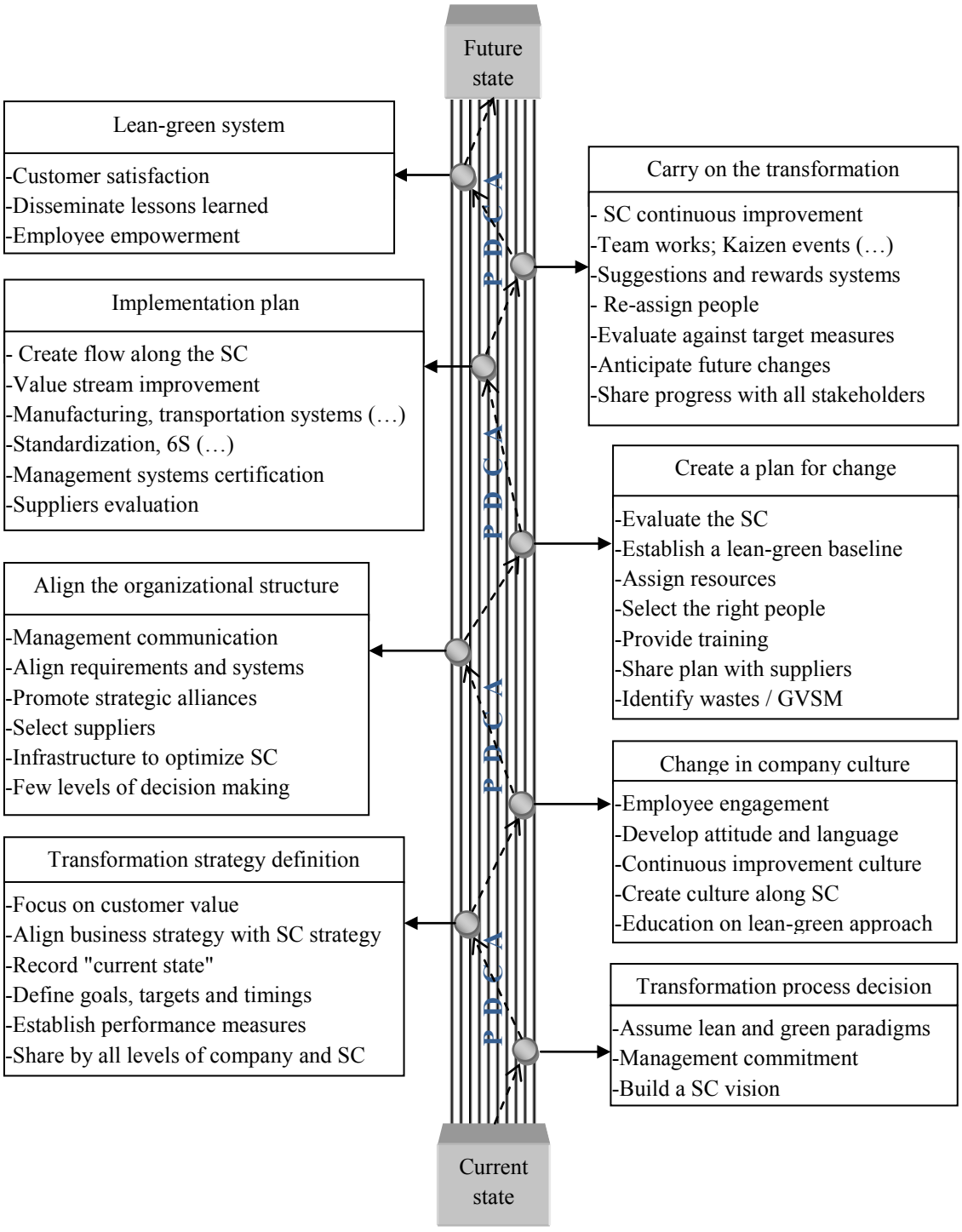

Figure 6. 1 - The roadmap for lean-green supply chain

This roadmap imbeds the PDCA spirit, as the "future state" will be in some time the "current state" and the SC should continue to improve its performance looking for a new "future state". It can be considered as "cycles of transformation" (definition based on the award Shingo Prize (SP, 2010)) to achieve a "best-in-class" lean-green organization`s supply chain.

6.1.1. The Transformation Process Decision

The transformation process typically begins when top management takes the decision to assume the lean and green paradigms. The management needs to understand the scope of the lean and green paradigm. Learning the initiatives is fundamental to be 100% involved and to act as the driving force, as lean and green will be established as the way the company conducts its business. Top management commitment is central for the entire company to realize that this transformation is important. Without their commitment it is not possible to carry out a lean-green transformation. Management is responsible for lean and green being integrated in the company strategy and in the supply chain strategy in the form of a "vision".

They must indicate what is motivating the change and the benefits for the business. They must understand the current value and be aware that their business, when embarking in lean-green transformation, should be driven by value. This value is represented by the customers` needs. Understand how the implementation of lean-green can change processes and how that influence the changes in the products according to the expectations set by customers. This represents transformation on every area of business especially in SC processes. Knowing how both approaches complement each other to have a faster implementation is a crucial factor. In sum:

- Top management must understand what represent lean and green approaches and recognize that lean-green implementation is the priority for the supply chain.
- Top management must be the first to shows involvement in the implementation of these approaches; define what lean-green means for your business and the benefits for the supply chain.
- Top management must define a clear lean and green company vision and mission of the future business.

In this stage of the roadmap the criterion leadership of the lean-green transformation framework has a significant weight, because it is the leadership that takes the decision of the lean-green transformation.

6.1.2. The Transformation Strategy Definition

The definition of a transformation strategy for a lean-green environment requires to understand the current value streams to realize where the organization`s supply chain should change. The analysis and evaluation of the "current state" will provide the inspiration for the processes that must be changed or improved. To outline goals, a first important requirement is to identify and collect the lean-green elements already applied. The lean and green priorities and goals must be incorporated into the business decisions. The lean-green approach must be integrated in business planning and budgeting and in the SC strategy.

The objectives should be incorporated in small, medium and long-term strategies. The transformation strategy must take into considerations non-financial and financial objectives, since some lean-green initiatives require upfront investments. Therefore, it is important to establish which investments should be applied to improve the supply chain business performance.

The target objectives must be established considering performance measures with the purpose of measure that "matters" (simple, meaningful, clear). Lean and green measures are important to evaluate the progress. These measures must reflect the beliefs and values of the business. Company strategy must take into consideration the SC strategy and must be shared by all levels of the company and by stakeholders. In this stage is important to:

- Define the transformation strategy with focus on customer value and needs.
- Record the current state. Apply the green value stream mapping to understand the value flows and where they can be improved, eliminating wastes. Consider time reduction, cost savings and carbon dioxide emissions, water or energy reduction.
- Incorporate lean-green goals into the business strategy and in the SC strategy. The lean and the green cannot be considered as side projects.
- Align business strategy with SC strategy.
- Top management must align their ideas and strategy with mid and lower management.
- Establish target objectives. Targets objectives can be defined as long-term (set a target with more than 3 years), medium-term (for 1 to 3 years) and small-term (one year). In this stage, define the long-term and medium-term targets.

- The long-term targets can undergo to be more competitive and create a brand image. Competitiveness can be attained by providing customers with green environment friendly product, in the time requested, with the quality required and at the same time improve supply chain activities.

- A mid-term targets may include investments in technology, changes to different materials on product or reduces natural resources, reduce wastes and improve processes.

- The baseline target is the elimination of wastes. This can achieve time reduction, cost savings, resource optimization, capacity optimization, productivity, product quality, reduction of air emissions and other natural resources. A leverage goal is to have zero waste.

- Define the performance measures, namely measures to evaluate a department, a company, to benchmark with other companies at the same industrial sector or brand, or to be presented to stakeholders; these measures should be align with the supply chain performance. These measures should consider (direct or indirectly) cost savings.

In this stage of roadmap elements from leadership, strategic planning, processes and results criteria are considered in way to develop the lean-green transformation.

6.1.3. The Change in Company Culture

The company`s culture is how the company acts in a given situation. Culture reveals the values and beliefs of the business. In a strong company culture, the values should be identified. The company culture must match with dynamic changes inherent to a lean-green transformation. The culture of the organization`s supply chain should engage managers, employees and other stakeholders, because the transformation requires changes in behavior and in mindsets of all the people.

The employees must be engaged with the transformation and must respond quickly to change; they must make good work putting the business` values into action. To achieve these requirements they must understand the lean-green approach. Therefore, education is necessary to obtained know-how relative to the transformation. In addition, the culture is based in motivate the employee to be creative and innovative, allowing them to share their ideas for improvement relative to lean-green issues, understanding the improvement made on SC

activities. The attitude and the language adopted by all the people are very important in a lean-green transformation.

The partnership culture with suppliers and customers is needed in all the SC. A continuous improvement culture must be developed along the SC processes with all partners, as it is always possible to eliminate more waste. In addition, a culture that expects and anticipates changes help the business to be better positioned in the market. In a culture of change, all supply chain partners must interact all together and assume that must improve the SC processes. In this regard, the procedures to carrying out are:

- Set the same terms, language and glossary for all people, for describing their work. This will eliminate possible barriers in a lean-green transformation.

- Engage people; only the employees who adopt the values of the company remain in the company helping in a lean-green implementation and transfer those values along the SC. These employees will give small contributions for improvements and have the responsibility for passing values to new employees. Employees who don`t follow those values usually turn out to leave. Therefore, engaging the employees in the change will improve the morale which results on improvement in productivity. Employees which are proud of the business they work for, normally are more talented and creative giving ideas of improvement.

- Develop an education program in order to assure that all people understand how to do the work and how it fit with whole structure of the supply chain; it is considered as learning at the company level. The literacy in this stage is very important to help to raise awareness, knowledge and responsibility to each employee; this is the starting point to understand how to develop a lean-green supply chain.

- Create an appropriate culture along the supply chain. If the leader partner in the supply chain has a strong lean and green culture, it will influence the other partners.

- Connected to company culture are the ethical and legal requirements that encourage the spirit of change and commitment to do better.

The leadership, people and stakeholders criteria are considered in this stage of the roadmap for a lean-green transformation.

6.1.4. Align the Organizational Structure

The company must have an adequate structure to the practice of lean-green. An important factor is to have a plant well organized where the processes and activities can be well performed. This will help to increase productivity on internal processes that will promote additional improvement in the external processes.

It must develop a structure where the SC act together and move in the same direction. The SC partners must be involved, where they can also have the commitment for a lean-green implementation; to build a partnership with suppliers is vital, as it improves interrelated activities, unified operations and common business purposes. The strategic alliances must privilege suppliers with specific knowledge of the product and work in harmony with operations. Working with nearby suppliers is important to reduce waste and a more effective continuous improvement can be developed. The suppliers must be committed and the company can negotiate policies with suppliers which may result in better alignment of supply chain operations. Suppliers committed to lean and green, try to deliver a good product without defects and so no need of rework or repair; a product using materials more durable are more robust, do not need maintenance and in the end-of-life can be reused, recycled or disposed. In addition suppliers assume to deliver the requested product, at the requested time, in the requested local, at the requested cost.

In this point, it is important that management enlighten customers, of what they can earn from it, what changes can privilege the product. The company should indicate their intentions towards the environment and the local community. The company structure must consider the scope of responsibilities, delegate or share responsibility for decisions throughout the supply chain. A company structure with few levels of decision making will develop better decisions and reduce decision time. The SC decision-makers must be selected and accordingly with the transformation.

The following activities in sequence shall be developed:

- Select employees that are motivated and are committed with the transformation process. Better productivity and costs reduction of turnover will be expected.

- Top management must communicate their intentions as internal and external communication. Internal communication is made to employees and external communication to other stakeholders. Communication is an important factor to disseminate the intentions on the transformation. They must encourage the change. The

company must use formal means transmit their intentions, via workshops, meetings, company newspapers, flyers, informal placards or e-mails and intranet.

- Establish the needs, as the tools and techniques for transformation process. Companies must apply tools to define the processes to achieve a better product or service, namely, the implementation of management systems for quality (e.g. ISO 9001), for environment (e.g. ISO 14001), and safety and health (e.g. OHSAS 18001). This will help in the process flows, document the processes, align SC activities and develop continuous improvement principle.

- Consider suppliers and LSPs that are committed to implement compatible solutions, embarking in a collaborative improvement process and assume targets and budgets. In some occasions, companies must be aware of the need to invest in suppliers to develop their activities as desired.

- Consider suppliers which have already the implementation and certification of management systems for quality and environment (ISO 9001 and ISO 14001). These include raw materials/components suppliers and service suppliers. If they are not yet, motivate and encourage them to establish ISO 9001 and ISO 14001, through clarification sessions.

- Consider suppliers that can guarantee a good delivery of the right product: a product with high quality, using materials more durable and possible to reuse or dispose in the end-of-life and at the same time reduce their lead-time.

- Strengthen inter-functional communication. Different alternatives are for different supply chain activities. For example, to manage the internal supply chain process, the company can use Enterprise Resource Planning (ERP) software; to share data with supplier and customers, companies can use EDI (Electronic data interchange) and internet or intranet. The benefits are to reduce dramatically communication errors (e.g. on time delivery). The e-mail is being a good mean of communication and is a way to reduce paper and toner to printing, which means reduction of recycling material.

- Work with nearby companies to simplify the value. With this geographic distribution it is possible to better control the wastes, reduce the time and distance in transportation at the same time, and reduce the carbon dioxide emissions. The company can share and be partner of some activities as recycle contracts or use the same sewage treatment, which

leads to costs reduction. When, it is not possible to have zero wastes, see if there are any nearby company that can reuse wastes; this can generate profit.

- Select the performance measurement system that will be used within the company. Define the system that represents the strategy at long-term, medium and small-term.

In this stage of the roadmap are considered all criteria of the lean-green supply chain conceptual framework. It is evident that criteria act together to achieve the next transformation stage.

6.1.5. Create a Plan for Change

Companies must take into consideration that the transformation plan must be made, known to all and understandable by all. Consequently, companies should create their own framework that represents the plan and that can explain the organization`s supply chain intentions. The plan should reflect the company`s internal and external processes, considering the opportunities to improve and consider the tradeoffs between both approaches. The lean and green synergies and divergences in company`s supply chain must be taken into consideration. It is also important to prioritize opportunities in the supply chain because some activities and processes can be changed. The implementation scope must include all departments, because implementing lean-green in all parts of the business will drive significant improvements in the supply chain. Through a top-down approach, all employees must be updated with the plan of changes. Managers must inform employees in a formal way, about the driver of the changes in their department or workplace. However, the decision to continue or cancel the lean-green transformation is the responsibility of top management. In this stage, the following topics should be considered:

- Evaluate the supply chain, to understand where to implement the best initiatives of both approaches.

- Select the initial implementation scope. Establish a lean-green baseline; it is important to determine the priorities of the implementation. To help in this task, the green value stream mapping assist on the identification of critical areas and identify wastes. Define the wastes as the lean wastes and the green wastes and how they can be eliminated in the process. Apply this tool on all important products or value streams.

- If necessary rearrange plant layout. As examples, consider an effective production line with capacity to produce mixed models in line, or consider some changes in the plant as lighting, ventilation and air conditioning systems, air infiltration or use of solar power among others. It must be taken into consideration that these changes must be aligned with the company`s budget/investment.

- Select the right people to execute the plan. This selection should be the managers to make since they know who the right people are.

- Inform the employees about changes in the company and its supply chain that affect their workplace.

- Provide training and orientation to employees on methods and tools on their workplace. Employees must understand that their work is essential for company and how they can help on the improvement of SC activities; they must understand how they can do their job well done.

- Share the plan and ideas with suppliers which must adhere to similar lean-green elements. For example, share how to achieve energy efficiency, how to develop a just-in-time production, how to have a synchronized transportation or how to reduce costs.

Considering the lean-green supply chain conceptual framework there are strong elements of leadership, people, stakeholders and processes criteria in this stage of the roadmap.

6.1.6. The Implementation Plan

The implementation of a lean-green working environment requires a plan. If the goals, structure and lean-green elements are fixed, the implementation must be designed and developed. To ensure a full implementation, it is important to deploy the lean-green environment in a systematic way; several areas it can be carried out simultaneously. The same way of work (standardization) in all areas and between areas is a good principle to help to streamline the value, namely, share best lean-green elements between areas and identify common issues to achieve the best solution. The same should be made with stakeholders, especially suppliers and customers. Some features should be addressed in the implementation plan, namely:

- Product Design: the product design should take into consideration the selection of materials with more durability, ease of disassembly, possible to recycle or possible to dispose. The use of raw materials and components more durable and with high quality can lead to products with long life-cycle which can improve the satisfaction of the customers. The product should allow an easier, safer and cheaper disassemble process; a product take back program can be developed to recycle or to reuse the materials.

  The product design offers the opportunity to reduce wastes, environmental impacts and product costs, during the product life-cycle. With the design of the product, optimization of other supply chain activities can be carried out (as manufacturing, distribution, and warehousing and the end-of-life product) which can reduce the process time.

- Manufacturing: the manufacturing process has a great weight in waste elimination; it is important to ensure a synchronized production, in a continuous flow through the value stream. The takt time (which represents the rhythm of sales) should be well defined and aligned with SC partners. Produce only what is going to be sold is important to control other factors as minimizing the consumption of materials, energy or water and the production of other wastes. Therefore, the suppliers can also apply the same type of manufacturing. If the focal company have a mixed line and if the supplier delivers different components/materials according to the final product, the suppliers should also have a mixed line with the same production rate. This will help to have low inventories and allows to reduce process time (or lead-time), and help to increase productivity.

- Transportation: the transportation process can cause more environmental impacts in the entire SC. The right packaging dimensions for the right product and, consequently maximizing the load capacity on vehicle are critical issues and sources of wastes. The routes of the vehicles, or even the selection of different transport modes (train, plane or ship) or multimodal transport should be studied and improved; the transportation planning must take into consideration the just-in-time delivery process, lead-time reduction, packaging process optimization, route and multimodal transport optimization and energy resources. To reduce possible tradeoffs between lean and green approach the legal legislation should be ensured. After, consider how to deliver materials (just-in-time deliveries are required); select the possible transport mode that can be applied, taking into account the distance, the time spent and cost (the more environmentally friendly transport mode should be selected). Select the type of standard package, and depending of the distance travelled, take the possibility of return and re-used

(considering the cost spent). If it is possible, choose a route that minimize the transport cost and transportation time.

- Packaging: the standard packages and containers can be reused in a closed-loop system. Agreement with suppliers may be required to define the return of the packages that are no longer in use and can be re-used to carry more material. With a standard packaging or containers can better manage deliveries, inventories and damaged material can be reduced (as it is transported in packages designed for the customized product). Considerations due to the distance between company and suppliers should be taken such as the carbon dioxide emissions associated to transport, the cost savings related to return of packaging, or the profit associated to recycle.

- Warehousing: the objective of this process is to reduce inventory and at the same time energy resources. In some occasions the warehouse space is improved adjusting the space to have better handling and access to the material. This can reduce waste and optimize energy resources. The leader partner pretends to have few or even no inventory; this must be well coordinated with their suppliers which also want to have minimum inventory. The objective is minimizing inventory throughout the chain and at the same time to reduce costs.

- Technology: the investment in new technology must have a return either directly or indirectly to achieve the SC objectives; to select new technology some features should be considered as the reduction of defects, reduction on air emission per product, the reduction of inputs resources, the control of hazardous materials, reduction of production time and no waste generated.

- Tools: the use of tools such as TPM, 6S and work standardization are important in a lean-green implementation; company should apply the 6S methodology as a way to eliminate wastes and optimize workplace; the work standardization should be considered to register how to perform the SC activities; the application of 3R`s in all areas of organization`s supply chain assist in the reduction of materials, reuse paper and others materials in work daily routine and recycle through collection of waste points for plastic, paper and toner, and metal, cardboard or hazardous products; in the manufacturing process, the scrap (from production) should be recycle.

- Partnership: it is important to evaluate suppliers relative to their supply chain performance; monitoring the SC activities to achieve a better process flow. However, if the company executes an intensive monitoring, the suppliers can hide issues from their

SC partners. To avoid this situation, the good suppliers should be rewarded with honour mention and communication to all suppliers, explaining why that specific supplier is being awarded. This process will help managers in future considerations.

- Management systems: Obtain third-party certifications for the management system. The success of the implementation of management systems must be verified through certification by an independent third-party.

  New management systems may be considered to optimize the process of lean-green transformation; to use energy efficiently the company can implement the ISO 50001 (energy management); the company uses energy more efficiently, and, at the same time, reduce cost and natural resources.

  Another management system to help in the implementation of lean-green is the "six sigma" which can be strategically used when integrated with lean and green. This merge could result in a "lean-green six sigma" that may be used to reduce waste and process variation. Adoption of lean-green six sigma projects with a belt training program; it consists in several levels of training having into consideration lean-green tools and "six sigma" procedures. This "lean-green six sigma" is shaped to achieve business goals and reduce product defects; a product with less defects leaves to less additional labour to rework or remanufactured materials, and less natural resources.

- Business Monitoring: to improve the company`s performance and monitor the progress to know how well the company is doing relative to the lean-green implementation; this analysis should be made by managers by day and week relative to SC performance. The performance of the overall company should be made quarterly, as well as, once a year.

This stage of the roadmap is the most complex as it covers the implementation of most lean-green elements. The processes criterion is the most developed.

6.1.7. Carry on the Transformation

At this stage it is important to look at the daily operations and continuous process improvement, to evaluate how lean-green environment is being changed, in the business and in the SC. Focus of this evaluation should be on results to create value for the customer: evaluate the implementation performance and review periodically to understand where is necessary to improve. At a long-term perspective, the management must define new strategic goals. The

small-term perspective is defined with a plan that represents the progress of the activities. With this perspective in mind, creativity, knowledge, tools and information to accomplish better lean-green SC activities are essential; the following activities should be addressed:

- Built a routine for process changes; institutionalize continuous process improvement to optimize all internal and external SC processes; identify improvements and prioritize opportunities (some examples are improvements in SC activities: reduce the number of movements to do the same work, reduce natural resources through change lighting or using new technology communication that reduce printing paper).

- Develop continuous improvement with suppliers will help to simplify value stream (for example, fix and optimize the plan route relative to delivery). Specify with suppliers which the times of the day to receive their goods (this will help to reduce the congestion of trucks to unload and the possibility of reducing carbon dioxide emissions, waiting costs, among others).

- Establish and implement work teams (cross-functional teams are important to develop a plan in constant improvement which identifies gaps, bottlenecks and inefficiencies). Consider the use of Kaizen events to improve processes in a lean-green manner.

- Organize the work defining the task execution, specifications and instructions. All processes must have their tasks well-defined and recorded so that their employees carry out the tasks similarly. Consider all aspects of the lean-green work.

- Have a system to catch suggestions of improvement and new ideas from employees; normally, the ideas results in improvements; assure intellectual property protection and ethical behaviour. Connected to employees ideas and suggestions are the incentives and compensations systems. Reward the employee for a good idea can generate more employee satisfaction.

- Use the A3 report, the 5 Why´s methodology, among other tools to assist in activity or process improvement taking into account a lean-green deployment.

- Apply an employee evaluation system to give feedback to employee how is his work. In this way the employee can improve its performance.

- Re-assign employees when it is verified that its skills can better utilized elsewhere.

- Establish meetings and communication between top management and employees in workplace; employees must be supported by managers (employees must share their daily working problems with managers).

- Anticipate future changes; this can express an image of a company with credibility. For example anticipate new legislation and regulation (e.g. the legal limit of air emissions).

- Evaluate the progress against target metrics. This can be made by the performance measure system selected.

- Share progress to all employees and other stakeholders. This progress can be in terms of measures and normally are different reports with different information.

6.1.8. The Lean-Green System

Lean-green is established as the way the company conducts its business. At this stage the lean-green approach should run at a "cruising speed". Lean-green transformation is carry on around values of sustainability and excellence. Consequently, the company must take responsibility for a sustainable future achieving cost savings with a high quality-environment friendly product. The differentiation is a reason for the company to achieve a lean-green transformation, because lean-green help to built reputation through a brand image and market share. Market needs to be aware how the company works and what are their commitment to deliver a good product. An innovative company that is always trying to improve its processes can get a better position in the market, than their competitors. A visible commitment to make a good quality product and at the same time, reduce environmental impacts will lead to become a "best-in-class" organization`s supply chain. Companies must be wholly transparent to the market. This stage in the roadmap is the last to achieve the future state:

- Elaborate customer satisfaction surveys to understand the customer`s point of view, relative to products and company.

- The product meets the needs and expectations of the customer and the customer service must be considered better than its competitors.

- Disseminate lessons learned. Share knowledge and implementation experience.

- Enable feedback to managers, employees and others stakeholders.

- The company must delegate responsibilities to employees to have authority and capacity to improve, plan and decide which take over this responsibility.

- Consider that the company do not have tradeoffs; the organization`s supply chain should take the better solution to minimize the divergence between lean and green. The company takes the responsibility for having chosen the best solution for all supply chain stakeholders.

- Management review can set new strategic targets. For example in a first time set target relative to carbon dioxide emissions to reduce in 10% and at a second time reduce to 25%.

This is the last stage of roadmap, which will achieve the "future state". In this phase, feedback is given to criteria to improve the SC activities; the roadmap may reach another initial state of "current state".

6.2. The Transformation Process Model

This roadmap indicates how to achieve a lean-green supply chain. It intends during time, the supply chain will be more and more lean-green, to achieve better performance and be closer to the "ideal state". The roadmap also indicates what it must take into consideration to achieve the "future state". From the current state to the future state, the transformation lean-green has three distinct business objectives:

- Prepare the transformation, which include the first four stages of the roadmap.

- Execute the transformation, which organizes and implements the lean-green elements.

- Maintain the transformation, which help to optimize the implementation and formalize all the lean-green procedures.

Table 6.1 represents a transformation plan to achieve a lean-green supply chain. The roadmap suggests the way the lean-green transformation needs to evolve and progress. In this table it was considered the main objective of each stage of the roadmap and give connected goals. These goals were defined as benchmarks rather than as goals to achieve for specific supply chain business.

Table 6. 1- Transformation plan

Stage	Transformation objective	Measurable goals	First year											Second year												Third year												Criteria	Resp.
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36		
1	Define what lean and green paradigms represent for your supply chain business	Leadership commitment: 90 to 100%	O▲																																		L	FC
2	Define the business planning, establishing targets for the lean-green implementation	GVSM: 50% of production Return on investment: 1 year		O▲																																	L; SP; PC; R	FC
3	Culture change match with dynamic changes inherent to transformation	Employee involvement: 80 to 90% Training given: 95% of employees				O	▬	▲																													L; PP; SH	FC
4	Create an adequate structure to the practice of lean-green	Information diffusion (reach all): 85%								O	▬	▲																									L; PP; SP; SH PC; R	FC
5	Create a lean-green plan to be executed, considering the internal and external processes	Level of productivity: 90 to 100% Process efficiency: 80 to 90%										O	▬	▬	▲																						L; PP; SH; PC	FC; UP
6	Implement the lean-green supply chain working environment	Cost savings: 0.5% to 5% Lead time reduction: 10% Carbon dioxide reduction: 20% Waste elimination: 25% Resource reduction: 25% Level of suppliers motivation: 90% Scrap reduction: 25% Cleaner working environment: 90%														O	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▬	▲			L; PP; SP; SH PC; R	FC; UP
7	Keep implementation through a continuous improvement	Savings in improvement: 1 to 2% Non-value added time reduction: 5%																																			PC	FC; UP
8	Consider a lean-green supply chain	Sales growth: 2 to 4% Customer satisfaction: 85 to 95%																																		O▲	L; PP; SP; SH PC; R	FC; UP; DW

Legend: O: Start; ▲: Completion; FC: Focal company; UP: Upstream supply chain; DW: Downstream supply chain
L: leadership; PP: people; SP: strategic planning; SH: stakeholders; PC: processes; R: results

For example, it is a strong believes that the measurable goal "Employee commitment", in the final of stage three, should have at least 80% of employees committed to lean-green supply chain transformation. Three years (thirty six months) are considered to execute the eight stages of the transformation plan (initial). This Table makes reference of which transformation framework criteria are considered in each stage and which entities in the supply chain is responsible for the execution of each stages.

At the end of the roadmap, the "future state" should be reached. At this moment, it would be possible to say that lean-green is implemented. However, successive "future states" can be traced, modelling a lean-green approach, improving the overall supply chain performance. It is possible to say that it is possible to outline successive "future state" trying to achieve the "ideal state". It must be taken into consideration that in the second transformation cycle (when "future state" becomes "current state") some elements should not be taken into consideration again. For instance, the decision of adopting lean and green paradigms is not to be taken into consideration in the beginning of a next "current stage" (since it has already been accepted). However with "cycles of transformation", intends that organizations overcome tradeoffs paradigms, improving the synergies between them.

6.3. Chapter Overview

There is no a single way to do a lean-green transformation. However, some topics are essential for a transformation to be successful. This roadmap considered the elements that should be part of a transformation for the organization`s supply chain to achieve a "future state". This roadmap is an oriented-tool to help managers to understand which supply chain issues they should pay special attention and in what moment should be put in practice.

Thereby lean and green approaches are established as the way the company conducts its business and sustain its supply chain. Management, employees and other stakeholders must interact all together. Lean-green is a modelling approach that can help redesign supply chains and improve performance. Modelling lean-green is not a simple journey. A strong belief is that a clear vision, the leadership commitment, a culture of change, and a strong partnership added to the applications of tools and techniques will be possible to achieve a lean-green transformation. That is, companies should select the appropriate lean-green approach based on their specific supply chain context and company ambitions.

7. Conclusions

This chapter draws the final conclusions of the thesis. It includes a thesis overview and the procedures adopted in the development of the thesis. The main results are discussed and the theoretical and managerial implications are drawn. Finally, an agenda for future research work is proposed.

7.1. Thesis Overview

The lean and green approaches revealed to have an important impact throughout the supply chain. The compatibilities that were identified between lean and green paradigms may help to achieve a more effective management system; this research makes several contributions on the supply chain management context and attempts to understand how to modelling a lean-green supply chain.

A literature review on supply chain management revealed that a number of paradigms namely lean, agile, resilient and green may influence the supply chain competitiveness. A comparison analysis between these paradigms was carried out, to understand eventual compatibilities and divergences. A structured literature review was refined to identify integrated approaches. This literature review revealed two things:

- lean and green issues were not well integrated; companies seemed to look at these issues with different approaches.
- business management frameworks were not well designed to help the integration process of lean and green and its implementation.

Having the chance to work with companies involved in a previous research project, it was confirmed that this problem was real. As such, further literature review on management frameworks was carried out. Thirteen different business management frameworks derived from international awards, standards and tools, were studied. These frameworks helped to understand the most important issues for an organization`s supply chain business. They were considered a convenient starting point for modelling a lean-green supply chain.

The literature review contributed to the knowledge of what may represent a lean-green approach; there are several studies about the two approaches, as they are considered of

importance for the supply chain activities, but no one associates it with the research on business management frameworks, as is the case of this thesis. The decision to apply these two paradigms was merely because the lean and green are seen as approaches to achieve "best-in-class".

Through a better understanding of these frameworks, as well as the lean and green characteristics, it was intended to propose connections between these frameworks and the lean-green approach. The management frameworks mentioned a number of characteristics, and some of them, may be considered as "near-common" characteristics namely, leadership, people, strategic planning, stakeholders, processes and results, were considered as key criteria that could be included in a lean-green supply chain management framework.

A lean-green conceptual framework was developed; various stages were defined to facilitate the lean-green transformation process. First, the key criteria to evaluate the supply chain was defined; second, in connection with key criteria, a number of lean-green elements (representing different principles, practices, techniques and tools) were described; these elements were considered important for the development of the framework and they had to be adapted for the development of guidelines. The list of elements can be used to guide future improvements. An important advantage of this model is that it provides connections between lean and green at the strategic, tactical and operational levels. Therefore, it is believed that this research makes several original contributions because it, not only indicates how the two ways of management can be considered as a single one, but also indicates what the most important topics are. An assessment method with criteria and irrespective weighting scores to evaluate a lean-green organization`s supply chain was derived and proposed.

To complement this research a case study was developed to get information that only in a real-scenario could be understood. This multiple case study was developed to provide a depth understanding of the research. Consequently, the external validity was enhanced and investigator bias reduced. The automotive supply chain was selected because this type of industry has high levels of lean and green implementation which allow a deep understanding of their integration. The study was based on the upstream supply chain; the case study included an automaker, first-tier suppliers and LSPs hosted in a nearby Industrial Park.

The individual criterions of the conceptual framework were applied to the subsequent case analysis to determine if they could facilitate or inhibit the success of lean-green SC. Consistent with the research questions and the conceptual framework, specific subjects were asked to company managers concerning to each criterion. Moreover, the case study draw on multiple

sources of evidence as interviews, documents, directs observation, internet sites, company newspapers and national newspapers.

This research tries to contribute for the understanding of how to address lean-green approach in a supply chain. It provides insights of which activities must be put into action and which tools may be used in the transformation journey. An oriented-tool to help managers in this journey was developed. The oriented-tool was designed as a roadmap considering eight different stages that should go through, from the "current stage" to a "future stage", to achieve a lean-green transformation. This research provided a broad perspective on combining lean and green to assist organizations to achieve an effective SC. Lean and green will be integrated in the future of supply chains and this research work was designed to help in the lean-green transformation in the automotive industry, and eventually in other supply chains from other industry sectors.

7.2. Main Results

The focus of the research work on the supply chain and the opportunities identified to improve its performance with the integration of lean and green paradigms led to the initial research questions. The outputs resulting from the research questions are the following:

- *How supply chain management paradigms are being applied and integrated?* A literature review contributed for the knowledge of supply chain management paradigms. It is possible to combine paradigms in the SC, however some tradeoffs can occur. From the classification scheme it was concluded that green has been, in recent times, an important approach to the supply chain, followed by lean.

- *How management frameworks give insights to modeling the supply chain?* From the literature review a number of recognized worldwide management frameworks were studied. The characteristics of thirteen management frameworks were studied and similarities were identified; the considerably outputs is that a number of "near-common" characteristics mentioned in almost all the frameworks are identified namely, leadership, people, strategic planning, stakeholders, processes and results. These provide references for modelling (a lean-green supply chain) purposes.

- *How to model the lean and green paradigms in the supply chain management context? How to evaluate the lean and green implementation?* A lean-green supply chain conceptual framework for the implementation and evaluation of a lean-green organization`s supply chain was proposed. This conceptual framework considered a number of basic mechanisms for a lean-green integrated approach; it addressed six criterions, namely leadership, people, strategic planning, stakeholders, processes and results. A number of lean-green supply chain elements and respective guidelines were connected to each criterion; relationships with lean-green supply chain perspective were established. The lean-green criterion weighting calculation was proposed, defined a criteria score with respective weight. It was proposed an assessment method for the evaluation of a lean-green organization`s supply chain.

- *How organizations implement the lean-green supply chain elements in a real-scenario?* The case study revealed that companies are deploying the elements considered in the conceptual framework; however, not all lean-green elements considered in the conceptual framework are implemented in both approaches, in all companies. Companies don`t use the GVSM. However, there were evidences that the six key criteria considered in the conceptual framework, namely leadership, people, strategic planning, stakeholders, processes and results, were important for a lean-green SC transformation. These findings and evidences support the conceptual framework; all key criteria play an important role in the development of SC processes.

  Another important output from case study is that companies are aware of lean thinking as well as green thinking. The companies studied put into action activities to be lean and green; lean and green can be executed as an integrated approach. Moreover, it is evident especially in the FC, that business value is aligned with lean and green SC strategy. The FC revealed a strong lean and green culture which influences its first-tier suppliers and LSPs. The FC determines the level of lean and green applied on the supply chain, especially to the direct partners; all of them try to improve SC processes focusing on cost savings. It was possible to conclude that organizational performance depends on the performance of its supply chain.

  The application of the assessment method, proposed in the conceptual framework, corroborate that the framework is focused on the adoption of the best of both approaches. An additional confirmation: the elements selected for the evaluation of

lean-green implementation were considered correct; the case study provided ideas on how and when a number of elements should be implemented.

- *How lean-green elements should be deployed to have a lean-green supply chain transformation?* Based on ideas and insights obtained from case study, a roadmap was proposed to indicate in which moment the lean-green SC elements should be executed. It proposes measurable goals considered as benchmarks, and the SC responsible for each stage of transformation.

  This roadmap intends (during time) that the supply chain will be more and more lean-green and be closer to the "ideal state". The roadmap begins with leadership criteria, achieving the "future state" with all criteria on action.

  An output from the roadmap should be outlined: it is possible to achieve a lean-green transformation considering a number of mechanisms, as for example leadership commitment, employee involvement, appropriate culture along the supply chain, adequate structure for the practice of lean and green paradigms, the right strategy for the transformation, strong alliances with partners and optimization of the resource utilization or waste elimination. This tool establishes a baseline to serve as an effective control on lean-green transformation level. In addition, through the "cycles of transformation" it is possible to achieve a "best-in-class" lean-green organization`s supply chain.

It is possible to implement both approaches at the same time. It is a strong believes that the initial objectives have been reached. This research work can be considered as a baseline for the development of a "Lean-Green Supply Chain Excellence Model". Modelling a lean-green supply chain should be a way of doing business.

7.3. Theoretical and Managerial Implications

This dissertation contributes for the understanding on how companies are addressing lean and green issues in the supply chain, what challenges can be encountered and what type of actions should developed. This research was focused on how to create genuine synergies by applying both approaches and explaining how to integrate them into current businesses. This research intends to contribute for the supply chain context with a lean-green supply chain

management framework which supports new theoretical development to achieve a lean-green organization`s supply chain.

Puvanasvaran *et al.* (2011) mentioned that the Lean-EMS integrative approach must take into account the differences of both and adopt the best of both approaches. They considered to be a lean and green approach which must be based on a number of variables, namely strong vision, employee participation, streamlining work processes, redesigning products, optimize resource utilization and eliminate risks; however this research study it did not mentioned how the proposed approach could achieve and evaluate the transformation process. This research is a step forward on the development of a framework for a lean-green supply chain approach; it provides the criteria and weighting criterion, the main elements and the corresponding guidelines that compose the framework.

Furthermore, the lean-green roadmap helps to define different directions to pursuit a lean-green transformation. It illustrates which lean-green supply chain elements in which sequence on transformation and provides insights of which measurable goals should take into consideration. Strandberg (2009) proposed a roadmap to green issues in ten different organizational business areas; this roadmap intends to be modular allowing to select only the topic area. Anand and Kodali (2008) provided a step-by-step approach for transforming the existing SC into an LSC. However, these examples of a roadmap are only for one of the both approaches under study. There are no theoretical evidences of a lean-green roadmap in the form of a sequence of stages. The lean-green supply chain roadmap proposed in this thesis intends to overcome this gap.

This research may assist managers and practitioners in the adoption of a lean-green supply chain. The lean-green supply chain management framework provides organizations with a deeper understanding on which activities must be put into action to achieve a lean-green transformation. It gives insights of how lean and green can act together at different SC business levels. This may give important information for their decision on lean-green supply chain transformation. Moreover, the framework developed in this thesis, propose an assessment method that allows the organization evaluate its actual state. The objective is that the managers and practitioners with this collection of data and procedures can in a future state achieve their "best-in-class" state.

The roadmap may help managers and practitioners to know in what moment of their SC transformation they should deploy the lean-green elements. This oriented-tool establishes a baseline to serve to control the lean-green supply chain transformation; it provides useful data to

managers propose business changes. It also may assist on the elaboration of a customized transformation plan, specific to the organization` supply chain. This will allows managers to benchmark their organization`s supply chain with other supply chains.

7.4. Recommendation for Future Research

This research may be further developed as the lean-green system, in a hybrid supply chain context. Some limitations were encountered in the development of this research; it could not be extended to obtain results both in different industrial sectors and in different countries. The results have some limitations as they cannot be generalized to other industry sectors. Other industry sectors may require different actions especially in the deployment of the lean-green elements framework.

Moreover, this study was focused in a single upstream SC, concentrated in a specific region of a specific country and it is possible that organizations in the same industrial sector but in different countries could have different behaviors. Examples are the legal requirements, supply chain process characteristics or product characteristics that could influence the deployment of the different elements taking different actions.

Another limitation is that the findings are only based on interpretation research which could be complemented with quantitative data through a large-scale empirical test. This study was addressed on the organization`s supply chain rather than across the supply chain, as this is typically viewed as extending from suppliers` supplier to customers` customer.

Considering these limitations, there are a number of opportunities for further research as consequence of this research work, namely:

- Develop the case study based on the downstream SC.
- The boundaries of the study across the supply chain can be enlarged extending from first-tier to second-tier and even third-tier suppliers and in the opposite direction, from first-tier to second-tier and third-tier customer.
- The same study can be extended to be developed in different SCs in a cross-supply chain; different supply chains representing different industry sectors where the lean and green implementation may not be so well developed.

- The same study can be expanded in different countries, moving the study to a cross-country study. Understand how different organizations see the lean and green approach. For example the legal requirements of each country may influence the supply chain.

- Through a quantitative study a questionnaire survey can be developed to test and analyze the hypothesized relationships between the key criteria proposed on the conceptual framework.

- A quantitative survey study in a cross-sector industry can be carried out. It is possible to adapt the elements and guidelines proposed in a questionnaire survey to analyze which kind of organizations are trying to cover a lean-green transformation and which levels of lean-green did they achieve.

- The lean-green Balanced Scorecard thematic can be developed. The application of the BSC framework to monitor the performance of a lean-green supply chain can be carried out. It should consider the lean-green cause-and-effect BSC framework (Figure 4.7) to develop one in a real-scenario, with data from an organization`s supply chain.

It is also possible to consider that the lean-green supply chain framework may be improved in the future. This statement is based on the different management frameworks that were under study in Chapter 3. All models have suffered changes over time. For example the Shingo Prize model suffered important changes: between versions four (2010) and five (2012) the scoring criteria for each dimension were changed and the green performance measures were introduced. This is an indicator that, even lean organizations should be aware to change their structures to become "greener".

Moreover, the lean-green supply chain framework may be adapted to other industry sectors even if they are not, by nature, lean and green. For example, "leadership commitment", "employee involvement", the "education and training programs" or "long-term alliances with partners" are elements that should be present in all behaviours and beliefs on any organization. Therefore the proposed model may have in the future, directions for some restrictions in assessment scheme. This is verified in ISO 9001 where it is possible to exclude some guidelines clause.

Future research requires more operational indications to obtain a specific lean-green supply chain, considering for example, the lean-green implementation level, the industry sector or the company size.

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Annexes

Annex 1. The Awards, Standards and Tools Characterization

This annex consists of a detailed analysis of the thirteen management frameworks studied in Chapter 3. This annex comprises 13 tables, each referring to one management framework: award, standard or tool. The table considers the management frameworks topics: i) Objectives; ii) Focus; iii) Principles; iv) Continuous improvement; v) Supportive techniques and tools; vi) Leadership; vii) People; viii) Strategic Planning; ix) Stakeholders; x) Processes; and xi) Results.

Annex 2. Structured Interview Protocol

The Structured Interview Protocol was created to serve as a guide in the case study, developed in Chapter 5. This guide was designed with three different sections: i) the organizational characterization; ii) lean-green general overview; and iii) lean-green criteria.

Annex 1. The Awards, Standards and Tools Characterization

Table A1.1 - Deming Prize characterization

Deming Prize (JUSE, 2011)	
Objectives	The purpose of the Deming Prize was to recognize those who excel in quality management and as a way of driving quality control.
Focus	Focused on achieved distinctive performance through the application of quality control.
Principles	Deming Prize has retained its basic correspondence with the philosophy of Deming as Deming´s 14 Points.
Continuous improvement	The model refers on continuous improvement as a basic category in which the organization makes improvements on quality and other aspects of its business in a planned and continual manner. The improvement on customer satisfaction rate is mentioned. Claims, defective product and problems in the market or the succeeding processes has been reduced.
Supportive techniques and tools	The organization manages its business by rotating the Deming cycle (PDCA: plan, do, check and act).
Leadership	Insights into top management leadership: i) strong leadership is exerted to share the values of the vision; ii) business strategies are established to become an excellent organization; iii) under the excellent vision, the organizational innovation and improvement takes place.
People	Employee development is an issue to evaluate. In "basic categories" the human resources development categories means that the organization educates and develops its human resources in a planned manner resulting in maintaining and improving product and operational qualities. In the "unique activities" the human resources development means the establishment of a system that can enhance employees' capabilities and satisfaction.
Strategic planning	Strategy as a proactive customer-oriented business objective. Consider "management policies and strategies and deployment of policies".
Stakeholders	Development of quality management systems that secure qualities in supply chain management.
Processes	In "basic categories" refers the work process innovation. The processes are related to the leadership with the innovation of quality management system and creation values to the customer.
Results	There is no separate "result". The evaluation of the "unique activities" is focused on performance. The results describe the improvements of organizational performance: quality improvement; speed and productivity improvement; cost reduction; securing environment and safety.

Table A1.2 - Shingo Prize characterization

Shingo Prize (SP, 2010)	
Objectives	The goal of this model pass through a cultural transformation through integration of principles of operational excellence across the enterprise and its value streams to create a complete, systemic view, leading to consistent achievement of results.
Focus	Focused on overall organizational performance.
Principles	The model defines 10 principles: i)Respect every individual; ii) Lead with humility; iii) Seek perfection; iv) Assure quality at the source; v) Follow and pull value; vi) Embrace scientific thinking; vii) Focus on process; viii) Think systematically; ix) Create constancy of purpose; x) Create value for the customer.
Continuous improvement	Continuous improvement begins by clearly defining value for the customers. It focused on flow of value, identifying and eliminating waste and incorporating all aspects of value as perceived by the customer, including cost, quality, flexibility, quick delivery, and a comprehensive view of environmental health and safety (SP, 2010).
Supportive techniques and tools	Characterizes the connections between Six Sigma, TQM, TPS, JIT and Lean. In addition, the use of Balanced Scorecard as a tool for evaluating all aspects of performance identifying cause-and-effect relationships. It refers a variety of application models, such as for example the management cycle PDCA (plan, do, check, and act), the QI Story, A3 thinking, and DMAIC (define, measure, analyze, improve, and control).
Leadership	A leader must have a philosophical and cultural commitment with organization: must be able to lead others with integrity; must define a strategic direction that provides a unifying vision; must assure a safe environment; Leaders must be in a systematic approach to finding and eliminating waste or anything that inhibits the flow of value.
People	People are an essential part of every value stream, process, and/or system. Respect every individual is a principle that enable the development of people (includes education, training, and coaching) and creates an environment for empowerment and involvement of everyone.
Strategic planning	Every aspect of an organization should be focused on creating value for the customers, investors, employees, and communities. The organizations must consider the true north concept that should guide decision making and continuous improvement.
Stakeholders	The principles of respect and humility lead to recognition of the importance of the relationships. Thus, it is important to nurture proactive and a long-term relationship.
Processes	Processes can be designed to meet customer needs. The processes are related to continuous improvement.
Results	An organization should drive all aspects of value, including quality, flexible responsiveness to customers and return to stakeholders (e.g., growth, revenue, profit, safety, and environmental impact). The results are represented by: i) Quality; ii) Cost/ productivity; iii) Delivery; iv) Customer satisfaction; and v) Morale. The term "true north measures" are frequently used to constant focus on customer. The results are spontaneous improvements in the flow of value, achievement of organizational objectives, and job enrichment.

Table A1.3 - MBNQA characterization

MBNQA (MBNQA, 2010)	
Objectives	The objective is to help the organizations to improve their competitiveness focusing on two results oriented goals: i) ensures continuous improvement in overall performance in delivering products and/or services; and ii) provides an approach for satisfying and responding to customers and stakeholders.
Focus	Focused on overall organizational performance. The focus is on results, not on procedures, tools, or organizational structure.
Principles	The MBNQA define a set of interrelated core values and concepts: i) Visionary leadership; ii) Customer-driven excellence; iii) Organizational and personal learning; iv) Valuing workforce members and partners; v) Agility; vi) Focus on the future; vii) Managing for innovation; viii) Management by fact; ix) Societal responsibility; x) Focus on results and creating value; and xi) Systems perspective.
Continuous improvement	The continuous improvement is necessary to achieve a performance improvement (which priorities for continuous improvement). Continuous improvement is direct related with organizational operations and organizational and personal learning.
Supportive techniques and tools	Approaches to performance improvement that are compatible with this framework might include implementing a Lean Enterprise System, applying Six Sigma methodology, using ISO standards (e.g., 9000 or 14000), the PDCA methodology, or other process improvement tools.
Leadership	In the MBNQA model the categories Leadership (category 1), Strategic Planning (category 2), and Customer Focus (category 3) represent the leadership triad. These categories are placed together to emphasize the importance of a leadership focus on strategy and customers. Senior leaders set your organizational direction and seek future opportunities for your organization. The leadership category represents how senior leaders' personal actions guide and sustain the organization. Also examined the organization's governance system and how the organization fulfills its legal, ethical, and societal responsibilities and supports its key communities.
People	People are related to workforce focus and operations focus categories. The definition of workforce is referred to the people actively involved in carry out the work of the organization. The environment for empowerment, agility, and learning are important issues.
Strategic planning	The strategic planning category examines how the organization develops his strategy and how implements that strategy. It is important to understand how converts their strategic objective into action plans.
Stakeholders	The stakeholders are a key for the definition of organizational relationships. Senior leader must define the commitments with stakeholders and the communications between them. Besides, organizations promote and ensure ethical behavior in all interactions; consider and balance the needs of all key stakeholders. In addition, an effective design must take into account all stakeholders in the value chain.
Processes	The process or work process are related with the operations focus category. It intends to look how the organization designs, manages, and improves its work systems and work processes in way to deliver customer value and achieve organizational success and sustainability.
Results	In this model the categories "Workforce Focus (category 5), Operations Focus (category 6), and Results (category 7) represent the results triad. The workforce and key operational processes accomplish the work of the organization that give in overall performance results. All actions point toward Results, a composite of product and process outcomes, customer-focused outcomes, workforce-focused outcomes, leadership and governance outcomes, and financial and market outcomes.

Table A1.4 - EFQM characterization

EFQM (EFQM, 2009; EFQM, 2011a)	
Objectives	The goals of EFQM Excellence Model include: i) for leaders: help deliver the strategy, understand what is important to do as a leader and develop a unique culture as the sustainable excellence is the norm; ii) for management: see the link between the strategy and operations, engage employee in change and lead improvements; and iii) for employees: provide their improve to built a common direction, understand the impact of their actions and contribute to progress.
Focus	Focused on overall organizational performance.
Principles	The model is defined by 8 principles, namely: i) Achieving balance results; ii) Adding Value for Customers; iii) Leading with Vision, Inspiration and Integrity; iv) Managing by Processes; v) Succeeding through People; vi) Nurturing Creativity and Innovation; vii) Building Partnerships; and viii) Taking Responsibility for a sustainable future.
Continuous improvement	EFQM motivate the people to drive an organization to continuous improvement, creating in employees the desire to learn and progress and provide independent assurance for customers and other stakeholders.
Supportive techniques and tools	Used the quality management as the basis. The EFQM excellence model may integrate a Balanced Scorecard approach as a management tool.
Leadership	The leadership category is an enabler criteria "Excellence organizations have leaders who shape the future and make it happen, acting has role models for its values and ethics and inspiring trust at all times. They are flexible, enabling the organization to anticipate and react in a timely manner to ensure the ongoing success of the organization."
People	People category is an enabler criterion: "Excellent organizations value their people and create a culture that allows the mutually beneficial achievement of organizational and personal goals. They develop capabilities of their people and promote fairness and equality. They care for, communicate, reward and recognize, in a way that motivates people, builds commitment and enables them to use their skills and knowledge for the benefit of the organization"
Strategic planning	Strategy category is an enabler criterion: "Excellent organizations implement their mission and vision by developing a stakeholder focused strategy. Policies, plans, objectives, and processes are developed by and deployed to deliver the strategy."
Stakeholders	The EFQM define and enabler as Partnership and resources: "Excellent organizations plan and manage external partnerships, suppliers and internal resources in order to support strategy and policies and the effective operation of processes."
Processes	The EFQM define as an enabler Processes, products and services: "Excellent organizations design, manage and improve their processes, products and services to generate increasing value for customers and other stakeholders."
Results	Results are divided into: customer results, people results, society results and key results. Results are required to monitor progress against the vision, mission and strategy, enabling leaders to make effective and timely decisions.

Table A1.5 - ISO 9001 characterization

ISO 9001 (ISO 9001, 2008)	
Objectives	The goals of ISO 9001 standard go to what organization must to fulfill the customer's quality requirements, and applicable regulatory requirements, while aiming to enhance customer satisfaction, and achieve continual improvement of its performance.
Focus	This norm is focus on process when develop, implement and improve the quality management in way to increased customer satisfaction, assuring the customer requirements.
Principles	The eight principles provide the basis for the performance improvement and are as follows: i) Customer focus; ii) Leadership; iii) Involvement of people; iv) Process approach; v) System approach to management; vi) Continual improvement; vii) Factual approach to decision making; viii) Mutually beneficial supplier relationships.
Continuous improvement	To achieve continual improvement the ISO 9001 introduces the eight quality management principles as well as the use of the process approach. The Continual improvement is a process of increasing the effectiveness of the organization to fulfill to quality policy and your quality objectives that you have established which are updated periodically.
Supportive techniques and tools	The ISO 9001 focus on quality management. The ISO 9000 framework includes the PDCA methodology.
Leadership	The leadership must: i) show evidence of top management commitment; ii) should meet the customer requirements and customer satisfaction; iii) must express quality intentions; iv) make sure everyone knows their responsibilities and obligations; v) appoint a manager as responsible by the quality system; and vi) review the quality system planned and its results.
People	People are related to human resources: i) organization must provide necessary resources to meet requirements; ii) ensure that everyone is working in a competent system; iii) have education and training and recognize their work; iv) a good infrastructure and a good work environment is need for achieve the product requirements and a good works perform.
Strategic planning	Planning is defined as sub category of management responsibility and ensures the quality objectives, defining and planning, set targets for products and processes and do plans for quality system.
Stakeholders	This norm refers to its customers and suppliers. The organization must communicate with customers. Customers may give specific product requirements; The Suppliers are connected to purchase process.
Processes	Processes for: i) management activities, ii) provision of resources; iii) product realization; and iv) measurement, analysis, and improvement.
Results	Measurement, analysis and improvement are related to the results. The analysis must give information relative to: i) customer satisfaction; ii) product conformity requirements; iii) characteristics and tendencies of process and product, including opportunities to preventing actions; iv) suppliers.

Table A1.6 - ISO 14001 characterization

ISO 14001 (ISO14001, 2004)	
Objectives	The ISO 14001 addresses the environmental management and allow an organization: i) identify and control the environmental impact of its activities, products or services, and to ii) improve its environmental performance continually, and to iii) implement a systematic approach to setting environmental objectives and targets, to achieving these and to demonstrating that they have been achieved.
Focus	This standard does not command a particular organization's optimum environmental performance level but describe a system to help an organization achieve its own environmental objectives.
Principles	The EMS model as defined by 5 principles: i) Commitment and environmental policy; ii) Planning; iii) Implementation and operation; iv) Measuring and evaluation; v) Review and improvement.
Continuous improvement	The model helps the organization achieve continual improvement of its environmental performance. Process of developing the EMS in way to achieve environment performance improvement according to the organization environment policy.
Supportive techniques and tools	The model follows a systematic PDCA methodology.
Leadership	The leadership should: i) show commitment to environmental management; ii) demonstrate their commitment in their communications and in their actions, to all the employees and stakeholders; iii) define an environment policy and certificate that is adequate to the organization (in terms of environment impacts); iv) achieve the continuous improvement and pollution prevention; and v) must apply the legal and others requirements.
People	The selection, responsibilities and authorities are defined, documented and communicated in way to establish an efficient environment management. Selection of an employee to assure the EMS is being established, implemented and maintained. The competency, training and environment sensibility must be set up by the organization.
Strategic planning	The organization shall establish, implement and maintain procedures to identify the environment aspects of their activities, products or services and determinate which have more impact.
Stakeholders	In operational control, this norm refers to the communication of the applicable procedures and requirements to suppliers.
Processes	Processes meet a good practice for environment process. Ensure the effective planning, operation and control of processes that relate to its significant environmental aspects.
Results	Measurement, monitoring, analysis are requisites to verify and evaluate the environment performance and impact.

Table A1.7 - OHSAS 18001 characterization

OHSAS 18001 (OHSAS 18001, 2007)	
Objectives	The OHSAS 18001 specifies requirements for an occupational health and safety (OH&S) management system. This standard enables an organization to control its OH&S risks and improve OH&S performance
Focus	All the requirements in this standard are intended to be incorporated in any OH&S management system. The model focuses on a process approach.
Principles	The principles are: i) OH&S policy; ii) Planning; iii) Implementation and operation; iv) Checking and corrective action; and v) review.
Continuous improvement	The organization must subscribe a continual improvement. The model helps to continually improve an OH&S management system. The OH&S policy is oriented for a continuous improvement.
Supportive techniques and tools	The model is based on PDCA methodology.
Leadership	The top management, leadership should: i) define and authorize the organization`s OH&S policy; ii) demonstrate a proactive and permanent commitment in the policy development and implementation; iii) takes specific responsibility for the management system. Must define the roles, allocating responsibilities and delegate authorities, to facilitate effective management system. Internal and external communication should take into account.
People	The organization shall ensure that any person performing tasks is competent on the basis of appropriate education, training or experience. People in the workplace must take responsibility for aspects of OH&S over which they have control. People must participate and have involvement in hazard identification, risk assessment, incident investigation and also in the development and review of OH&S policies and objectives.
Strategic planning	The organization should establish, implement and maintain procedures for ongoing hazards identification, risk assessment, and determination of necessary controls. Ensure OH&S objectives at relevant levels within the organization. Legal and others requirements must have into consideration.
Stakeholders	Communication and operational control with contractors and others visitors to the workplace.
Processes	Process must be documented and controlled. To manage OH&S risk is necessary to control the operations and activities.
Results	Monitor and measure OH&S performance on a regular basis and evaluate of compliance, analyze incidents and nonconformities

Table A1.8 - NP 4457 characterization

NP 4557 (NP4557, 2007)	
Objectives	The NP 4557 has by goal defined the requirements of the investigation, development and innovation management system, allowing that organizations define their RDI policy and to reach their innovation objectives
Focus	The model pretends to establish a referential that contributes for the organization performance improvement, with emphasis in its research, development and innovation (RDI) management system, as a fundamental method for create knowledge and transform them in economic and social prosperity.
Principles	No evidence of principles.
Continuous improvement	The organization must continuously improvement the efficiency of the IDI management system through the utilization of investigation, development and innovation policies, the review by management, the assess results, the audits results, and the internal and external communication.
Supportive techniques and tools	The norm follows a PDCA methodology.
Leadership	The leadership must: i) define, approve and communicate the RDI policy; ii) show commitment and create conditions to promote an innovation culture, internal creativity and knowledge management; iii) nominate a representative; iv) establish and review the IDI objectives; and iv) provide the necessary resources, human, technical, organizational and financial resources.
People	Organization must assure that people perform RDI activities and having the necessary competencies to perform those activities. Competency, training and others acts must be establish by the organization. The creativity must drive into the organization.
Strategic planning	The organization must establish: i) a process for manage the interface of technology, marketing and organizational innovation process; ii) plan the RDI projects; and iii) establish procedures to manage the ideas and evaluate the opportunities.
Stakeholders	Communication with internal and external stakeholders.
Processes	The organization must identify the activities necessaries to the IDI process: i) Project management and coordination; ii) intellectual propriety management; iii) knowledge management; iv) creativity; v) ideas management; vi) problems and opportunities identification and analysis; vii) project analysis; viii) evaluation, selection and management; ix) others identify by organization.
Results	IDI results being innovations of products, processes, marketing or organizational or a combination between them. The results must consider the finance component, the competitive advantage and the benefits achieved.

Table A1.9 - ISO 26000 characterization

ISO 26000 (ISO 26000, 2010)	
Objectives	ISO 26000 is guidance on social responsibility concepts, definitions and methods, to all types of organizations, regardless of their size or location.
Focus	Focus on what issues organizations need to address to operate in a socially responsible manner, and what the best practices are for implementing social responsible effectively and efficiently.
Principles	The principles are: i) Accountability; ii) Transparency; iii) Ethical behavior; iv) Respect for stakeholder interests; v) Respect for the rule of law; vi) Respect for international norms of behavior; and vii) Respect for human rights.
Continuous improvement	It should be used continuous improvement in an organization´s social responsibility.
Supportive techniques and tools	There are some techniques for decision making and activities as well as effective systems for communication and for monitoring, reviewing and improving their performance on social responsibility. Some examples of tools for social responsibility: EFQM and GRI.
Leadership	The commitment and understanding of the benefits of social responsibility should start at the top of the organization. Leadership can promote the principles and practices of social responsibility.
People	Direct to people is the human rights and labor practices.
Strategic planning	Social responsibility should be integral part of the core organizational strategy, with assigned responsibilities to all appropriate levels of organization.
Stakeholders	Stakeholder engagement.
Processes	Process that conducive to social responsibility.
Results	The model emphasis the importance of results and improvements in performance and social responsibility.

Table A1.10 - ISO/CD 13053 characterization

ISO/CD 13053 (ISO/CD 13053-1, 2009)	
Objectives	The purpose of this norm is to manage a continuous improvement approach based on getting under control the variability of processes and events.
Focus	Six Sigma is the best suited towards constant problems, i.e., problems that seem persistent over time. It reports process oriented problems and product and services oriented problems. In addition, Every Six Sigma project must start with the customer's needs and requirements
Principles	The principles are: i) continuous improvement; ii) control de variety of the processes and events; iii) define; iv) measure; v) analyze; vi) improve; and vii) control.
Continuous improvement	As process approach to achieving quality and the practice of continual improvement.
Supportive techniques and tools	The model follows the DMAIC (define-measure-analyze-improve-control) methodology. The norm 13053-2 refers to tools and techniques that may be used on the five different stages, referring the tools and techniques as mandatory, recommended and suggested by stage.
Leadership	It may be describe in a Six sigma project as the Champion. Project Champion is a senior member of the organization with sufficient integrity.
People	In a six sigma project the personnel must be training and be defined relative to their roles: yellow belt; green belt; black belt; master black belt; project sponsor; deployment manager and champion.
Strategic planning	Six Sigma project must be linked to an organization's business objective. The objective of the project will deliver a significant impact on the organization.
Stakeholders	Every Six Sigma project must start with the customer's needs and requirements.
Processes	The process must be improved and controlled.
Results	The outcome of each project should contribute to the overall improvement of the profitability of an organization.

Table A1.11 - SCOR characterization

SCOR (SCC, 2010; SCC, 2013)	
Objectives	The goal of this model is to identify, measure, reorganize and improve supply chain processes; build a superior supply chain that is integrated with the overall organizational strategy.
Focus	Focus on supply chain improvement activities.
Principles	No evidence of principles.
Continuous improvement	This framework supports the supply chain improvement by capture the current state and through the performance evaluation determines the future state.
Supportive techniques and tools	The re-aligning supply chain processes can be achieved through the combination of: Lean manufacturing analysis and process change, Six Sigma analysis of defective processes, the use of ISO standards or other process improvement tools.
Leadership	"Supply chain leaders align the skills of their people and organizational structure with strategic objectives".
People	Talented people are at the heart of supply chains that effectively respond to and benefit from opportunities. Training and skills requirements must be aligned with processes, best practices, and metrics.
Strategic planning	Deploy supply chain strategies. Develop strategies to meet new customers` needs.
Stakeholders	Coordination with customers, suppliers, and other stakeholders.
Process	Standard descriptions of management processes and a framework of process relationships. SCOR process categories: i) Plan; ii)Source; iii) Make; iv) Deliver; and v) Return.
Results	Standard metrics to measure process performance; supply chain performance is focused on: i) Reliability; ii) Responsiveness; iii) Agility; iv) Cost; and v) Assets. The framework provides a structure for measuring environmental performance and identifying where performance can be improved.

Table A1.12 - EMAS characterization

EMAS (EMAS, 2009; EMAS, 2011b)	
Objectives	The EMAS allow an organization to have a better management of environmental issues and credible information on these issues. It pretends evaluate, report and improve environmental performance. Its objectives are to conserve natural resources, limit emissions of pollutants, environmental hazards and create a safe workplace.
Focus	The core elements of EMAS are performance, credibility and transparency. With this model the organizations continually improve their environmental performance and provide evidence that they comply with all environmental legislation that is applicable to them.
Principles	These model is based on ISO 14001 requirements.
Continuous improvement	Continual improvements in the environmental performance of organizations.
Supportive techniques and tools	The model follows a systematic PDCA methodology. The model refers to the implementation of ISO 9001, ISO 14001, clean technology, regional pilot programs and awards.
Leadership	Understand exactly how the activities, products and services of the organization have a significant environmental impact; The legal responsible must delegate tasks and authority into the organization. "Environmental policy means the overall intentions and direction of an organization relating to its environmental performance as formally expressed by top management including compliance with all applicable legal requirements relating to the environment and also a commitment to continuous improvement of environmental performance. It provides a framework for action and for the setting of environmental objectives and targets."
People	The employees will respond to what the manager communicates. This model refers those employees that take training and acquiring new skills, better recognize their role and understand why their action matters. This increase employee commitment and involvement and better can achieve a good performance.
Strategic planning	Must establish action plan to bring the environmental objectives and targets in a way that is compatible with the organization itself.
Stakeholders	Communication with internal and external stakeholders. Communication establishing and maintaining confidence and understanding among the stakeholders.
Processes	Process is important on the organizations' environmental performance. Process is an important part of the EMS for developing, implementing, achieving, reviewing and maintaining the environmental policy and managing the environmental aspects.
Results	"Monitoring and measurement is about verifying the results of all the work further back in the production processes and the management system, that is, controlling the significant environmental aspects of the organization"; "Environmental performance' means the measurable results of an organization's management of its environmental aspects".

Table A1.13 - GRI characterization

GRI (GRI, 2011)	
Objectives	Providing a trusted and credible framework for sustainability reporting where transparency about economic, environmental, and social impacts is a fundamental component in effective stakeholder relations, investment decisions, and other market relations is expected.
Focus	The GRI is a tool to support an organization in reporting considering all three sustainability's dimensions: economic, environment and social.
Principles	No evidence of principles.
Continuous improvement	Reporting can support continuous improvement in performance over time.
Supportive techniques and tools	No evidence of which techniques and tools should be applied.
Leadership	Disclosures on the statement from the most senior decision maker of the organization about the relevance of sustainability to the organization and its strategy.
People	Consider the people rights. The organization must considered policies that define the organization's overall commitment to the human rights.
Strategic planning	It should mention the strategic priorities and key topics for the short/medium-term with regard to sustainability, including respect for internationally agreed standards and how they relate to long-term organizational strategy and success; description of key impacts, risks, and opportunities .
Stakeholders	Disclosure to stakeholder engagement.
Processes	"New knowledge and innovations in technology, management, and public policy are challenging organizations to make new choices in the way their operations, products, services, and activities impact the earth, people, and economies."; "Transparency about the sustainability of organizational activities".
Results	GRI provides performance measures. The economic performance introduces aspects such economic performance, market presence, indirect economic impact. The Environmental performance is related to the inputs (e.g., material, energy, water) and the outputs (e.g., emissions, effluents, waste). In addition, cover performance related to biodiversity, environmental compliance, transport, product and services. The Social performance identifies key performance aspects enclosing labor practices, human rights, and society and product responsibility.

Annex 2. Structured Interview Protocol

A – Characterization

Company type: ___

Position in Supply Chain:___

Number of employees: ___

Product(s) type:____

Job title:

Awards implemented

	Yes	No	Comments
Deming Prize			
Shingo Prize			
MBQNA			
EFQM			
Others			

Standards implemented

	Yes	No	Comments
Quality Management System			
Environment Management System			
Occupational health and safety management system			
Innovation management system			
Six Sigma management system			
Others			

Tools implemented

	Yes	No	Comments
Eco-Management and Audit Scheme (EMAS)			
Global Reporting Initiative (GRI).			
Others			

B – General Data

	Response	Comments
How implement the lean and the green approach?	a) At the same time	
	b) first lean	
	c) first green	
	d) Not know	
The implementation are disseminate in all departments?	a) Yes, both	
	b) Only for lean	
	c) Only for green	
	d) No	
Your organization has only one department for manage lean and green issues?	a) Yes, only one	
	b) One for lean	
	c) One for green	
	d) One for each	
Is there any external specialist to help in the implementation?	a) Yes, for both	
	b) Only for lean	
	c) Only for green	
	d) No	
Which approach inhibits more the SC activities?	a) None	
	b) lean	
	c) green	
	d) Not know	

C – Leadership

Organizational structure	Response	Comments
Your organization chooses by having a flat organizational structure, to help in the decision-making?	a) Yes	
	b) No	
The management make sure that legal requirements and other regulation are considered?	a) Yes	
	b) No	
Your organization works based on a long-term thinking?	a) Yes	
	b) No	
The management assures a long-term employment?	a) Yes	
	b) No	
Consider having a Quality culture?	a) In company	
	b) In suppliers	
	c) In SC	
Consider having an Environmental culture?	a) In company	
	b) In suppliers	
	b) In SC	
The management assures the social responsibility?	a) Yes	
	b) No	

C – Leadership (cont.)

Nature of management	Response	Comments
The top management demonstrates its commitment and involvement to the implementation?	a) Yes, for both b) Only for lean c) Only for green d) No	
The management ensure the principles of the lean and green approach?	a) Yes, for both b) Only for lean c) Only for green d) No	
The management communicates the importance of the implementation?	a) Yes, of both b) Only for lean c) Only for green d) No	
Top management demonstrates that have a clear vision	a) Yes, for both b) Only for lean c) Only for green d) No	
Regular conduct of management leading with integrity?	a) Yes b) No	

D. People

People	Response	Comments
Have a program of education and training for the employees in order to increase employee´s skills?	a) Yes, for both b) Only for lean c) Only for green d) No	
Apply the cross-functional teams in way to resolve the problems?	a) Yes, for both b) Only for lean c) Only for green d) No	
Are employees multi-skilled in way to assure a lean and green work?	a) Yes, for both b) Only for lean c) Only for green d) No	
Does your organization have a formal employee evaluation system?	a) Yes, for both b) Only for lean c) Only for green d) No	
Employees are encouraged to explore new ways and suggest innovative ideas?	a) Yes, for both b) Only for lean c) Only for green d) No	

D. People (Cont.)

	Response	Comments
All employees can register their ideas and suggestion for all areas of SC?	a) Yes, for both	
	b) Only for lean	
	c) Only for green	
	d) No	
Employees are properly recognized and rewarded?	a) Yes, for both	
	b) Only for lean	
	c) Only for green	
	d) No	
Are the employees engaging to root out lean and green wastes and continuously improve SC activities?	a) Yes, for both	
	b) Only for lean	
	c) Only for green	
	d) No	
All employees have defined their necessary competences?	a) Yes, for both	
	b) Only for lean	
	c) Only for green	
	d) No	

E - Strategic Planning

Strategy deployment	Response	Comments
Is lean-green integrated into the strategy and mission?	a) Yes	
	b) No	
Is lean-green strategy shared by all levels of organization?	a) Yes	
	b) No	
Are lean-green policies, plans and objectives established?	a) Yes	
	b) No	
Is the strategy focus on customers and others key stakeholders?	a) Yes	
	b) No	
The goals and objectives are consistent with the ones of key stakeholders?	a) Yes	
	b) No	
Is the strategy review and improved regularly?	a) Yes	
	b) No	
Employees translate the strategy into their daily decision making?	a) Yes	
	b) No	

F - Stakeholders

Key stakeholders	**Response**	**Comments**
Consider the principle of create value for the customer?	a) Yes	
	b) No	
The organization care for a long-term relationship with their key stakeholders?	a) Yes	
	b) No	
The organization communicates with their key stakeholders (e.g. meetings)?	a) Yes	
	b) No	
Involvement of key stakeholders in lean-green initiatives?	a) Yes	
	b) No	
The organization shares the environmental risk with their key stakeholders?	a) Yes	
	b) No	
The continuous improvement is promoted through supply chain?	a) Yes	
	b) No	
Commitment with their key stakeholders in way to reduce cost and time?	a) Yes	
	b) No	
Suppliers		
The objectives and goals are consistent with their key suppliers?	a) Yes	
	b) No	
Assure regular conduct with key suppliers (suppliers mettings)?	a) Yes	
	b) No	
Your suppliers apply the same approach lean-green?	a) Yes	
	b) No	
Assure that their suppliers have ISO 9001	a) Yes	
	b) No	
Assure that their suppliers have ISO14001 certification	a) Yes	
	b) No	
Apply a supplier evaluation through a formal system?	a) Yes	
	b) No	
Management undertakes efforts to move lean-green into their suppliers ` operations?	a) Yes	
	b) No	
Your organization selects their suppliers through lean-green criterion?	a) Yes	
	b) No	
Your organization is geographically closer to its suppliers?	a) Yes	
	b) No	
Customers		
Is there a proper identification of customer needs / focus on the customer needs?	a) Yes	
	b) No	
Customers feel satisfied by the quality of the product?	a) Yes	
	b) No	
Customers apply the same approach lean-green?	a) Yes	
	b) No	
Does your organization provide information to customers about your products?	a) Yes	
	b) No	

G - Processes

Processes	Response	Comments
Improve transport mode?	a) Yes, for both	
	b) Only for lean	
	c) Only for green	
	d) No	
Improve transport routes?	a) Yes, for both	
	b) Only for lean	
	c) Only for green	
	d) No	
Improve replenishment frequency (deliveries)	a) Yes, for both	
	b) Only for lean	
	c) Only for green	
	d) No	
Improve resource capacity?	a) Yes	
	b) Only key process	
	c) No	
Improve storage space?	a) Yes, for both	
	b) Only for lean	
	c) Only for green	
	d) No	
Improve the lot production size?	a) Yes, for both	
	b) Only for lean	
	c) Only for green	
	d) No	
Use of re-used standard packaging and containers?	a) Yes	
	b) Only with key suppliers	
	b) No	
Use of re-used material/components?	a) Yes	
	c) No	
Use of standard packaging and containers?	a) Yes	
	c) No	
Use of standardization parts?	a) Yes	
	b) No	
Use of alternative source of energy?	a) Yes	
	b) No	
Toolkit	**Response**	**Comments**
Use the Value stream mapping	a) Yes, for both	
	b) Only for lean	
	c) Only for green	
	d) No	
Use the A3 report	a) Yes, for both	
	b) Only for lean	
	c) Only for green	
	d) No	

G - Processes (Cont.)

	Response	Comments
Apply 6S methodology (5S +S)	a) Yes, for both	
	b) Only for lean	
	c) Only for green	
	d) No	
Apply 5 why`s tool?	a) Yes, for both	
	b) Only for lean	
	c) Only for green	
	d) No	
Apply analytical tools (such as Pareto charts, Ishikawa diagrams)?	a) Yes, for both	
	b) Only for lean	
	c) Only for green	
	d) No	
Apply standardization and work instructions?	a) Yes, for both	
	b) Only for lean	
	c) Only for green	
	d) No	
Apply Kaizen events?	a) Yes, for both	
	b) Only for lean	
	c) Only for green	
	d) No	
Use the life cycle assessment?	a) Yes, for both	
	b) Only for lean	
	c) Only for green	
	d) No	

H – Results

	Response	Comments
Does your organization use the balanced scorecard tool?	a) Yes, for both	
	b) Only for lean	
	c) Only for green	
	d) No	
Does your organization consider cause-and-effect relationships?	a) Yes, for both	
	b) Only for lean	
	c) Only for green	
	d) No	
Your organization monitors the performance measures?	a) Yes, for both	
	b) Only for lean	
	c) Only for green	
	d) No	
Which performance measures are the most important to evaluate your SC?		