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Impact of supply chain management practices on sustainability

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ABSTRACT

This paper aims to investigate the impact of lean, resilient and green supply chain management practices on supply chain sustainability. A deductive research approach was used to derive a conceptual model. Eighteen research propositions are suggested and tested with empirical data derived from five case studies belonging to the Portuguese automotive supply chain. A conceptual model to assess the impact of lean, resilient and green practices on supply chain sustainability was derived from the data analysis. The practices with significant impact on supply chain sustainability are: "waste elimination," "supply chain risk management" and "cleaner production." The following lean, resilient and green supply chain management practices do not have a significant impact on supply chain sustainability: "flexible transportation," "flexible sourcing," "ISO 14001 certification," and "reverse logistics." The paper provides a taxonomy for lean, resilient and green supply chain management practices at three levels: upstream, organization and downstream. Practitioners can use this taxonomy as a checklist to identify possible practices to achieve their sustainability goals. The proposed model makes it possible for researchers to develop surveys in order to better explore the proposed relationships. This paper presents an innovative approach since it studies simultaneously the three dimensions of sustainability (environmental, social and economic), and the lean, resilient and green supply chain management paradigms which are considered strategic for supply chain competitiveness. Identification of the conceptual relationships between supply chain management practices and sustainability is a contribution that the authors hope will become a forward step in the development of new theoretical approaches and empirical research in the field of supply chain management and sustainability.

1. Introduction

In the supply chain (SC) context, it is necessary to implement management practices that not only promote company and overall SC performance, but also that focus on social, economic and environmental concerns (Beske, 2012; Amin and Zhang, 2014; Alzaman, 2014). In other words, supply chain management (SCM) should be concerned with its sustainability as well. Lean, resilient, and green approaches are referred to as SCM paradigms which allow companies to become more competitive and sustainable in a volatile and high demand market. Existing literature focuses on two of these SCM paradigms and sustainability, e.g. the lean and green paradigms and sustainability are studied by Mollenkopf et al. (2010), and green and resilient as a way to increase the sustainability of companies and their supply chains by Azevedo et al. (2013).

However, there are no researches exploring simultaneously the three SCM paradigms and their impact on SC sustainability. So, this study intends to overcome this research gap and aims to propose a conceptual model to analyze the impact of lean, resilient and green SCM practices on SC sustainability. This approach will help the companies and their respective SCs to reduce their business wastes while it increases value to the customer, sustain their operations and overcome disruptions, and at the same time to reduce the negative environmental impacts. A deductive research approach is used to develop a conceptual model from the literature review and a case study is used to address the following three research questions: 1) Which lean SCM practices impact the SC sustainability?; 2) Which resilient SCM practices impact the SC sustainability?; and 3) Which green SCM practices impact the SC sustainability?

The paper is organized as follows. Following the introduction, a literature review on the lean, resilient and green paradigms is provided from a SCM perspective, and several management practices are proposed. After that, some insights on SC sustainability are presented. Subsequently, a conceptual model is proposed as a

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means of suggesting a set of lean, resilient and green practices and their relationships with environmental, social and economic dimensions of SC sustainability. After that, a case study on automotive companies is developed to validate the proposed conceptual model. Finally, some considerations are drawn.

2. Literature background

A SC can be described as a chain that links various entities, from the customer to the supplier, through manufacturing and services so that the flow of materials, money and information can be effectively managed to meet the business requirements (Stevens, 1989; Charkha and Jaju, 2014; Viskari and Karri, 2013). Researchers have started advocating radical changes in the way SCs are managed so far with profit as the sole aim. Efforts to make SCs more environmentally friendly have gained priority due to increasing threats arising from global warming and climate change (Shukla et al., 2009). Only more recently academics have recognized the importance of addressing sustainability issues in SCM (Linton et al., 2007; Carter and Rogers, 2008; Seuring et al., 2008; Krause et al., 2009; Seuring and Müller, 2008; Winter and Knemeyer, 2013; Santos et al., 2013; Topcu et al., 2013; Gobbo et al., 2014; Salimifard and Raeesi, 2014). The World Commission on Environment and Development (WCED, 1987) considers sustainability as economic practices which meet the needs of the present without compromising the ability of future generations to meet their own needs.

Azevedo et al. (2012a) consider that green and lean practices are two important pillars of the sustainable development of business. The deployment of these practices along the SC enables an enhanced social, environmental and economic performance. According to Vinodh et al. (2011) and Fliedner (2008), some of the benefits of synchronizing lean and sustainability principles include reduced costs and lead time, improved process flow, compliance with customer expectations, improvement of environmental quality, as well as employee morale, and commitment. Vinodh et al. (2011) argue that the implementation of green SC practices can influence sustainability; one example is related to Ford that had implemented recyclable plastic containers for shipping their car parts as opposed to cardboard, reducing CO_2 emissions during transportation, improving process efficiency since new containers are handled easily by plant workers, and reducing transportation cost by over 25%.

According to Srivastava (2007) within the context of sustainability, an organization must manage not only short-term financial results, but also the risk factors resulting from its products, environmental waste, and worker and public safety. Carter and Rogers (2008) also consider that SC sustainability encompasses the ability to understand and manage the SC economic, environmental, and social risks. Because of the costs and SC disruption (fragility), the operations field has also become the focus of serious concerns about environmental sustainability, often involving the triple bottom line: planet, people, and profit (Stonebraker et al., 2009). More recently, Ahi and Searcy (2013) expand the business sustainability characteristics to an integrated perspective, including not only the environmental, social and economic focus, but also resilience along the focus on stakeholders, volunteers and long-term performance. Moore and Manring (2009) considered that small and medium size companies could find synergistic effects among resilience and sustainability to increase value creation. In this sense SC resilience is a critical pillar of SC sustainability.

These previous arguments support the simultaneous deployment of lean, resilient and green SCM paradigms to develop a sustainable SC. However, the literature shows that most researches have been focused on the study of individual paradigms in SCM or on the integration of only a couple of paradigms. A review about the integration between lean management and SC sustainability can be found in Martínez-Jurado and Moyano-Fuentes (2014); the study of resilient SCM and sustainability is developed by Fiksel (2006) and Rosič et al. (2009); and the study of green and sustainability in a SC context is explored by Kainuma and Tawara (2006). In a review study about the definitions of SC sustainability, Ahi and Searcy (2013) conclude that resilience is also rarely addressed in definitions of business sustainability. So, new integrative management approaches are needed to deal with the SC sustainability challenge.

In this paper the focus is on lean, green and resilient SCM management paradigms considering its different, but complementary objectives (Carvalho et al., 2011), such as: i) increase value: the lean intents a systematic approach to identify and eliminate all non-value-added activities or "wastes" through continuous improvement; ii) cope with unexpected events: resilience refers to the SC's ability to react efficiently and overcome the negative effects of disturbances; iii) reduce negative environmental impacts: green SCM intends to reduce environmental risks and impacts while improving the SC ecological efficiency. Table 1 contains some of the main lean, resilient and green SCM practices found in literature.

Carvalho et al. (2011) provide a useful comparison of lean, green and resilient paradigms highlighting the existence of synergies and trade-offs among the SCM paradigms, e.g., the presence of strategic inventory reduces the companies' vulnerability to unexpected events that may interrupt the supply of materials, but this same practice could hide the causes of a bad supply chain performance and generate material obsolescence; for that reason, the lean and green paradigms prescribe the minimization of inventory levels. According to Govindan et al. (in press) the definition of lean, green and resilient constructs must take into consideration the interactions among practices. With this in mind, the interactions between practices was one criteria used in the selection of the practices belonging to each SCM paradigm. One example of these interactions is concerned with the practice of lead-time reduction (resilient) which is promoted by the just-in-time practice (lean) but could contribute to a reduction on the practice of energy consumption (green) since it demands higher fuel cost from urgent transportation utilization. The proposed set of lean, green and resilient practices was derived from Table 1 but also considering the practices more relevant for leanness, greenness and resilience of the automotive SC (e.g. Azevedo et al., 2012a,b; 2013; Govindan et al., in press). Also, according to the suggestion of Govindan et al. (in press), in order to guarantee the construct validity, each paradigm is defined using practices that contribute only to that paradigm and that are not related to the other ones. A set of three practices is suggested as follows:

- Lean paradigm: waste elimination, total quality management and just-in-time.
- Green paradigm: cleaner production, ISO 14001 and reverse logistics
- Resilient paradigm: flexible sourcing, SC risk management and flexible transportation

This paper aims to analyze the impact of lean, resilient and green practices on SC sustainability. To this end, the three dimensions of sustainability are considered: i) environmental; ii) social and ii) economic.

3. Conceptual model

In this section, a conceptual model is proposed to explore the impact of lean, resilient and green SCM practices on SC sustainability. That is, it intends to explore the relationships between the

Table 1
Lean, resilient and green supply chain management practices.

SCM practices	Upstream	Focal company	Downstream
Lean	• Supplier relationships (Panizzolo, 1998; Perez and Sanchez, 2000; Berry et al., 2002; Sezen and Turkkantos, 2013) • Just-in-time (Panizzolo, 1998; Berry et al., 2002; Shah and Ward, 2003) • Suppliers involvement in product development (Perez and Sanchez, 2000; Olorunniwo and Jolayemi, 2014)	•Lot size reduction (Shah and Ward, 2003; Saleem et al., 2013; Manna et al., 2013; Hozak, 2013) •Total quality management (Shah and Ward, 2003; Doolen and Hacker, 2005) • Cycle/Setup time reduction (Doolen and Hacker, 2005) • Waste elimination (Schulze and Störmer, 2012)	• Just-in-time (Panizzolo, 1998) • Delivery flexibility (Perez and Sanchez, 2000; Niranjan and Ciarallo, 2013; Sharma and Bhat, 2013) • Customer relationships (Perez and Sanchez, 2000; Doolen and Hacker, 2005)
Resilient	• Sourcing strategies to allow switching of suppliers (Rice and Caniato, 2003) • Flexible supply base/flexible sourcing (Tang, 2006) • Developing visibility (Christopher and Peck, 2004)	• Minimal batch sizes (Christopher and Peck, 2004) • Lead time reduction (Viskari and Karri, 2013; Bansal et al., 2014; Christopher and Peck, 2004) • Supply chain risk management (Christopher and Peck, 2004)	• Flexible transportation (Tang, 2006) • Silent product rollover (Tang, 2006) • Demand-based management (Iakovou et al., 2007)
Green	• Environmental collaboration with suppliers (Vachon and Klassen, 2006) • To encourage suppliers to take back packaging (Rao and Holt, 2005) • Certification of suppliers' environmental management systems (Vachon and Klassen, 2006)	• Cleaner production practices (Rao and Holt, 2005) • To minimize waste (Rao and Holt, 2005) • To decrease the consumption of Hazardous and toxic materials (Zhu et al., 2005) • ISO 14001 certification (Rao and Holt, 2005; Vachon and Klassen, 2006)	• Reverse logistics (Zhu et al., 2005; Jindal and Sangwan, 2013) • Environmental monitoring by customers (Zhu et al., 2005; Vachon and Klassen, 2006) • Discuss with customers about changes in existing packaging (Zhu et al., 2005)

proposed set of practices and the three dimensions of sustainability in order to discover which practices have an effect on which dimension.

A deductive research approach was used to develop the conceptual model from the literature review.

3.1. Impacts of lean practices on supply chain sustainability

There are evidences in literature about the influence of lean philosophy on economic and social sustainability of SCs. According to Fliedner and Majeske (2010) sustainability is the next evolutionary stage of lean as it goes beyond the internal waste elimination of Ohno's seven lean principles encouraging external waste reduction across the SC and leading to improved social conditions globally. One of the contemporary issues is that the lean principles which facilitate waste reduction lead to enhance environmental performance. Non value-added activities consume resources and therefore are not economically sustainable over a long time. Lean and sustainability promote the ability to reduce resource or capacity requirements through conservation and reclamation activities. They also promote the ability to capture resources for a cost that is less than the value recovered. There is no doubt that cost reduction has enhanced companies' bottom-line performance through lean and sustainability initiatives (Fliedner and Majeske, 2010). From this perspective, the following propositions are derived:

P_1: The lean practice "waste elimination" impacts economic sustainability
P_2: The lean practice "waste elimination" impacts social sustainability

Total Quality Management (TQM) is also considered a lean practice that influences the three dimensions of sustainability. Also, due to increased competitive pressure, today's managers are looking to TQM as a way to improve and sustain organizational performance (Abusa and Gibson, 2013). Salajeghen et al. (2013) argue that the existence of qualitative concerns in companies is a must for encouraging organizational resources in order to achieve higher productivity and efficiency. The implementation of TQM practices also involves training of employees in multiple skill sets and empowering them to make decisions relevant to their work in organizations (Ahmad and Schroeder, 2002). Moreover, focusing on cultural and behavioral issues, Gunasekaran (1999) identified communication, team work cross-functional activities, empowerment, training, and education as important enablers of TQM implementation. Correspondingly, environmental education and training for employees solidifies their perception of organizational commitment with respect to sustainability. Being so, there exists a relationship between the implementation of TQM practice and social sustainability. So, the following propositions are derived:

P_3: The lean practice "Total Quality Management" impacts economic sustainability.
P_4: The lean practice "Total Quality Management" impacts social sustainability.

In literature, there are also evidences about the influence of the lean practice "Just-in-time" (JIT) on environmental and economic sustainability. Beamon (2003) considers that JIT principles requiring small transportation batch sizes appears to be at odds with environmental management, in general, and with environmentally-conscious distribution in particular. JIT distribution requires that items are delivered on an as-needed basis, in very small batches. This practice leads to reduced storage costs and increased available capital. However, small volume shipments yield more frequent deliveries, which lead to increased traffic congestion and environmental degradation (Porter and Linde, 1995). JIT practice seems to also have some impact on economic sustainability. Msimangira (2003) argues that the use of JIT can improve a company's manufacturing performance. Ansari and Modarress (1986) defend its positive impact on the inventory levels, Beamon (2003) on increased productivity and efficiency, improved quality, reduced lead times, and improved customer service. Also, Klassen (2000) concluded in his work that the implementation of JIT manufacturing is an important step towards more sustainable manufacturing practices. According to literature, the next propositions are suggested as follows:

P_5: The lean practice "Just-in-time" impacts environmental sustainability.
P_6: The lean practice "Just-in-time" impacts economic sustainability.

3.2. Impact of resilient practices on supply chain sustainability

Researchers in resilience and ecological topics have focused on the ecological properties that are correlated with system resilience. They argue that the following attributes of a system affect its resilience: i) its adaptive capacity, which is broadly equivalent to the diversity amongst organizations and assets available in social systems Folke et al., 2002); and ii) its robustness, which refers to the properties of a system that allow it to accommodate perturbations without additional adaptation (Webb and Levin, 2005). In economic terms, these bear on the ability of the system to withstand either market or environmental shocks without losing the capacity to allocate resources efficiently or deliver essential services (Perrings, 2006). In the literature, there are also evidences of the influence of the resilient practice "SC risk management culture" on economic sustainability. Beamon (1999) argues that total SC cost and profit that account for both benefits and costs of risk management strategies are important outcomes that need to be measured to ascertain the effectiveness of a risk management strategy. On the supply side, two outcomes of interest in global SCs emphasized supply disruptions (Chopra and Sodhi, 2004), and total inbound lead time (Fagan, 1991). On the demand side, the outcomes most emphasized include stock-outs (Chopra and Sodhi, 2004), fill rates (Chang and Makatsoris, 2001), lead times, and delays to customers (Chopra and Sodhi, 2004). Operational outcomes of interest in global SCs include average inventory (Min and Zhou, 2002). The proposition derived is:

P_7: The resilient practice "SC risk management" impacts economic sustainability.

Another resilient practice found in literature about SC sustainability is "flexible transportation." To support SC contingency plans in case of a disruption, many companies are working in a flexible base of transportation modes. Most of them, however, are motor-based which have the most unfavorable environmental impact per ton-mile (Golicic et al., 2010).

Transportation represents a key component of the SC and researchers increasingly recognize its impact upon the overall supply chain (Sanchez-Rodrigues et al., 2010). According to EPA reports, transportation is the fastest growing source of greenhouse gas emissions and also the largest end-use source of CO_2 (Ilyas et al., 2010). According to Crilly and Zhelev (2010), an important means for reducing the pollution caused by transportation is improving the quality of transporting networks. Also, Golicic et al. (2010) consider that the use of flexible transportation modes contributes to a lead time reduction and consequently to less holding inventories, thereby influencing the economic sustainability of SCs. That leads to the following propositions:

P_8: The resilient practice "flexible transportation" impacts environmental sustainability.
P_9: The resilient practice "flexible transportation" impacts economic sustainability.

As regards the resilient practice "flexible sourcing," it seems to impact both the social and economic sustainability. Sourcing activities include analyzing expenses, identifying potential suppliers, requesting quotations, negotiating contracts, monitoring and improving suppliers (Kumar et al., 2003). Sourcing flexibility is the ready capability of the company's SC architecture to cope with change; to realign the chain in response to market uncertainty and change; to rapidly send and receive products cost effectively; and to configure information systems with existing SC entities to meet changing information needs (Stevenson and Spring, 2007).

The impact of "flexible sourcing" on social sustainability is argued by Porter (1995). This author considers adopting a flexible sourcing strategy less risky domestically than abroad. From his point of view, although the cost benefits of sourcing abroad cannot be ignored, the volatile nature of various cultural, economic and political environments in conjunction with logistics issues that might occur could lead to failed sourcing strategies. He argues that implementing flexible domestic sourcing strategies can be a potential source of opportunity and innovation for achieving competitive advantage and social progress when a company applies its considerable resources, expertise and insights to activities that benefit society. Christopher et al. (2011) introduced the term sustainability risk to refer to increasing vulnerability across the chain due to the negative impacts of global sourcing on economic, social and environmental sustainability. They consider that ineffective reverse logistics practices, under-utilized transportation, waste generation, and long distances between suppliers and manufacturers are responsible for increasing the negative impacts of sourcing activities on the environment, and can lead to pollution and emissions of greenhouse gases, particularly CO_2. Also, Gunasekaran and Tirtiroglu (2001) defend the impact of flexible sourcing on performance of organizations and SCs. Considering the literature, the following propositions are suggested:

P_{10}: The resilient practice "flexible sourcing" impacts social sustainability.
P_{11}: The resilient practice "flexible sourcing" impacts economic sustainability.

3.3. Impact of green practices on supply chain sustainability

Industry plays an important role in sustainability. This role is related to the changes in production processes, products and services aimed at reducing the environment impact according to the life cycle perspective. This results in the improvement of environmental, economic and social performance of companies (Honkasalo et al., 2005). Besides the green practices considered within the environmental dimension of the sustainability concept, it is interesting to analyze which of them are recognized as the most important to SC sustainability. Considering the green practice "cleaner production," this concept was founded by UNEP in 1989, along with other terms similar in meaning such as eco-efficiency, green productivity, pollution prevention, etc. (UNEP, 2002). For Kjaerheim (2004), "cleaner production" means using energy and resources efficiently to eliminate toxic raw materials, and to reduce both the amount and toxicity of all emissions and wastes before they leave the production process. There are many benefits that a company can avail in using cleaner production methods. When applying cleaner production, the following economic, environmental and social improvements can be achieved (Halme et al., 2002): improved efficiency; lower costs; conservation of raw materials and energy; improved compliance to market requirements; improved environment; better compliance with environmental regulations; more cohesive working environment for laborers and; better public image of the company. Attending to that, the following propositions are derived:

P_{12}: The green practice "cleaner production" impacts economic sustainability
P_{13}: The green practice "cleaner production" impacts social sustainability
P_{14}: The green practice "cleaner production" impacts environmental sustainability

As regards the green practice "ISO 14001 certification" from the point of view of Schaltegger and Burritt (2000), the impact of this practice on environmental and economic sustainability occurs as company' prepare for certification since their facilities may realize a variety of technological and managerial opportunities to cut material and energy waste in their production processes. Sambasivan and Fei (2008) have identified some perceived benefits of implementing ISO 14001 such as: improved company reputation and image, increased staff morale and motivation, profit, performance and opportunity, customer loyalty and trust. Beyond these benefits, Tan (2005) also identified better business control, transparency/openness, marketing advantages, cost reduction, less injuries/environmental accidents, more research and development, improvement in operations efficiency, improved company image and improved work culture. Moreover, internal analysis of waste streams and decision processes, driven initially by voluntary certification program requirements, may result in process and product innovations that create new products that appeal to environmentally aware consumers (Wagner et al., 2001), which contribute to increased expectations of direct economic advantages. Being so, the following two propositions are suggested:

P_{15}: The green practice "ISO 14001 certification" impacts economic sustainability.
P_{16}: The green practice "ISO 14001 certification" impacts environmental sustainability.

The green practice "reverse logistics" is defined by "the process of planning, implementing, and controlling the efficient, cost effective flow of raw materials, in-process inventory, finished goods, and related information from the point of consumption to the point of origin for the purpose of recapturing value or proper disposal" (Rogers and Tibben-Lembke, 1999). Product recovery and reuse contribute to reduce the negative effects on environment, mainly reducing waste disposal, extraction of raw materials, and transport and distribution emissions (Turrisi et al., 2013). In the literature, evidence exists of its impact on environmental and economic sustainability. The impact of "reverse logistics" on environmental sustainability could be found in Beullens (2004) who states that this green practice prevents waste by diverting materials from landfills and conserving natural resources such as energy and materials. The influence of reverse logistics on economic sustainability can be found in Tonanont (2008) who argues that a well organized reverse logistics not only reduces costs but also increases customer satisfaction and gains competitive advantages. Based on the anecdotal evidences from literature, the following propositions are derived:

P_{17}: The green practice "reverse logistics" impacts economic sustainability.
P_{18}: The green practice "reverse logistics" impacts environmental sustainability.

Based on the eighteen propositions derived from the literature, the following conceptual model is suggested to translate the relationships between lean, resilient and green SCM practices and sustainability (Fig. 1).

As can be seen in Fig. 1, economic sustainability is the dimension with more arrows towards it. This means that in literature there are more evidences on the impact of lean, resilient and green SCM practices on the economic dimension of sustainability. Social sustainability is impacted only by a few lean, resilient and green SCM practices.

4. Methodology

The main objective of this research is to explore and understand the impact of lean, resilient and green SCM practices on SC sustainability. Unfortunately, as noted by Markides (2007) and Shapiro et al. (2007) there is sometimes a gap between management research and practice. To fill this gap, a descriptive case study approach (Yin, 2002) is performed in this study. The importance of

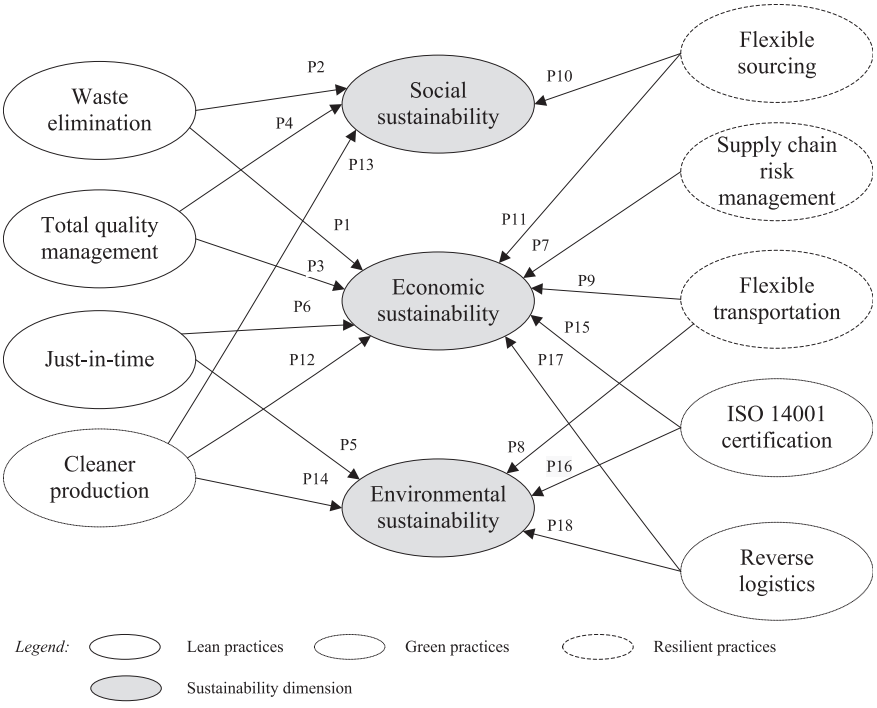

Fig. 1. Conceptual model proposed.

case studies as research methodology has been highlighted by many authors in operations (Voss et al., 2002); logistics management (Ellram, 1996); and supply chain management (Seuring, 2008). Therefore, the conceptual model that was developed using evidences from literature will be verified using data from a real-world context. According to Ellram (1996), case studies are the best means to understand certain phenomenon since they provide depth and richness allowing the researcher to really understand the what, how and why questions pertaining to a given situation. Also, a case study approach is adequate when a phenomenon is not clear and there is also no control over behavioural events (Rowley, 2002), as in this case. Studying the same problem with a multiplicity of methods and from a variety of perspectives can be useful, not only for the study itself, but also for the validity of the analysis. To this end a triangulation approach can be used (Singleton and Straits, 1999) combining multiple data sources (data triangulation), using multiple research methods to analyze the same problem (methodological triangulation), or using multiple investigators to work on the same task (investigator triangulation) (Oppermann, 2000). In this paper, investigator triangulation was used since the research team is composed by four researchers, two experts in industrial engineering, and two on business and logistics.

By using more than one case in a study it is possible to find similarities and differences across the cases deploying various cross-case analysis tools (Yin, 2002). This practice can help in i) identifying critical predictor variables and causal interactions, and ii) validating or extending existing theoretical models. Thus, pattern-matching is rightly characterized as a form of empirical validation for qualitative data (Johnston et al., 2001).

This research is based on the qualitative data-analysis method developed by Miles and Huberman (1994), which consists of anticipatory conceptual model development and simultaneous data collection, reduction, display and conclusion testing. This same methodology can be found in Azevedo et al. (2011) to determine the impact of green SCM practices on SC performance. The objective is not to offer further insight into the single cases, but to bring them together to get a wider picture and learn from the cross-case analysis. The case studies were analyzed as a means to identify the lean, resilient and green practices with significant impact on each dimension of the SC sustainability.

4.1. Sample selection

The study focuses on the automotive industry because this industry seems to be the most developed in terms of environmental issues and sustainability and is also vulnerable to SC disruptions. The automotive sector experiences great expectations from customers and society concerning environmental performance, as its products are by nature resource-burning products (Thun and Müller, 2010). The automotive SC is also under pressure to become more sustainable and, therefore, more environmentally friendly while achieving the expected economic benefits from a more greening behavior (Koplin et al., 2007). Also, there is evidence that the tendency of many automotive companies to seek out low-cost solutions may have led to leaner but also more vulnerable SCs (Svensson, 2000; Azevedo et al., 2008). The automotive SC is a typical example of high vulnerability levels to disturbances (Svensson, 2000). According to Thun and Hoenig (2011), the trends in globalization and the necessity to offer many product variants are the key drivers for increasing the vulnerability of this industry.

According to this, and to attain the paper' objective, a purposive sample (Patton, 1990) constituted by five typical case studies was used, based on a semi-structured interview to obtain the perception of the automotive company professional regarding the impact of the focused SCM practices on SC sustainability. Despite the fact that the companies are located in Portugal, all of them belong to multinational groups and follow their corporations' directives concerning the development of sustainability in business operations. However, as stressed by Moon (2007), corporate social responsibility agendas may differ from country to country and among companies. Moreover, Rosenzweig and Singh (1991) refer that SC environmental behaviour may also differ from country to country. Therefore it is desirable to focus on one SC in one country before moving on to cross-supply chains and cross-country studies. A single SC research design concerned with the Portuguese automotive SC was chosen because of proximity convenience.

In the SC context, case studies should be performed at different stages and nodes of the same supply network in order to get a proper network perspective, thus overcoming the limitations of traditional research (Seuring, 2008). Following this request, the case study companies cover different SC echelons and include two focal companies (automakers), two first-tier suppliers, and one company that acts simultaneously as a first-tier supplier and second-tier supplier. In case study research, there are no unique ideal number of cases (Voss et al., 2002): in traditional sampling methods, a random or stratified sample is used, however, in case study research a convenience sample is used. Multiple case studies often use replication logic, but can also be used to select typical cases within a certain domain (Eisenhardt, 1991). In this case, the replication logic justifies the use of five case studies. The selected suppliers produce metallic components, electric cabling and harness. The design and production of these components represent a challenge for the sustainability of the automotive industry (Alonso et al., 2007). Therefore, the selected sample is representative of automotive companies that intend to achieve sustainability in their operations.

4.2. Data collection

For the collection of primary data and to limit expert bias, the data concerning the personal judgment of the participants were obtained through semi-structured interviews according to the interview protocol in Appendix A. Based on the literature review regarding lean, resilient and green SCM practices and SC sustainability, as well as on the conceptual model developed (Fig. 1), a set of semi-structured interview questions was devised. The protocol was pre-tested by a professional from automotive companies and also three academics. The pre-test consisted of first mailing the protocol and then interviewing these individuals by phone and in person regarding the appropriateness and clarity of the questions. The individual provided written and verbal comments which helped to validate the appropriateness of the protocol and to improve it.

Multiple interviews were used to provide a broader view regarding the perception of professionals from automotive companies about the impact of lean, resilient and green practices on SC sustainability. The same structured interview protocol was used at each session to avoid bias by the interviewer. Follow-up questions devised to clarify and elaborate on the responses were added when necessary. After the interviews, additional follow-up questions were conducted by e-mail. In all cases, the company names were withheld in accordance with the general request for confidentiality.

In the research design, five case studies ($j = 1, 2, \ldots 5$) were used to collect data concerning three lean practices ($k = 1, 2, 3$), three resilient practices ($\beta = 1, 2, 3$), three green practices ($\alpha = 1, 2, 3$) and three dimensions of SC sustainability ($w = 1, 2, 3$; being 1 = social, 2 = economic and 3 = environmental) according to the proposed conceptual model. Using a methodology similar to that of Azevedo et al. (2011), a pure data interview was used to attribute values to the research variables according to the following notation:

i. $(l_{kw})_j$ is the impact level of lean practice k on sustainable SC dimension w in the case study j;
ii. $(r_{\beta w})_j$ is the impact level of resilient practice β on sustainable SC dimension w in the case study j;
iii. $(g_{\alpha w})_j$ is the impact level of green practice α on sustainable SC dimension w in the case study j;

The variables are measured on a 5-point Likert scale, with 1 meaning that the variable does not impact the sustainability dimension, and 5 meaning that the variable has an extremely high impact on the sustainability dimension.

4.3. Data analysis

The collected data in the five case studies was explored in a cross-case analysis to identify the lean, resilient and green SCM practices among all case studies with more impact on social, economic and environmental sustainability and which dimension of SC sustainability is more impacted by SCM practices. Each variable is examined in turn, and a score is calculated. The scores are taken forward in the cross-case analysis to indicate the impact of SCM practices on SC sustainability for the five companies in the case study.

Equation (1) contains a cross-case score to assess the impact level (L_{kw}) of each lean practice l_k on each dimension w of SC sustainability:

$$L_{kw} = \sum_{j=1}^{5} (l_{kw})_j \tag{1}$$

The proposed score in Equation (1) can be replicated according to Equations (2) and (3) for deriving the cross-case impact level of resilient (r_β) and green practices (g_α) respectively on each dimension w of SC sustainability:

$$R_{\beta w} = \sum_{j=1}^{5} (r_{\beta w})_j \tag{2}$$

$$G_{aw} = \sum_{j=1}^{5} (g_{aw})_j \tag{3}$$

To assess the overall effect of each lean, resilient and green practices on the SC sustainability, three scores denoted by L_k_SSC, R_β_SSC, G_α_SSC are proposed which aggregate the impact of each practice (l_k, r_β and g_α respectively) on the three dimensions w of sustainability. These scores are translated by Equations (4)–(6):

$$L_k\text{-SSC} = l_{k1} + l_{k2} + l_{k3} \tag{4}$$

$$R_\beta\text{-SSC} = r_{\beta 1} + r_{\beta 2} + r_{\beta 3} \tag{5}$$

$$G_\beta\text{-SSC} = g_{\beta 1} + g_{\beta 2} + g_{\beta 3} \tag{6}$$

The impact of each set of lean, resilient and green practices on each dimension w of SC sustainability is then aggregated into three scores, namely, $Lean\_SSC_w$, $Resil\_SSC_w$ and $Green\_SSC_w$, as shown in Equations (7)–(9):

$$Lean\_SSC_w = \sum_{k=1}^{3} l_{kw} \tag{7}$$

$$Resil\_SSC_w = \sum_{k=1}^{3} r_{\beta w} \tag{8}$$

$$Green\_SSC_w = \sum_{k=1}^{3} g_{aw} \tag{9}$$

Finally, the impact of lean, resilient and green practices on SC sustainability can be computed by three scores named *Lean_SSC*, *Resil_SSC Green_SSC*. To this end, the impact of practices on SC sustainability Lk_SSC, Rβ_SSC and Gα_SSC are aggregated according to Equations (10), (11) and (12), as follows:

$$Lean\_SSC = L_1\_SSC + L_2\_SSC + L_3\_SSC \tag{10}$$

$$Resil\_SSC = R_1\_SSC + R_2\_SSC + R_3\_SSC \tag{11}$$

$$Green\_SSC = G_1\_SSC + G_2\_SSC + G_3\_SSC \tag{12}$$

5. Case study

To answer the three research questions presented in the introduction, this section purposes to identify the main impacts of lean, resilient and green SCM practices on social, economic and environmental sustainability of automotive SCs. More specifically, the study intends to validate the proposed conceptual model and the eighteen propositions associated with it through a pattern-matching (Johnston et al., 2001).

This section is organised as follows: first, the case studies' profile is presented; second, cross-case analyses are performed to provide a better understanding about the impact of lean, resilient and green SCM practices on SC sustainability. In the end, a final model is proposed based on the case study to illustrate which lean, resilient and green practices impact each dimension of SC sustainability.

5.1. Case study profile

The Portuguese auto component sector employs more than 42.000 workers in about 177 companies (AFIA, 2012). With 80.5% of component production sold to other countries, the auto component industry is one of Portugal's biggest export sectors, playing a strategic role in the economy and representing 8.9% of the country's exports (AFIA, 2012). All the case study companies belong to the

Table 2
Profile of companies.

	Product lines	Position in the supply chain	Company size (employees)	Interviewed
Company 1	Light duty trucks	Focal company	350	Assistant Manager -Quality Assurance
Company 2	Components metallic to automotive industry	Second-tier supplier First-tier supplier	200	Quality Engineer
Company 3	Cars	Focal company	1300	Process Engineer
Company 4	Electric cabling	First-tier supplier	900	Lean manager
Company 5	Harness	First-tier supplier	650	Supplier Management

automotive industry and are sited in Portugal. They represent typical cases allowing to study the impact of lean, resilient and green SCM practices on the sustainability of SCs. Table 2 summarises the five case–studies profile.

The selected companies have some common characteristics. The suppliers studied use a just-in-sequence production philosophy, producing components according to the daily requirements of the automakers, although some sub-assemblies are produced in batches according to a make-to-order policy. The transport of final products to the automaker is performed using specific reusable containers or racks adapted to each product type. These reusable containers or racks will directly supply the assembly line and act as a kanban, that is, their return to the suppliers will act as a signal that more components are needed.

In the automotive industry, the automaker corporations are an important driver for SC sustainability since they are responsible for the environmental and social externalities caused by their suppliers (Koplin et al., 2007). Therefore, the sustainability concerns of the automakers are extended to their suppliers, stimulating the adoption of management systems to improve their economic, social and environmental performance. The companies under study belong to international corporations which already have strong corporate sustainability policies, with global milestones, self-auditing and improvement programmes.

5.2. Impact of lean practices on supply chain sustainability

Table 3 shows the perception of the professionals regarding the impact of lean practices on social, economic and environmental sustainability of SC using a 5-point Likert scale where 1 means "without impact" and 5 means "extremely high impact."

According to Table 3, professionals from automotive SC companies consider that the lean practices with more impact on social sustainability are "waste elimination" and "Total Quality Management." They both reflect a score of twenty two, which means that all the professionals consider the impact of these two practices on social sustainability as high or extremely high (score above 4 on a 5-point Likert scale).

As regards the impact of lean practices on economic sustainability of the SC, according to the values presented in Table 3, "waste elimination" has a higher impact on this dimension of SC sustainability. Now, considering environmental sustainability, "waste elimination" and "Total Quality Management" are the two lean practices with more impact than the "just-in-time" practice, which presents only a weak impact; it has a score of eighteen reflecting the low impact scores that professionals had attributed to it. Considering the three dimensions of SC sustainability jointly, it is possible to observe that "waste elimination" is the lean practice with high impact on overall SC sustainability. It presents an aggregated score of sixty eight.

To decide on which impacts are considered significant between the lean practices and the three dimensions of SC, a reference value equal to or higher than twenty was considered. This baseline of twenty points reflects impact levels equal to or higher than four on a 5-point Likert scale signed by each professional of the five research companies. Bearing in mind this criteria, and according to the Table 3, only the "Just-in-time" practice seems to not have a significant impact on environmental sustainability. The evidences from Table 3 indicate that the propositions P_1, P_2, P_3, P_4 and P_6 are supported.

5.3. Impact of resilient practices on supply chain sustainability

The main objective here is to analyse the relationships between resilient practices and social, economic and environmental sustainability of SCs. In Table 4, a score for each relationship was computed according to the professionals' perception about the impact of each resilient practice on the different dimensions of SC sustainability. To this end, a 5-point Likert scale was used, where 1 means "without impact" and 5 means "extremely high impact."

According to Table 4, the "SC risk management" is the only resilient practice with a significant impact on social sustainability. This practice presents a score of twenty three which is above the baseline of twenty. Now, analysing the impact of resilient practices on economic sustainability of SC, "flexible sourcing" is the one presenting a higher impact with a score of twenty two. Also, all the focused resilient practices have a considerable impact on this dimension, since all of them present a score value equal or above twenty. As regards the impact of resilient SCM practices on environmental sustainability, it can be stated that "flexible sourcing" is the one with a score below twenty. This reflects the professionals'

Table 3
Impact of lean SCM practices on SC sustainability.

Companies (j)	Lean SCM practices (l_k)	Social sustainability ($w = 1$)	Economic sustainability ($w = 2$)	Environmental sustainability ($w = 3$)		
Company 1	Waste elimination	4	5	4	68	$L_1\_SSC = l_{11} + l_{12} + l_{13}$
Company 2	(WE = l_1)	5	5	5		
Company 3		5	5	3		
Company 4		4	5	5		
Company 5		4	5	4		
$L_{1w} = \sum_{j=1}^{5}(l_{1w})_j$		22	25	21		
Company 1	Total Quality Management	4	5	4	66	$L_2\_SSC = l_{21} + l_{22} + l_{23}$
Company 2	(TQM = l_2)	5	5	5		
Company 3		5	5	2		
Company 4		4	5	5		
Company 5		4	4	4		
$L_{2w} = \sum_{j=1}^{5}(l_{2w})_j$		22	24	20		
Company 1	Just-in-time (JIT = l_3)	4	5	4	62	$L_3\_SSC = l_{31} + l_{32} + l_{33}$
Company 2		5	5	5		
Company 3		4	4	2		
Company 4		4	5	4		
Company 5		3	3	3		
$L_{3w} = \sum_{j=1}^{5}(l_{3w})_j$		20	22	18		
$Lean\_SSC_w = \sum_{k=1}^{3} l_{kw}$		64	71	59	194	$Lean\_SSC = \sum_{k=1}^{3} l_{k1} + \sum_{k=1}^{3} l_{k2} + \sum_{k=1}^{3} l_{k3}$

Table 4
Impact of resilient SCM practices on SC sustainability.

Companies (j)	Resilient SCM practices (β)	Social sustainability ($w = 1$)	Economic sustainability ($w = 2$)	Environmental sustainability ($w = 3$)		
Company 1	SC risk management	5	3	4	64	$R_1\_SSC = r_{11} + r_{12} + r_{13}$
Company 2	(SCRM = r_1)	5	5	5		
Company 3		5	5	3		
Company 4		3	5	5		
Company 5		5	3	3		
$R_{1w} = \sum_{j=1}^{5}(r_{1w})_j$		23	21	20		
Company 1	Flexible transportation	4	3	4	59	$R_2\_SSC = r_{21} + r_{22} + r_{23}$
Company 2	(FT = r_2)	5	5	5		
Company 3		3	4	3		
Company 4		3	4	5		
Company 5		4	4	3		
$R_{2w} = \sum_{j=1}^{5}(r_{2w})_j$		19	20	20		
Company 1	Flexible Sourcing (FS = r_3)	4	3	4	59	$R_3\_SSC = r_{31}+r_{32}+r_{33}$
Company 2		5	5	5		
Company 3		3	5	2		
Company 4		3	5	4		
Company 5		4	4	3		
$R_{3w} = \sum_{j=1}^{5}(r_{3w})_j$		19	22	18		
Resil_SSC$_w = \sum_{\beta=1}^{3} r_{\beta w}$		61	63	58	182	Resil_SSC $= \sum_{\beta=1}^{3} r_{\beta 1} + \sum_{\beta=1}^{3} r_{\beta 2} + \sum_{\beta=1}^{3} r_{\beta 3}$

perception of the weak influence of this practice on this particular dimension of sustainability. Both "SC risk management" and also "flexible transportation" are considered as having a significant impact on the environmental sustainability of SCs.

Table 4 also shows that, considering the aggregated sustainability of SC (computed by the sum of the social, economic and environmental sustainability), "SC risk management" is the resilient practice with higher value (sixty four from a maximum value of seventy five). In conclusion, Table 4 gives evidence to support the next propositions P_7, P_8, P_9 and P_{11}.

5.4. Impact of green practices on supply chain sustainability

The professionals' perception about the impact of each green practice on the different dimensions of SC sustainability was collected using a 5-point Likert scale where 1 means "without impact" and 5 means "extremely high impact" as shown in Table 5.

In a cross-case analysis, it is possible to infer that the green practice with higher impact on social sustainability is "cleaner production" with a score of twenty (Table 5). Both "ISO 14001 certification" and also "reverse logistics" present scores of eighteen which are below the baseline of twenty. This means that the impact of these two green practices on social sustainability is not considered significant by the companies' professionals. The economic sustainability is impacted by both "cleaner production" and "reverse logistics." The green practice "ISO 14001 certification" presents a score of twenty three, representing the green practice with higher impact on the environmental sustainability of SCs.

Among the green research SCM practices, "cleaner production" with an aggregate score of sixty two, is considered by the researched companies as the one having significant impact on overall SC sustainability, The analysis of data from Table 5 gives evidence to support the propositions P_{12}, P_{13}, P_{14}, P_{16}, P_{17} and P_{18}.

Table 5
Impact of green practices on SC sustainability.

Companies (j)	Green SCM practices (α)	Social sustainability ($w = 1$)	Economic sustainability ($w = 2$)	Environmental sustainability ($w = 3$)		
Company 1	Cleaner Production	4	4	4	62	$G_1\_SSC = g_{11} + g_{12} + g_{13}$
Company 2	(CP = g_1)	5	5	5		
Company 3		4	4	3		
Company 4		4	5	5		
Company 5		3	3	4		
$G_{1w} = \sum_{j=1}^{5}(g_{1w})_j$		20	21	21		
Company 1	ISO 14001 certification	5	3	5	59	$G_2\_SSC = g_{21} + g_{22} + g_{23}$
Company 2	(ISO = g_2)	3	3	3		
Company 3		3	3	5		
Company 4		3	4	5		
Company 5		4	5	5		
$G_{2w} = \sum_{j=1}^{5}(g_{2w})_j$		18	18	23		
Company 1	Reverse Logistics	3	3	4	60	$G_3\_SSC = g_{31} + g_{32} + g_{33}$
Company 2	(RL = g_3)	5	5	5		
Company 3		3	4	3		
Company 4		3	5	4		
Company 5		5	4	5		
$G_{3w} = \sum_{j=1}^{5}(g3w)_j$		18	21	21		
$Green\_SSC_w = \sum_{\alpha=1}^{3} g_{\alpha w}$		56	60	65	181	$Green\_SSC = \sum_{\alpha=1}^{3} g_{\alpha 1} + \sum_{v=1}^{3} g_{\alpha 2} + \sum_{\alpha=1}^{3} g_{\alpha 3}$

5.5. Impact of lean, resilient and green practices on supply chain sustainability

The shaded cell in each of the Tables 3–5 provides evidence of the overall impact level of the lean, resilient and green practices on SC sustainability. According to these values, the total impact of lean practices on SC sustainability is 194, impact of resilient practices on SC sustainability is 182, and finally, the overall impact of the green practices on the SC sustainability is 181.

The data analysis of the case study helps to assess the validity of the proposed conceptual model. The qualitative approach adopted in this research allows us to explore the automotive SC professionals' perceptions about the impact of lean, resilient and green practices on social, economic and environmental sustainability of SCs. This research design made it possible to elaborate a model adjusted to the realities of business. Therefore, according to the data collected from the five case studies and its analysis, the model in Fig. 2 is proposed to provide a global overview and understanding about which lean, resilient and green SCM practices impacts SC sustainability.

Based on the proposed model, a relationship occurs when in the case study the practice was identified as highly impacting a specific dimension of sustainability. This model was derived from the initial, conceptual model, but not all relationships are supported. Given the case-study data, it was not possible to establish a relationship between the lean practice "Just-in-time" and environmental sustainability; " the resilient practice "flexible sourcing" and social sustainability; and the green practice "ISO 14001 certification" and economic sustainability. Beyond the proposed relationships, other relationships that were not previously identified in the conceptual model were pointed out by the case study data, such as: the impact of "waste elimination" on environmental sustainability; "Total Quality Management" on environmental sustainability; and the impact of "Just-in-time" on social sustainability; and finally, the impact of "SC risk management" on social sustainability and environmental sustainability.

6. Conclusions

6.1. Conclusions -remarks

This paper investigates the impact of lean, resilient and green practices on social, economic and environmental sustainability of SCs. A comprehensive review of the literature to date was performed to identify a set of practices associated with lean, resilient and green SCM paradigms, and also the sustainability of SCs. A deductive research approach was used to develop a conceptual model from the literature review.

Based on data obtained from five case studies of Portuguese companies belonging to the automotive SC, it was found that not all the lean, resilient and green SCM practices have significant impact on the SCs sustainability. The resilient practices "flexible transportation" and "flexible sourcing" do not have a significant impact on SC sustainability and also, the same happens with the green practices "ISO 14001 certification" and "reverse logistics." As regards "flexible transportation," the researched companies consider that this practice does not have a significant impact on social sustainability, but the economic and environmental sustainability of SCs are impacted by it. This same result could be found in Golicic et al. (2010). With respect to "flexible sourcing," only economic sustainability was identified as being impacted by this resilient practice, which is also in line with Beamon (1999) and Gunasekaran and Tirtiroglu (2001).

Considering the green practice "ISO 14001 certification," the case study companies believe that it has a significant impact only on the environmental sustainability which allows us to conclude

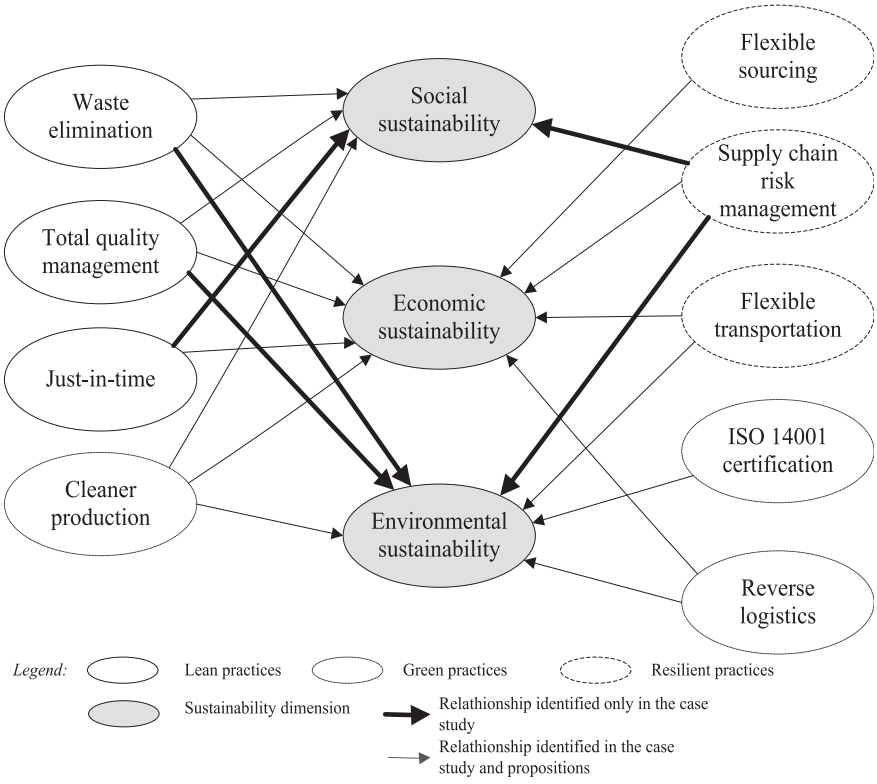

Fig. 2. Model for the impact of lean, resilient and green SCM practices on SC sustainability.

that this practice does not have an impact on the aggregated sustainability of SCs. This result is supported by Schaltegger and Burritt (2000) considering its impact on environmental sustainability, but is contrary to the conclusions drawn by Wagner et al. (2001). According to Wagner et al. (2001), the "ISO 14001 certification" has an impact (negative) on the economic dimension of sustainability. However, the authors justify this conclusion arguing that this relation may be very specific to the paper industry. So, it must be noted in regard to the conclusions, that these relationships are influenced by the type of industry studied. Moreover, the research companies also consider that the green practice "reverse logistics" has only a significant impact on economic and environmental sustainability. This same conclusion can be found in Beullens (2004) and Tonanont (2008).

Summing up, according to the literature review and also the case study approach, the lean, resilient and green SCM practices with significant impact on SC sustainability are: "waste elimination," "supply chain risk management" and "cleaner production." This is because these are the only three SCM practices with significant impact on both social, economic and environmental sustainability of SCs.

The above results support fifteen propositions from the eighteen of this research. According to these results, the only propositions that were not supported by this study are P_5, P_{10} and P_{15}. The identification of the conceptual relationships between SCM practices and SC sustainability is a contribution that the authors hope will become a forward step in the development of new theoretical approaches and empirical research in the field of supply chain management and sustainability.

This paper makes several contributions. First, this conceptual model for the impact of lean, resilient and green practices on supply chain sustainability is theory-driven and can be applied to any SC setting. Second, Table 1 provides a taxonomy for lean, resilient and green SC practices at three levels: upstream, organization level, and downstream. Practitioners can use this taxonomy as a checklist to identify possible practices to achieve their sustainability goals. Third, by utilising the proposed model here, researchers can develop empirical research studies that can better explore the suggested relationships.

6.2. Limitations and scope of research

Although the objective of the study was successfully accomplished, some limitations should be noted. The social dimension of sustainability is underexplored since there is a lack of literature about it. The conceptual model was developed using anecdotal and empirical evidences present in the literature and no validation was performed. Although the above findings are generalizable, some attention must be given to the fact that only five companies were studied. According to Yin (2002) the qualitative research is generalizable by a quite different logic from that of a sample survey. Many qualitative studies involve making one of two types of generalizations: case-to-case transfer or analytic generalizations (Miles and Huberman, 1994). Case-to-case transfer involves making generalizations from one case to another case. Analytic generalization is not generalization to some defined population that has been sampled, but to a theory of the phenomenon being studied, a theory that may have much wider applicability than the particular case studies (Yin, 2002), as it is in this case.

Future research requires testing the propositions derived from the model, being necessary to develop scales for both the SCM practices and sustainability indicators, and to perform the Structural Equation Modeling to empirically test the proposed model.

It will also be interesting to perform the same study in the automotive supply chain sited in developing countries (ex. Brazil, China, India) and compare both results. The automotive industry in developing countries presents different characteristics, such as: capital-intensive, lack manufacturing and design technology, related industries are weak, and capital investment in production, marketing, and R&D activities is limited (Jan and Hsiao, 2004). Considering these differences, it will be interesting to study, on one side the level of implementation of lean, resilient and green practices across the automotive industry in these developing countries, and on the other side, their impact on the sustainability of SCs.

6.3. Managerial implications

This study represents an important contribution for managers. It gives insights on the kind of lean, resilient and green practices with significant impact on SC sustainability. In the presence of this information, it is easier for companies to choose the set of practices that should be employed to improve social, economic and environmental sustainability.

Moreover, the proposed model represents an important framework making it easier to assess the impact of each SCM practice on SC sustainability.

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Appendix A

Dear expert/professional,

Kindly provide us your perception about the impact level of a set of supply chain management practices on supply chain sustainability. This makes part of a research about the supply chain sustainability. Data will be used only academically.

Personal data
Experts/Professionals identification
Country:

_____

Affiliation:

_____

Main activity of the company: _____
Number of employees: _____
Job title/areas of expertise: _____
Experience (years): _____
Primary product(s) (if applicable): _____
How do you define your position in your supply chain (if applicable)?

4th tier supplier	3rd tier supplier	2nd tier supplier	1st tier Supplier	Focal firm	1st tier customer	2nd tier customer	Retailer	End-customer

1 For the following supply chain management practices, please indicate your perception about their level of impact on the social sustainability of supply chains.

The social sustainability refers to the human capital of the supply chain. It involves developing and maintaining business practices that are fair and favourable to the labour, communities, and regions touched by the supply chain.

Supply chain management practices	Social sustainability				
	1 Without impact	2	3	4	5 Extremely high impact
Waste elimination					
Total quality management					
Just in time					
Cleaner production					
ISO 14001					
Reverse logistics					
Flexible sourcing					
Supply chain risk management					
Flexible transportation					

2 For the following supply chain management practices, please indicate your perception about their level of impact on the environmental sustainability of supply chains.
The environmental sustainability refers to all of the living and non-living things that occur naturally on Earth, including the land, water, plants, animals, etc. Improving environmental sustainability means reducing the supply chain ecological footprint.

Supply chain management practices	Environmental sustainability				
	1 Without impact	2	3	4	5 Extremely high impact
Waste elimination					
Total quality management					
Just in time					
Cleaner production					
ISO 14001					
Reverse logistics					
Flexible sourcing					
Supply chain risk management					
Flexible transportation					

3 For the following supply chain management practices, please indicate your perception about their level of impact on the economic sustainability of supply chains.
The economic dimension refers to the profits earned by the supply chain members.

Supply chain management practices	Economic sustainability				
	1 Without impact	2	3	4	5 Extremely high impact
Waste elimination					
Total quality management					
Just in time					
Cleaner production					
ISO 14001					
Reverse logistics					
Flexible sourcing					
Supply chain risk management					
Flexible transportation					

Thank you for your kind collaboration.

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