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ORIGINAL PAPER

Lean, green and resilient practices influence on supply chain performance: interpretive structural modeling approach

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Abstract Nowadays, companies are struggling to find an appropriate supply chain strategy to achieve competitiveness. Among the available strategies lean, green and resilient are considered as a new management strategies for the supply chain management to achieve competitiveness. The major issues with theses strategies are the integration and identification of critical issues related to the strategies. This paper aims to identify the critical lean, green and resilient practices on which top management should focus in order to improve the performance of automotive supply chains. The systematic analysis of the lean, green and resilient practices is expected to be of great value for their effective implementation by the automotive companies. The interpretive structural modeling approach is used as a useful methodology to identify inter-relationships among lean, green and resilient practices and supply chain performance and to classify them according to their driving or dependence power. According to this research, the practices with the main driving power are just-in-time (lean practice), flexible transportation (resilient practice) and environmentally friendly packaging (green practice). Customer satisfaction is the performance measure with strong dependence and weak driving power; that is, it is strongly influenced by the other researched variables but does not affect them.

Keywords Lean · Green · Resilient · Supply chain performance · Interpretive structural modeling · Automotive supply chain

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Introduction

Supply chain management is considered as a strategic factor for increasing organizational effectiveness and better attainment of organizational goals such as enhanced competitiveness, better customer service and increased profitability (Gunasekaran et al. 2001). Among the various supply chain management paradigms, the lean, green and resilient are considered critical to supply chain competitiveness and success (Carvalho et al. 2010, 2011; Azevedo et al. 2010).

Many organizations throughout the world are using the lean principles and methods to reduce costs, improve product quality and increase customer responsiveness. Lean paradigm strives to identify and eliminate all non-value-added activities, or waste, involved in any kind of business process (Anand and Kodali 2008). Organizations, however, do not necessarily integrate environmental concerns into the implementation of lean paradigm. Research on organizational experience with lean and green paradigms suggests that while lean and green have different drivers and approaches, they can be compatible and even synergistic systems. Lean paradigm can add value to green efforts by reducing many types of environmental impacts, connecting green practices to stronger financial drivers and improving the effectiveness of green procedures (Tice et al. 2005). Environmental wastes and risks are not explicitly included in the wastes targeted by lean. However, lean practices contribute to reduce some of these environmental impacts because of their intrinsic focus on waste elimination (Tice et al. 2005). There is evidence that many organisations tend to seek out low-cost solutions. This is because the pressure on margins may have led to leaner but also made supply chains more vulnerable (Azevedo et al. 2008). In a global economy, with supply chains crossing several countries and continents, the risk of critical and unexpected events is higher; this can create large-scale disruptions. These disruptions are propagated throughout the supply chain, causing severe and negative effects in all partners (Zsidisin et al. 2005). It seems that what can be good, from the competitive point of view, can cause a disaster in crisis situations; organizations must be resilient and robust to sustain their competitiveness (Carvalho et al. 2012).

From the literature review, it is clear that most of the researches have focused on studying individual paradigms in supply chain management with the focus on lean or green or resilience (Anand and Kodali 2008; Hong et al. 2009; Glickman and White 2006) or on the integration of only a couple of them, e.g., lean versus green (Kainuma and Tawara 2006) or resilience versus green (Rosic et al. 2009; Azevedo et al. 2013a). Although studies on simultaneous integration of lean, green and resilient paradigms in supply chain management are unknown, they are considered crucial to help supply chains to become more efficient, streamlined and sustainable (Carvalho et al. 2011). This work intends to fulfill the research gap that exists on this topic and to improve the knowledge as regards the simultaneous influence of lean, green and resilient paradigms on supply chain performance.

Based on the research gap, this study aims to address the following issues: (1) identify the critical lean, green and resilient practices affecting automotive supply chain performance; (2) evolve a hierarchical relationship among lean, green and resilient practices and supply chain performance measures, their driving powers, and dependence; (3) synthesis of a conceptual interpretive structural model (ISM) of lean, green and resilient, and performance measures for automotive supply chain.

The paper is organized as follows. After the introduction, a brief review of literature concerned to lean, green and resilient paradigms is presented; then, the ISM approach is described and after that the main results are highlighted and discussed. Finally, conclusions are drawn.

Review of literature

In this section, the review is classified into following areas such as review of lean, green and resilient supply chain management paradigms highlighting their synergies and divergences. The literature reviewed follows a purposive sample of articles, i.e., the literature included in this study was based on central and pivotal articles published in the academic journals in the field.

Lean management approach, developed by Ohno (1988) at Toyota Motor Corporation in Japan, forms the basis of the Toyota Production System with two main pillars: "autonomation" and "just-in-time" (JIT) production. The focus of lean paradigm has essentially been on the waste reduction used for increasing actual value adding activities, to fulfill customer needs and maintaining profits. Reichhart and Holweg (2007) had extended the concept of lean production to the downstream or distribution level: "we define lean distribution as minimizing waste in the downstream supply chain, while making the right product available to the end customer at the right time and location". To Vonderembse et al. (2006), a lean supply chain is the one that employs continuous improvement efforts that focus on eliminating waste or non-value steps along the chain. The internal manufacturing efficiency and setup time reduction are the enablers of the economic production of small quantities, cost reduction, profitability and manufacturing flexibility (Vonderembse et al. 2006).

Green supply chain management has emerged as an organizational philosophy to achieve corporate profit and market share objectives by reducing environmental risks and impacts while improving the ecological efficiency of these organizations and their partners (Zhu et al. 2008a, b; Rao and Holt 2005). Several factors lead firms to pursue green supply chain practices in a global context, including common global environmental standards such as ISO 14000 (Rondinelli and Berry 2000; Miles and Russell 1997), policies from corporate headquarters (Hanson et al. 2004), effects of environmental performance on organizations's global reputations (Christmann 1998), cost reduction (Zhu et al. 2005; Brito et al. 2008), and pressures from stakeholders (Zhu et al. 2008a, b, Christmann and Taylor 2001) and competitors (Walker et al. 2008). To improve the sustainability and competitiveness of supply chains, it is necessary to integrate environmental management practices into the entire supply chain (Zhu et al. 2005; Linton et al. 2007). Srivastava (2007) referred that green supply chain management can reduce the ecological impact of industrial activity without sacrificing quality, cost, reliability, performance or energy utilization efficiency, meeting environmental regulations to not only minimizing ecological damage, but also leading to overall economic profit. The green supply chain management practices should cover all the supply chain activities, from green purchasing to integrate life cycle management, through the manufacturers and customers and closing the loop with reverse logistics (Zhu et al. 2005). According to Bowen et al. (2002), green supply practices include: (1) greening the supply process—representing adaptations to supplier or management activities, including collaboration with suppliers to eliminate packaging and implementing recycling initiatives; (2) product-based green supply—managing the by-products of supplied inputs such as packing; (3) advanced green supply—proactive approaches such as the use of environmental criteria in risk sharing, evaluation of buyer performance and joint clean technology programs with suppliers.

Today's marketplace is characterized by higher levels of turbulence and volatility. As a result, supply chains are more vulnerable to disruptions and, in consequence, the risk of business continuity has increased (Azevedo et al. 2008). Whereas in the past, the principal objective in supply chain design was cost minimization or service optimization, and the emphasis today has to be upon resilience (Tang 2006). Resilient supply chains may not be the lowest-cost supply chains, but they are more capable of coping with the business environment uncertainty. Resilience refers to the ability of the supply chain to cope with unexpected disturbances. In supply chain systems, the objective is to react efficiently to the negative effects of disturbances (which could be more or less severe) (Zobel 2011). The aim of the resilient strategies has two manifolds (Haimes 2006): (1) to recover the desired values of the states of a system that has been disturbed, within an acceptable time period and at an acceptable cost; and (2) to reduce the effectiveness of the disturbance by changing the level of the effectiveness of a potential threat. Tang (2006) proposes the use of robust supply chain strategies based on (1) postponement; (2) strategic stock; (3) flexible supply base; (4) make-and-buy trade-off; (5) economic supply incentives; (6) flexible transportation; (7) revenue management; (8) dynamic assortment planning; and (9) silent product rollover. Christopher and Peck (2004) propose the following principles to design resilient supply chains: (1) selecting supply chain strategies that keep several options open; (2) re-examining the "efficiency versus redundancy" trade-off; (3) developing collaborative working; (4) developing visibility; (5) improving supply chain velocity and acceleration. Iakovou et al. (2007) refer the following resilient interventions: (1) flexible sourcing; (2) demand-based management; (3) strategic emergency stock; (4) total supply chain visibility; and (5) process and knowledge backup.

There is no agree upon a definition of lean, green or resilient paradigm in the supply chain, and formulations for the overall purpose of each paradigm and respective management practices are divergent (Pettersen 2009; Srivastava; 2007; Ponomarov and Holcomb 2009). Formulating a definition that captures all dimensions of lean, green and resilience supply chain management paradigms is challenging. Carvalho et al. (2011) provide a useful comparison of lean, green and resilient paradigms. According to these authors, each paradigm follows the following purpose: (1) Lean—looks for cost reduction and flexibility, for already available products, through continuous elimination of waste or non-value added activities across the chain. (2) Green—focuses on sustainable development, this is in the reduction in ecological impacts on industrial activity. (3) Resilient—is related to the system' ability to return to its original state or to a new, more desirable, after experiencing a disturbance, and avoiding the occurrence of failure modes. Attending to the literature review, the Fig. 1 illustrates a summing up of the main characteristics of the lean, green and resilient paradigms with their joint positive influence on supply chain performance.

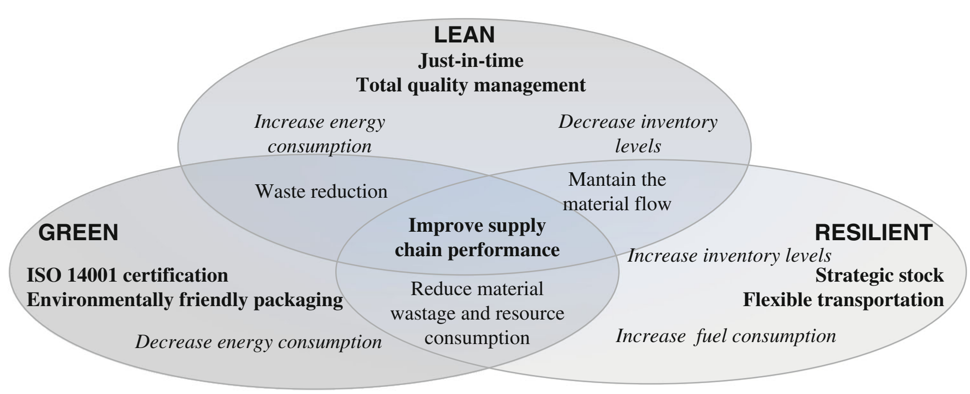

Fig. 1 Lean, green and resilient main characteristics and their influence on SC performance

In literature, it is possible to find an extensive set of practices associated with these paradigms and also some works on the comparison between them, namely green and resilient practices (Carvalho et al. 2012); lean, green and resilient practices (Carvalho et al. 2011); and lean and green practices (Carvalho et al. 2010). Table 1 contains the paradigms characterization considering four dimensions: manufacturing focus, alliances with suppliers and customers, organizational structure, and materials management, in addition the practices associated with each one of these dimensions.

Cabral et al. (2012) argue that there are synergies and divergences between the lean, green and resilient paradigms. Carvalho et al. (2011) argue that the implementation of these paradigms in the supply chain creates synergies promoting improvements on "information frequency", "integration level", "production lead-time" and "transportation lead-time". However, they found some apparent divergences in the paradigms deployment, namely in what is concerned to the "capacity surplus", "replenishment frequency" and "inventory level". For example, the presence of strategic inventory, which reduces the companies' vulnerability to unexpected events that may interrupt materials supply, 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.

In a recent study, Carvalho and Cruz-Machado (2014) verify that in companies belonging to different automotive supply chain echelon presented different behaviors: (1) the manufacturer is more lean, while the first-tier suppliers deploy resilient practices with higher implementation degree, being more resilient; (2) all companies present a similar green behavior. This suggests that, in a supply chain context, not all companies need to have a higher implementation score for all paradigms practices: some companies can be more resilient than others; and the same happens with the lean paradigm not all companies in a supply chain need to be totally lean. Therefore, supply chains, and respective companies, can comprise various degrees of lean, green and resilient behaviors.

The definition of lean, green and resilient constructs also must take in consideration the practices interaction. One example of these interactions is concerned with the practice lead-time reduction (resilient) which is promoted by the JIT practice (lean) but could reduce the practice energy consumption (green) since it demands higher fuel cost from urgent transportation utilization. The following constructs and respective variables (practices) are proposed for the automotive supply chain as defined in Table 2:

- Lean paradigm: JIT and total quality management (TQM) programs.

Table 1 Lean, green and resilient supply chain paradigms characterization

Paradigms	Lean	Green	Resilient
Dimensions			
Manufacturing focus	Objective: High average utilization rate	Objective: Eco efficiency and waste reduction	Objective: Improve flexibility and build capacity redundancies
	Practices: Just-in-time	Practices: Reduce energy consumption	Practices: Lead-time reduction
	Pull flow	Minimize waste and pollution emissions	Strategic disposition of additional capacity
Alliances with suppliers and customers	Objective: Long-term partnerships and joint ventures at the operational level	Objective: Transfer or/and disseminate green knowledge	Objective: Develop security practices and share knowledge
	Practices: Supplier relationships/long-term business relationships	Practices: Environmental collaboration with suppliers and customers	Practices: Creating total supply chain visibility
	Customer relationship programs	Environmental monitoring of suppliers	Flexible supply base/flexible sourcing
Organizational structure	Objective: Improve process and product quality	Objective: Environmental management system	Objective: Risk management culture
	Practices: Total quality management (TQM) programs	Practices: ISO 14001 certification	Practices: Risk management programs
Materials management	Objective: Streamline material flow	Objective: Reduce material wastage and resource consumption along the supply chain	Objective: Maintain the material flow after a disturbance occurrence
	Practices: Lot-size reduction	Practices: Reuse/recycling materials	Practices: Strategic stock
	Inventory minimization	Environmentally friendly packaging	Flexible transportation
		Reverse logistics	

Table 2 Variables considered in the case study

Constructs	Variable	Clarification
Lean	Just-in-time	A production scheduling concept that calls for all raw materials, work in process and finished goods to be available precisely when needed. It promotes the use of minimal inventories of raw materials, work in process and finished goods. Therefore, it is expected to reduce the inventory levels, quality and throughput levels (Kannan and Tan 2005)
	TQM	An integrative organization-wide approach focused on continuous improvement. It is associated with higher levels of product quality; it is a driver for customer satisfaction and improves efficiency in organization's operations function (Kannan and Tan 2005)
Green	ISO 14001 certification	A systematic approach to reduce organization's environmental impacts. In supply chain context, it can act indirectly to influence all partners to adopt more environmentally friendly practices. It promotes the reduction in resource usage and waste reduction, and contributes to quality improvement (Nawrocka et al. 2009)
	Environmentally friendly packaging	The term is used in the broader sense to include reusable, returnable, degradable or easy to recycle packing materials (boxes, bags, pallets, racks, containers, among others). It is expected that the application of environmentally friendly packaging initiatives will reduce environmental costs and business waste (Huang and Matthews 2008) while improving customer satisfaction (Nair and Menon 2008)
Resilient	Strategic stock	It is used as buffers between demand fluctuating and/or product variety and smooth production output (Naylor et al. 1999). It increases materials availability reducing the stock-out ratio and improvements in service level are expected (Jeffery et al. 2008)
	Flexible transportation	It comprises the rapid change of transport mode, multimodal transportation or use of multiple routes. It ensures a continuous flow of materials and sustains supply chain performance in case of disruptions (Rosic et al. 2009; Tang 2006)
Supply chain performance	Operational cost	It is related to the expenses of running a business; it includes production costs, transportation costs and inventory holding costs, among others. It is an important aid to making judgments and decisions, because its purpose is to evaluate, control and improve operational processes (Jeffery et al. 2008)
	Business wastage	It is used in its broader sense including typical lean wastages, e.g., effects in products, excessive inventory, excessive lead-time, excessive scrap, excessive transportation (Singh et al. 2010) and also solid and liquid wastes, percentage of materials remanufactured, recycled and re-used, hazardous and toxic material output
	Environmental cost	It is crucial to have information about environmental practice's costs to scrap/rework (Christiansen et al. 2003), disposal (Tsai and Hung 2009) and purchasing environmentally friendly materials (Zhu et al. 2005), certification, among others
	Customer satisfaction	The degree to which customers along the supply chain are satisfied with the product and/or service received, (Beamon 1999). It includes after-sales service efficiency, rates of customer complaints, stock-out ratio, delivery time, among others indicators.

- Green paradigm: ISO 14001 certification and environmentally friendly packaging.
- Resilient paradigm: Strategic stock and flexible transportation.

The lean, green and resilient paradigms are deployed with the intention of improving supply chain and company' performance. The choice of the appropriate set of performance measures to be part of a supply chain performance measure system is not a trivial task (Azevedo et al. 2013b). In this study, to define the construct "supply chain performance," the introduction of complex relationships among performance measures was avoided. Only autonomous performance measures (i.e., measures having a weak influence on others performance measures) were considered. According to Azevedo et al. (2013b), these measures are operational costs, business wastage, environmental costs, customer satisfaction and delivery time. To assure the validity of the construct "supply chain performance", the performance measure "customer satisfaction" was considered being defined in the following way: the degree to which customers are satisfied with the product and/or service received along the supply chain. A satisfied customer will repeat the purchases of the goods or services; therefore, it is a measure of the company's competitiveness. Since in the supply chain context, each company must satisfy the demand of next level, this measure is not related exclusively to the end consumer but with all customers along the supply chain. It includes several dimensions such as after-sales service efficiency, rates of customer complaints, stock-out ratio, quality, cost and delivery; therefore is related to the measure delivery time proposed by Azevedo et al. (2013b).

Considering these arguments, the supply chain performance construct is composed by four measures as defined in Table 2: operational costs, business wastage, environmental costs and customer satisfaction.

Attending to the literature review and the research gap, the identification of the relationships between lean, green and resilient practices and supply chain performance is critical to a better understanding of the main characteristics of supply chain performance.

Keeping in mind the literature review and also the main characteristics of the automotive supply chain, the addressed research questions are as follows:

- Which practices deployed by the automotive supply chain are most important to it be considered as lean, green and resilient?
- Which measures are considered most important to assess the influence of lean, green and resilient practices on the automotive supply chain performance?
- What relationships are there between lean, green and resilient practices and supply chain performance in the automotive supply chain?

Materials and methods

The ISM approach is used to identify the relationships between lean, green and resilient practices and also supply chain performance measures. This methodology was chosen because it supports the identification of the main relationships among specific variables, which define a problem or an issue (Charan et al. 2008; Sage 1977). It allows in the identification of the main research variables, and also it can act as a tool for imposing order and direction on the complexity of relationships among variables (Kannan and Haq 2007).

The ISM approach was first proposed by Warfield in 1973 (Warfield 1974a, b; Sage 1977) to analyze the complex socioeconomic systems. ISM is a graph-theoretic method that belongs to the causal mapping family of approaches. It can be used to address problems that are complex and subjective. The ISM approach is useful when a multilevel research design is required and where the outcome of the research cannot be predicted based on available research (Klein and Kozlowski 2000). Its basic idea is to use expert's practical experience and knowledge to decompose a complicated system into several sub-systems (elements) and construct a multilevel structural model (Anantatmula and Kanungo 2005; Warfield 1976).

ISM can also be used for identifying and the summarizing relationships among specific variables, which defines a problem or an issue (Sage 1977; Warfield 1974a, b). It provides a means by which order can be imposed on the complexity of such variables Mandal and Deshmukh 1994; Jharkharia and Shankar 2004). This section deals with the discussion of ISM methodology. The ISM approach has been widely applied in various applications (Table 3).

The steps involved in the ISM approach are described as follows and also in the flow chart (Fig. 2) (Charan et al. 2008; Talib et al. 2011):

1. *Organize an ISM implementation group*: To begin with, a group of people with relevant knowledge, skills and backgrounds related to the researched topic must be chosen;
2. *Identify and select the relevant lean, green, resilient practices and performance measures*: During this stage, group members work together to document the lean, green and resilient practices and also performance measures which could be used to evaluate the influence of those practices on supply chain performance. This can be done, for example, via group brainstorming.
3. *Determine the adjacent matrix*: Through the use of the expert group, the directed relationships among the ten variables are hypothesized. This is a way of working on the trade-offs that could exist among supply chain practices and performance measures. Here, the adjective "directed" refers to the need to specify the direction of the relationship (if any) between any two supply chain performance measures—e.g., from A to B, from B to A, in both directions between A and B, or A and B unrelated.
4. *Determine the reachability matrix*: Based on the adjacent matrix, a binary matrix (elements are 0 or 1) that reflects the directed relationships between all the supply chain practices and performance measures is created. Reachability matrix is developed from the SSIM, and next the matrix is checked for transitivity. Basically, the reachability matrix answers the question: yes or no—can we "reach" factor B by starting at factor A, where by "reach" we mean is there a direct or indirect relationship from A to B? (In practice, it might sometimes be possible and more convenient to construct the reachability matrix directly simply by using the experts' knowledge and Delphi techniques.)
5. *Decompose the lean, green, resilient practices and supply chain performance measures into different levels*: Here, the reachability matrix is decomposed to create structural models, that is, a directed graph is drawn and the transitive links are removed. This is an algorithm-based process which provides for the grouping of the ten research variables into different levels,

Table 3 Applications of ISM approach

Year	Author	Application
1975	Hawthorne and Sage (1975)	Higher-education program planning
1977	Sage (1977)	Modeling on complex situations presented by large systems
1980	Jedlicka and Mayer (1980)	Exploring factors involved in a cross-cultural context
1992	Saxena et al. (1992)	Determining the hierarchy and class of elements in cement industry
1993	Mandal and Deshmukh (1994)	Vendor selection in supply chain
1999	Kanungo et al. (1999)	To develop an information system effectiveness framework
2004	Ravi and Shankar (2004)	Barriers of reverse logistics
2005	Jharkharia and Shankar (2004)	Enablers of IT implementation in supply chain
2005	Ravi et al. (2005)	Identifying key reverse logistic variables
2006	Faisal et al. (2006)	Modeling the enablers for supply chain risk mitigation
2006	Sahney et al. (2006)	Identifying the set of minimum design characteristics/quality components that meet the requirements of the students as an important customer in institutions offering professional courses
2007	Thakkar et al. (2007)	Integrated approach with ISM and ANP to develop a balanced score card
2008	Thakkar et al. (2008)	A mathematical solution based on interpretive structural modeling and graph theory matrix to determine the supply chain relationship index.
2009	Pandey and Garg (2009)	Identifying the key supply chain variables, on which the practitioner should focus, to make supply chains of manufacturing enterprises more agile
2010	Manoharan et al. (2010)	Analyzing inter-relationships among performance appraisal factors to design and plan a training program for employees
2010	Kannan et al. (2010)	Identifying and ranking the criteria used for the supplier development
2011	Talib et al. (2011)	Analysing interactions among the barriers to total quality management (TQM) implementation in organisations
2012	Kannan et al. (2012)	Third party reverse logistics provider selection
2013	Mathiyazhagan et al. (2013)	Barrier analysis for green supply chain management implementation

depending upon their interrelationships. This provides a multilevel ISM model in which the relationships among variables are clarified.

The ISM approach suggests the use of the expert opinions, using some management techniques such as brain storming or nominal group techniques, to develop the contextual relationships among the variables (Kannan et al. 2010). To collect data about the relationships between lean, green and resilient practices, and supply chain performance measures, a questionnaire was administered to each expert (section "Appendix"). Initially, the study objective was presented and each variable meaning clarified to the panel of experts. This step provides the necessary support to ensure that the respondent concentrated on the direct relationships between each pair of performance measures. The written opinions of experts were taken separately, to avoid possible influence of one expert over another. In a subsequent phase, the answers were combined, analyzed and convergence identified in the relationships. The results were then discussed with the experts and a final matrix was achieved reflecting the experts' consensus on their judgement.

Construct validity, internal validity, external validity and reliability are important issues in overall research design and hence in the overall effectiveness of a research study (Yin 2002; Voss et al. 2002). Construct validity means that the operational measures used to translate the constructs actually measures the concepts that they are meant to measure. To guaranty, the construct validity is necessary to assure (Carmines and Zeller 1979): (1) convergent validity—means that multiple items of a construct are related; (2) discriminant validity—assesses the extent to which the individual items of a construct are unique and do not measure any other constructs. The proposed lean, green and resilient practices and supply chain performance measures were derived from the literature review in the area of supply chain management and performance measurement systems in the automotive industry. To guaranty construct validity, each paradigm is

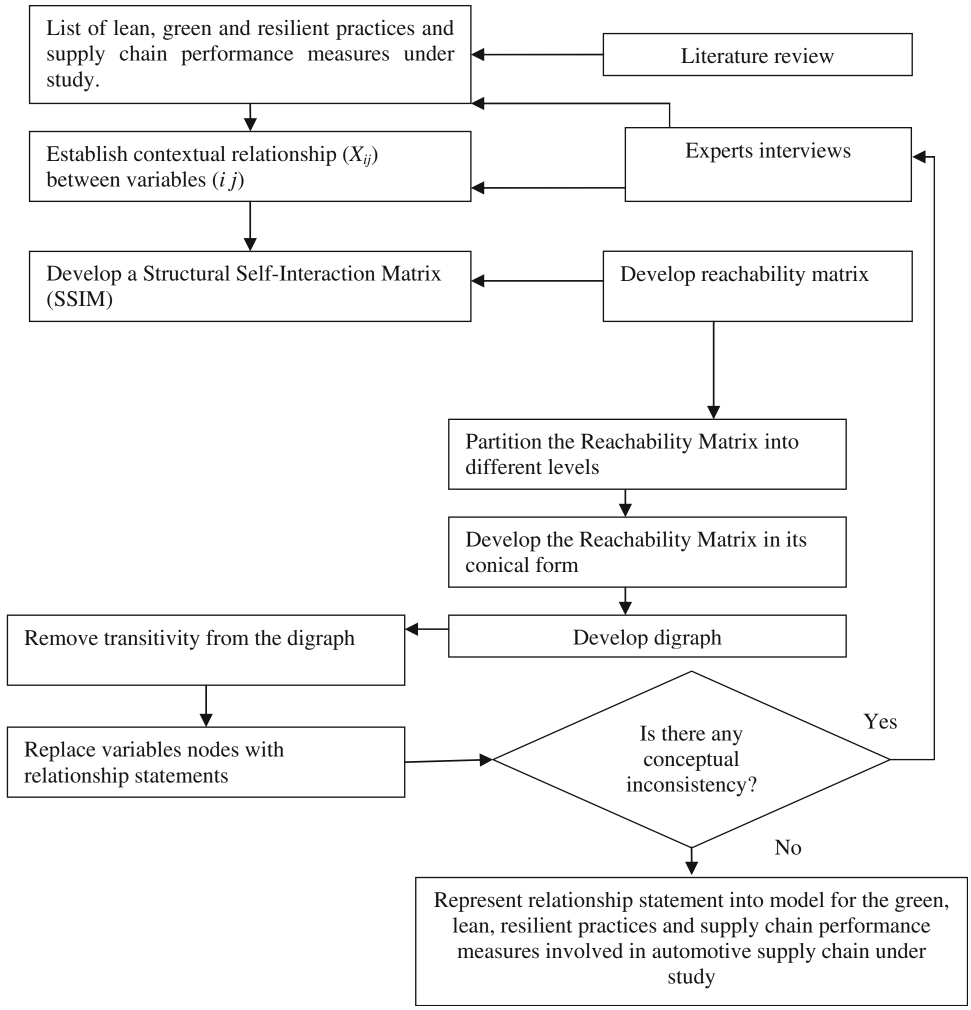

Fig. 2 Flow chart for the ISM approach (modified from Kannan et al. 2008)

defined using two practices that contribute only to each paradigm and that are not related to the others ones. And the supply chain performance construct was defined using autonomous performance measures.

Internal validity means that the study actually measures what it is supposed to and that the demonstrated relationships are explained by the described practices and performance measures and no others. To achieve internal validity, the respondents were previously briefed about the study objectives and the definition of variables. Also the researcher provides instructions and supports respondents during the completion of the questionnaires. External validity means that the results are valid in similar settings outside the studied objects. Reliability means that the study is objective in the sense that other researchers could reach the same conclusions in the same setting. To assure validity and reliability, the triangulation was used (Mathison 1988; Singleton and Straits 1999). Triangulation may involve 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). In this research, data and investigator triangulation were used since the ISM approach was developed with the contributions of experts from academia and professionals from the automotive industry. This gives the research the perspectives of those who study the phenomenon (academics) and those who deal with the issues on a daily base (professionals from the industry).

The two academics and the three professionals were selected because they are well conversant with the lean, green and resilient practices and supply chain performance in the automotive industry. The professionals belong to important companies in the automotive industry which besides sited in Portugal, they represent foreign organizational cultures making them good representatives of the automotive supply chain reality. Bolaños et al. (2005) argue that there should be not many experts involved in the ISM method. From their point of view, if the number of respondents is large, other

Table 4 Profile of professionals and academics

	Product Lines	Position in the supply chain	Company size (employees)	Interviewed
Professionals				
Company 1	Car	Focal company (automaker)	3,207	Supply chain analyst
Company 2	Seats	First-tier supplier	130	Quality engineer
Company 3	Auto radios and air conditioner front panels	Second-tier supplier	800	Quality engineer

	Experience	Expertise	Affiliation
Academics			
Academic 1	18 Years	Member of a research project on lean, agile, resilient and green SCM in the automotive supply chain	University of Beira Interior
Academic 2	12 Years	Resilient and green SCM in automotive companies	University Nova de Lisboa, FCT

methodologies are required to compute distances between pairs of structures, or agreements on the distance and characteristics of relations, leading to the identification of clusters of respondents with substantial shared knowledge with the analysis becoming much more complex. The panel members' profiles are described in Table 4.

The following ten variables to study the influence of lean, green and resilient practices on supply chain performance were considered:

1. JIT
2. Total quality management (TQM)
3. Strategic stock
4. Flexible transportation
5. Environmentally friendly packaging
6. ISO 14001
7. Operational cost
8. Business wastage
9. Environmental cost
10. Customer satisfaction

Results and discussion

In this section, the interactions between lean, green and resilient paradigms and supply chain performance are identified for the Portuguese automotive supply chain. This paper focuses the companies belonging to the automotive supply chain which are situated in Portugal. The automotive supply chain was chosen because of its importance for the Portuguese economy. The automotive industry in Portugal has 40 years of tradition and presents an annual turnover of around 4.8 billion euros and delivering about 170,000 passenger cars, light and heavy commercial vehicles, per year. This industry is a center pillar of the Portuguese economy representing 4 % of the total GDP (Gross Domestic Product) and mobilizes a workforce of about 40,000 people and is one of the main exporting Portuguese sectors (AICEP 2013). Also the automotive supply chain seems to be the most developed in terms of environmental issues and sustainability and it is also more vulnerable to supply chain disruptions. The automotive industry experiences great expectations from customers and society concerning environmental performance, as its products are by nature resource-burning products (Thun and Müller 2010). Moreover, it 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, the tendency of many automotive companies to seek out low-cost solutions may have led to leaner but also more vulnerable supply chains (Svensson 2000; Azevedo et al. 2008).

Table 5 Structural self-interaction matrix, Initial and Final Reachability Matrix

Variables	10	9	8	7	6	5	4	3	2	1
(a): Structural self-interaction matrix—SSIM										
1. Just-in-time	V	V	V	X	O	A	X	A	V	
2. Total quality management	V	V	V	A	X	O	A	A		
3. Strategic stock	V	O	A	A	O	O	V			
4. Flexible transportation	V	V	V	V	O	A				
5. Environmentally friendly packaging	O	V	V	A	X					
6. ISO 14001	V	X	V	A						
7. Operational cost	O	A	X							
8. Business wastage	O	X								
9. Environmental cost	V									
10. Customer satisfaction										

Variables	1	2	3	4	5	6	7	8	9	10
(b): Initial reachability matrix										
1. Just-in-time	1	1	0	1	0	0	1	1	1	1
2. Total quality management	0	1	0	0	0	1	0	1	1	1
3. Strategic stock	1	1	1	1	0	0	0	0	0	1
4. Flexible transportation	1	1	0	1	0	0	1	1	1	1
5. Environmentally friendly packaging	1	0	0	1	1	1	0	1	1	0
6. ISO 14001	0	1	0	0	1	1	0	1	1	1
7. Operational cost	1	1	1	0	1	1	1	1	0	0
8. Business wastage	0	0	1	0	0	0	1	1	1	0
9. Environmental cost	0	0	0	0	0	1	1	1	1	1
10. Customer satisfaction	0	0	0	0	0	0	0	0	0	1

Variables	1	2	3	4	5	6	7	8	9	10	Driving power
(c): Final reachability matrix											
1. Just-in-time	1	1	1	1	1	1	1	1	1	1	10
2. Total quality management	0	1	1	0	1	1	1	1	1	1	8
3. Strategic stock	1	1	1	1	0	1	1	1	1	1	9
4. Flexible transportation	1	1	1	1	1	1	1	1	1	1	10
5. Environmentally friendly packaging	1	1	1	1	1	1	1	1	1	1	10
6. ISO 14001	1	1	1	1	1	1	1	1	1	1	10
7. Operational cost	1	1	1	1	1	1	1	1	1	1	10
8. Business wastage	1	1	1	1	1	1	1	1	1	1	10
9. Environmental cost	1	1	1	0	1	1	1	1	1	1	9
10. Customer satisfaction	0	0	0	0	0	0	0	0	0	1	1
Dependence power	8	9	9	7	8	9	9	9	9	10	

Structural self-interaction matrix (SSIM)

ISM methodology suggests the use of the expert opinions based on some management techniques such as brainstorming, nominal technique, among others, in developing the contextual relationship among the variables (Talib et al. 2011). For analyzing all the variables, the contextual relationship of "leads to" type is chosen.

This means that one variable leads to another variable. Based on this, contextual relationship between the variables is developed. Keeping in mind the contextual relationship for each variable, the existence of a relation between any two variables (*i* and *j*) and the associated direction of the relation is questioned. Four symbols are used to denote the direction of the relationship between the variables (*i* and *j*):

- V—variable *i* will help to achieve variable *j*;
- A—variable *j* will be achieved by variable *i*;
- *X*—variable *i* and *j* will help to achieve each other; and
- O—variable *i* and *j* are unrelated.

The following would explain the use of the symbols V, A, X and O in SSIM (Table 5a):

- Variable 1 helps achieve variable 10. This means that as the level of "just-in-time" deployment increases, it increases the "customer satisfaction". Thus, the relationship between variable 1 and 10 is denoted by "V" in the Table 5a.
- Variable 2 can be achieved by variable 7, i.e., variable 2, namely "total quality management" would help achieve variable 7 "operational costs". Total quality management would improve the operational costs. Thus, the relationship between these variables is denoted by "A" in the Table 5a.
- Variable 6 and 9 help achieve each other. Variable 6, namely "ISO 14001", and variable 4, namely "environmental cost", help achieve each other. Thus, the relationship between these variables is denoted by "X" in the Table 5a.
- No relationship exists between "strategic stock" (variable 3) and "environmental cost" (variable 9), and hence, the relationship between these variables is denoted by "O" in the Table 5a.

Based on similar contextual relationships, the SSIM is developed for all the ten variables associated with the lean, green and resilient supply chain management practices and also supply chain performance measures (Table 5a).

Reachability matrix

The SSIM is transformed into a binary matrix, called the initial reachability matrix by substituting V, A, X and O by 1 and 0 as per the case. The rules for the substitution of 1's and 0's are the following:

- If the (*i*, *j*) entry in the SSIM is V, then the (*i*, *j*) entry in the reachability matrix becomes 1 and the (*j, i*) entry becomes 0.
- If the (*i*, *j*) entry in the SSIM is A, then the (*i*, *j*) entry in the reachability matrix becomes 0 and the (*j, i*) entry becomes 1.
- If the (*i*, *j*) entry in the SSIM is X, then the (*i*, *j*) entry in the reachability matrix becomes 1 and the (*j, i*) entry becomes 1.
- If the (*i*, *j*) entry in the SSIM is O, then the (*i*, *j*) entry in the reachability matrix becomes 0 and the (*j, i*) entry also becomes 0.

Following these rules, initial reachability matrix for the variables is shown in Table 5b. The final reachability matrix is obtained by incorporating the transitivities as enumerated in Step 4 of the ISM methodology.

Level partitions

The reachability and antecedent sets for each variable are found out from the final reachability matrix (Warfield 1974a, b) (Table 5c). In this matrix, the driving and dependence power of each variable are also shown. The driving power of a particular variable is the total number of variables (including itself) which it may help achieve. The dependence is the total number of variables which may help in achieving it. These driving and dependence power will be used in the MICMAC analysis, where the variables will be classified into four groups of autonomous, dependent, linkage and independent.

The *reachability set* for a particular variable consists of the variable itself and the other variables, which it may help to achieve. The *antecedent set* consists of the variable itself and the other variables, which may help in achieving it. Subsequently, *intersection set* for each variable is the intersection of the corresponding reachability and antecedent sets. If the reachability set and the intersection set are the same, then the variable is considered to be in level 1 and is given the top position in the ISM hierarchy, meaning that the variable which would not help in achieving any other variable above its own level. After the identification of the top-level element, it is discarded from the other remaining variables.

From Table 6, it is seen that "customer satisfaction" (variable 10) is found at Level I. Thus, it would be positioned at the top of the ISM model. This iteration is continued until the levels of each measure are found out. The identified levels aid in building the digraph and the final framework of ISM. After the identification of the top-level element, it is discarded from remaining variables.

Formation of ISM-based framework

From the final reachability matrix, the structural model is generated. If the relationship exists between the variables *j* and *i*, an arrow pointing from *j* and *i* shows this. This resulting graph is called a digraph. Digraph is a graphical representation of the elements, their directed relationships and hierarchical levels. Removing the transitivities as described in the ISM methodology, the digraph is finally converted into the ISM model as shown in Fig. 3.

It is observed from Fig. 3 that "customer satisfaction" (variable 10) is a very significant variable (performance measure) to the automotive supply chain as it comes at the

Table 6 Partition of reachability matrix

Variable	Reachability set	Antecedent set	Intersection	Level
Interaction 1				
1. Just-in-time	1,2,3,4,5,6,7,8,9,10	1,3,4,5,6,7,8,9	1,3,4,5,6,7,8,9	
2. Total quality management	2,3,5,6,7,8,9,10	1,2,3,4,5,6,7,8,9	2,3,5,6,7,8,9	
3. Strategic stock	1,2,3,4,6,7,8,9,10	1,2,3,4,5,6,7,8,9	1,2,3,4,6,7,8,9	
4. Flexible transportation	1,2,3,4,5,6,7,8,9,10	1,3,4,5,6,7,8	1,3,4,5,6,7,8	
5. Environmentally friendly packaging	1,2,3,4,5,6,7,8,9,10	1,2,4,5,6,7,8,9	1,2,3,4,5,6,7,8,9	
6. ISO 14001	1,2,3,4,5,6,7,8,9,10	1,2,3,4,5,6,7,8,9	1,2,3,4,5,6,7,8,9	
7. Operational cost	1,2,3,4,5,6,7,8,9,10	1,2,3,4,5,6,7,8,9,	1,2,3,4,5,6,7,8,9	
8. Business wastage	1,2,3,4,5,6,7,8,9,10	1,2,3,4,5,6,7,8,9,	1,2,3,4,5,6,7,8,9	
9. Environmental cost	1,2,3,5,6,7,8,9,10	1,2,3,4,5,6,7,8,9,	1,2,3,5,6,7,8,9	
10. Customer satisfaction	10	1,2,3,4,5,6,7,8,9,10	10	I
Interaction 2				
1. Just-in-time	1,2,3,4,5,6,7,8,9	1,3,4,5,6,7,8,9	1,3,4,5,6,7,8,9	
2. Total quality management	2,3,5,6,7,8,9	1,2,3,4,5,6,7,8,9	2,3,5,6,7,8,9	II
3. Strategic stock	1,2,3,4,6,7,8,9	1,2,3,4,5,6,7,8,9	1,2,3,4,6,7,8,9	II
4. Flexible transportation	1,2,3,4,5,6,7,8,9	1,3,4,5,6,7,8	1,3,4,5,6,7,8	
5. Environmentally friendly packaging	1,2,3,4,5,6,7,8,9	1,2,4,5,6,7,8,9	1,2,4,5,6,7,8,9	
6. ISO 14001	1,2,3,4,5,6,7,8,9	1,2,3,4,5,6,7,8,9	1,2,3,4,5,6,7,8,9	II
7. Operational cost	1,2,3,4,5,6,7,8,9	1,2,3,4,5,6,7,8,9	1,2,3,4,5,6,7,8,9	II
8. Business wastage	1,2,3,4,5,6,7,8,9	1,2,3,4,5,6,7,8,9	1,2,3,4,5,6,7,8,9	II
9. Environmental cost	1,2,3,5,6,7,8,9	1,2,3,4,5,6,7,8,9	1,2,3,5,6,7,8,9	II
Interaction 3				
1. Just-in-time	1,4,5	1,4,5	1,4,5	III
4. Flexible transportation	1,4,5	1,4,5	1,4,5	III
5. Environmentally friendly packaging	1,4,5	1,4,5	1,4,5	III

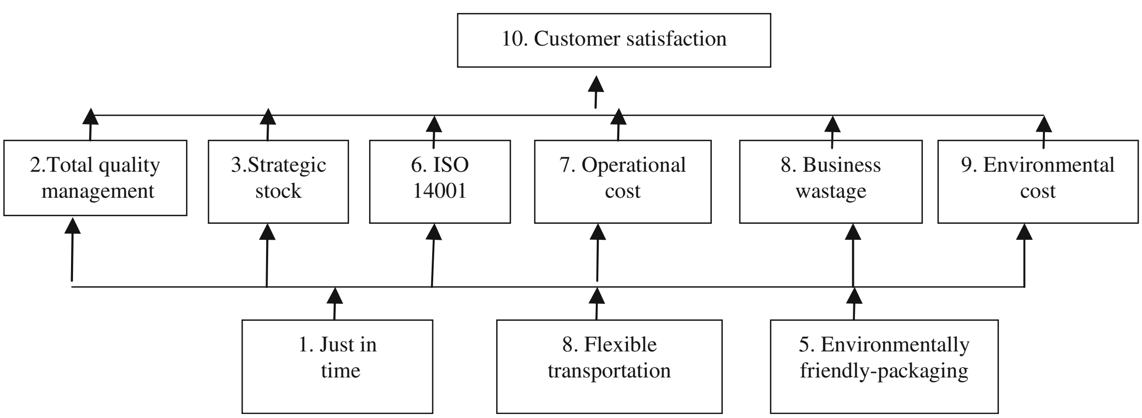

Fig. 3 Final digraph depicting the relationships among variables

top of the ISM hierarchy. Customer satisfaction is the performance measure on which the competitiveness of automotive supply chain depends.

The ISM model also suggests that "just-in-time", "flexible transportation" and "environmentally friendly packaging" are very significant practices for the automotive supply chains as they come as the base of the ISM hierarchy. The "total quality management", "strategic stock", "ISO 14001", "operational cost", "business wastage" and "environmental cost" lead to "customer satisfaction" and are practices and performance measures on which the leanness, greenness and

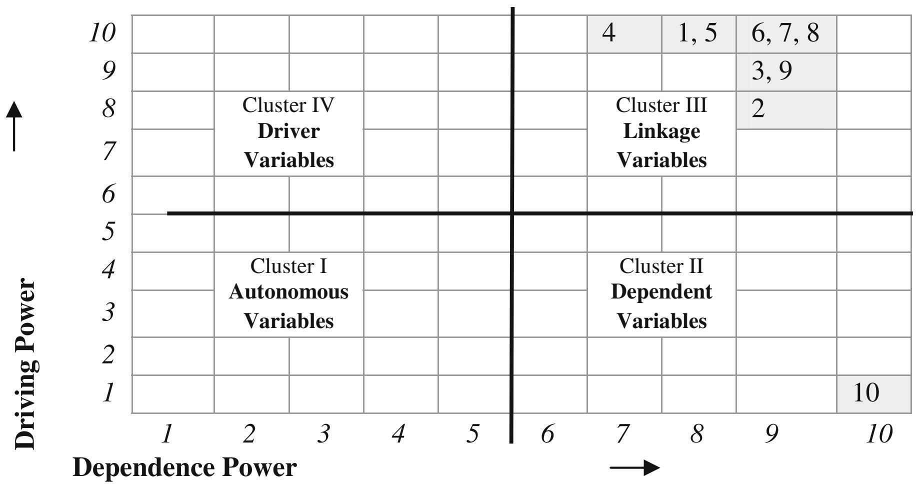

Fig. 4 Driving and dependence power diagram for the suggested variables

resilience of automotive supply chains depend. These variables have appeared at the middle level of the hierarchy.

MICMAC analysis: classification of variables

MICMAC stands for *Methode de hiérarchisation des élèments d'un sistème* (Duperrin 1973) and involves development of a graph to classify different enablers based on their driving and dependence power. All variables have been classified, based on their driving power and dependence power (Table 5c), into four categories as: (1) autonomous measures; (2) dependent measures; (3) linkage measures; and (4) independent measures. This classification is similar to Mandal and Deshmukh (1994) classification. The driving and dependence power diagram for the suggested performance measures is shown in Fig. 4.

It is observed from Fig. 4 that nine out of ten research variables have a considerable driving and also dependence power since their values are above the middle of both scales. So, almost all variables are in the cluster II which means that they represent linkage variables. This means that any action on these variables will have an effect on other variables and also a feedback on themselves. This implies that they can drive the system but are dependent on other variables. Only variable 10 "customer satisfaction" is in cluster II, which makes it a dependent variable, since it has weak driving power and strong dependence power.

Discussion

According to the ISM methodology, the most significant practices for the automotive supply chain be considered lean, green and resilient are "just-in-time", "flexible transportation" and "environmentally friendly packaging". The same results could be found in other works. The "just-in-time" as a significant practice to the leanness of the automotive supply chain can be found in Cooney (2002). According to Matson and Matson (2007), today's emphasis on lean manufacturing for global competitiveness supports the need for efficient JIT supply chains. With a JIT system, work-in-process inventory is moved through production stages only when it is needed and in the necessary quantities, making easier to respond to changes in demand, improving production flexibility, reducing inventory costs (Matson and Matson 2007) and also reducing raw materials inventories (Biggart and Gargeya 2002). However, in the automotive supply chain, a trade-off could emerge from the lean, green and resilient philosophy by the adoption of the JIT. The use of JIT practices in individual companies may contribute to reduce inventory waste, but it can also increase the energy used in logistics due to more frequent deliveries (King and Lenox 2001; Zhu and Sarkis 2004) and provoke a failure in the production systems when the normal flow of materials is disturbed and a material shortage occurs (Faria et al. 2006), having by this way a negative impact on the greenness and resilience of the automotive supply chain. A way of overcoming this trade-offs is sitting the main suppliers near the automakers, if possible in the same industrial area, avoiding long distances between supply chain partners. Through this strategy, the automotive supply chain can be at the same time lean, green and resilient. This is a reality in almost all automotive supply chains because of the adoption of not only the JIT but also the just-in-sequence philosophy (Thun et al. 2007).

As in this study, the "flexible transportation" is identified by Tsiakouri (2008) and Azevedo et al. (2013a) as a significant resilient practice to the automotive supply chain. This is because this practice contributes to a reduction in the transportation lead-time (Carvalho et al. 2011) and consequently an increase in the customer satisfaction. Moreover, it is critical that the transportation system has the ability to accommodate also changing demands and traffic patterns allowing flexibility in traffic patterns, which reduces the amount of excess capacity needed at any point in the system to accommodate increased demand (Morlok and Chang (2004) and contributes to reduce the CO_2 emissions through more efficient transportation (Barany et al. 2011). This implies that the ability to shift travel routes, times, modes and destinations, through transportation demand management, can increase capacity to deal with sudden increases in peak demand, becoming supply chain more resilient, lean and green.

In Azevedo et al. (2011) and Thun and Müller (2010) the "environmentally friendly packaging" is identified also as a practice contributing to the greenness of the automotive supply chain. This practice is already deployed by some automotive players that have environmental concerns and want to avoid waste associated with packaging materials and its disposal. For example, the Toyota company improved packing and reusable metal shipping containers rather than disposable cardboard and wood pallets. Also, the Volkswagen company reduced the use of cardboard packaging in-house logistics (Nunes and Bennett 2010).

As regard the researched performance measures, the ones considered most important to assess the influence of lean, green and resilient practices on the automotive supply chain performance are operational cost, business wastage, environmental cost and customer satisfaction. Ghalayini and Noble (1996) consider that it is crucial to incorporate the "operational cost" in any supply chain performance measurement system, since it will make possible control and improve operational processes. This measure allows the identification of wastes across the several processes that are developed in automotive companies. The "business wastage" is highlighted by several authors (Srivastava 2007; Rao and Holt 2005; Linton et al. 2007, Zhu et al. 2008a, b) since it is considered important to integrate environmental thinking into supply chain management. This measure makes possible to analyze the influence of the environmental behavior of organizations and corresponding supply chain on their performance. The business wastage is a supply chain performance measure suggested also in many researches (Zhu et al. 2005; Tsai and Hung 2009; Pochampally et al. 2009). As regard the "environmental cost", this measure is considered extremely important to monitor the influence of green practices on supply chain performance. According to Zhu et al. (2005), besides the environmental concerns, the economic performance must be monitored because it is the most important driver for organizations which seek to implement environmental management practices. Consequently, it is crucial to have information about costs associated, for example, to scrap/rework (Christiansen et al. (2003); disposal (Tsai and Hung (2009) and purchasing environmentally friendly materials (Zhu et al. 2005).

Andersson et al. (1989) believe that a supply chain performance measurement system should include a balanced collection of four to six performance measures in which the customer satisfaction should be part. So the decision on to include the "customer satisfaction" as a supply chain performance measure to assess the influence of lean, resilient and lean practices on supply chain performance is consistent with the literature. This performance measure is also in the top of the ISM hierarchy, which means that it is a very significant measure to the automotive industry. This is because automotive companies face stiff competition and demanding customers. The implementation of mass production, which is based on a forecast-driven strategy, leads to overstocking, extra marketing expenses and low profitability (Holweg and Pil 2004). Hence, many vehicle manufacturers adopt mass customization and customer-order-driven strategy in the hope that the drawbacks of mass production can be overcome. In this context, it is important to evaluate whether the customers are still satisfied and whether the different lean, green and resilient practices that have been deployed by automotive companies are not jeopardizing the satisfaction level of their customers.

Managerial implications

Being as reference the results reached by the application of the ISM approach, the following managerial implications can be inferred from this study:

1. Key lessons for auto company management—the supply chain practices, namely "just-in-time", "flexible transportation" and "environmentally friendly packaging" are strong drivers and may be treated as the root of leanness, greenness and resilience of the automotive supply chain, so decision makers should target these practices so that the desired level of customer satisfaction objectives could be attained;
2. Supply chain function—these three supply chain management practices (JIT, flexible transportation and environmentally friendly packaging) being considered drivers, not only for the deployment of the

other research supply chain management practices but also for the suggested performance measures, should present high levels of implementation across the various supply chain partners; this is only possible if there is a closer relationship between them. So the individual companies should develop a closer relationship with their suppliers and customers;

3. Operations function—the JIT being a pillar of the suggested supply chain management practices and performance measures forces companies to speed their operations not only inward but also across supply chain partners. Also, the production and inventory planning should be adapted to this philosophy since it involves more frequent deliveries but in less quantities. So, as the inventory levels are too small or not exist, the failures in terms of quantity or quality could lead a stoppage in the production. To smooth the risk associated with this practice, the companies should also implement the total quality management and strategic stock practices; for companies, as a way of ensuring a continuous flow of materials in case of a disruption, the flexible transportation practice can be deployed. This practice could involve a rapid change of transport mode, multimodal transportation or even multiple routes. Moreover, automotive companies should also deploy the environmentally friendly packaging practice using reusable, returnable, degradable or easy-to-recycle packing materials;
4. Marketing function—the results obtained from the application of the ISM model highlights the customer satisfaction as critical for the competitiveness of the automotive supply chain. So considering that the ISO 14001 is a green practice that leads also to customer satisfaction, and the automotive companies' marketers should still associate a green image to this sector in order to improve its competitiveness catching environmental-concern consumers;
5. Customer groups—the suggested lean, green and resilient practices make possible to respond in a more efficiently way to customers requirements along the supply chain. Implementing the suggested practices, this industry is prepared to respond to different customers' needs offering eco-products (ISO 14001), in short lead-times (flexible transportation, strategic stocks) with high levels of quality (total quality management).

Conclusion

The implementation of lean, green and resilient practices and supply chain performance measures creates considerable challenges for managers from the automotive supply chain. Some of the main lean, green and resilient practices and also performance measures have been highlighted here and put into an ISM model, to analyze the interaction between them. These practices are: JIT, TQM, environmentally friendly packaging, ISO 14001, strategic stock and flexible transportation

A major contribution of this research lies in the development of linkages among various lean, green and resilient practices and performance measures through a single systemic framework. The utility of the proposed ISM methodology in imposing order and direction on the complexity of relationships among elements of a system assumes a handy research method to the decision makers.

Some of the observations from the ISM model, which give important managerial implications, are discussed below. The following supply chain practices are considered very significant: "just-in-time" (lean practice), "flexible transportation" (resilient practice) and "environmentally friendly packaging" (green practice). These supply chain practices are at the bottom level of the hierarchy, implying higher driving power (Fig. 2). Therefore, top management from automotive supply chains should focus on them in order to become their companies and corresponding supply chain leanness, greenness and resilient. Only the "customer satisfaction" measure is not found under the linkage element category. This means that almost all the practices and performance measures possess a strong driving power with strong dependence.

The driver-dependence diagram gives some valuable insights about the relative importance and the interdependencies among both practices and performance measures.

The main implication of using ISM for researchers is that the use of such approaches can form an extremely effective and efficient method for capturing interactions among lean, green and resilient practices and supply chain performance. It allows researchers to perform research that is interpretive and grounded in data efficiently. This is important because, in many instances, supply chain phenomena are so dynamic and changes occur so fast that it is unreasonable to expect researchers to study stable phenomena and replicate or disconfirm results obtained by other researchers. Hence, it is important to employ methodologies like ISM that efficiently allow the capture and synthesis of practitioner's viewpoints.

Considering that the relationships and hierarchy among practices and performance measures were identified according to the perceptions of academics and professionals from the Portuguese automotive industry and they will not be so different from the perceptions of a panel from a different country, these findings could be generalizable to other realities.

Moreover, besides the importance of the study, some limitations could be pointed out.

A hypothetical model of lean, green and resilient practices and supply chain performance measures were developed based upon experts and professionals' opinions. The model may be tested in real-world setting to check that the researched practices and their relationships with supply chain performance measures exist as in the literature. The results of model may vary in real-world setting. The lean, green and resilient practices may be incomplete or their relationships between them and with supply chain performance measures may be different from the derived model.

Despite the fact that the ISM model developed in this research is management paradigms and also performance measures in the automotive supply chain, some generalization of results are still possible. Thus, the identification of both supply chain practices and performance measures in any supply chain assumes great importance. This can aid the top management in deciding the priority so that it can proactively take steps in deploying these practices and performance measures.

At the end, we examine the scope of further research. In this research, using the ISM methodology, a relationship model among lean, green and resilient practices and performance measures in Portuguese companies belonging to the automotive supply chain have been developed. But this model has not been statistically validated. Structural equation modeling has the capability of testing the validity of such hypothetical models. Thus, this approach can be applied in future research to test the validity of the research ISM model.

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Appendix: Protocol for experts

The following table intends to register the perception of professionals from automotive industry and academics on the relationships between lean, green and resilient practices and supply chain performance measures.

A - COMPANY CHARACTERIZATION

A.1 Sector / SIC: ____________

A.2 Number of employees: __________

A.3 Primary product(s): ______________________________________

A.4 Primary customer activity (s): ____

A.5 Your Job title: ____

A.6 How do you define your firms' position in your supply chain?

4 Tier supplier	3 tier supplier	2nd tier supplier	1st tier Supplier	**Focal firm**	1st tier customer	2nd tier customer	Retailer	End-customer
○	○	○	○	○	○	○	○	○

B - ACADEMIC PROFILE

B.1 Research areas:____

B.2 Affiliation: ____

C – LEAN, GREEN AND RESILIENT PRACTICES AND SUPPLY CHAIN PERFORMANCE

Please, fill the table considering the following symbols:

V - variable *i* will help to achieve variable *j*
A - variable *J* will help to achieve variable *i*
X - variable *i* and *J* will help to achieve each other
O - variable *i* and *J* are unrelated.

	Variable j / Variable i	10 Customer Satisfaction	9 Environmental Cost	8 Business Wastage	7 Operational Cost	6 ISO 14001	5 Environmentally Friendly-Packaging	4 Flexible Transportation	3 Strategic Stock	2 Total Quality Management	1 Just In Time
1	Just In Time										
2	Total Quality Management										
3	Strategic Stock										
4	Flexible Transportation										
5	Environmentally Friendly-Packaging										
6	ISO 14001										
7	Operational Cost										
8	Business Wastage										
9	Environmental Cost										
10	Customer Satisfaction										

Performance Measures **Supply Chain Practices**

Thank you for collaboration.

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