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BARRIERS TO GREEN SUPPLY CHAIN MANAGEMENT IN THE AUTOMOTIVE INDUSTRY

Barreiras à gestão da cadeia de suprimentos verde na indústria automotiva

Barreras a la gestión de la cadena de suministro verde en la industria automotriz

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ABSTRACT

This study identified the barriers to Green Supply Chain Management (GSCM) and analyzed their degree of influence from the perspective of a first-tier supplier in the Brazilian automotive industry. The literature indicates a total of 43 barriers, of which 13 were validated in the following areas: support and involvement (five), operational performance (three), economic performance (two), environmental performance (two), and knowledge and information (one). The validation was based on the perception of technical and academic specialists familiar with environmental and supply chain management in various sectors. The hierarchy of the barriers by priority was obtained using the Analytic Hierarchy Process (AHP) method, with decision makers representing an industry in the automotive sector. The study showed that cost implications are the most influential barrier to GSCM from the perspective of a first-tier supplier in the sector.

KEYWORDS | Green supply chain management, barriers, automotive industry, content validation, analytic hierarchy process.

RESUMO

Este estudo identificou as barreiras e analisou seu grau de influência na Gestão da Cadeia de Suprimentos Verde (GCSV), de acordo com a perspectiva de um fornecedor de primeira camada da indústria automotiva brasileira. Foram encontradas 43 barreiras na literatura especializada, e 13 validadas: apoio e envolvimento (cinco), desempenho operacional (três), desempenho econômico (duas), desempenho ambiental (duas), conhecimento e informação (uma). A validação ocorreu por meio da percepção de especialistas técnicos e acadêmicos com familiaridade nos temas gestão ambiental e cadeia de suprimentos de diversos setores. A hierarquia das prioridades das barreiras foi obtida por meio da aplicação do método Analytic Hierarchy Process (Análise Hierárquica do Processo [AHP]), tendo como decisores representantes de uma indústria do setor automotivo. A pesquisa mostrou que as implicações de custo representam a barreira mais influente à GCSV, do ponto de vista de um fornecedor de primeira camada do setor estudado.

PALAVRAS-CHAVE | *Gestão da cadeia de suprimentos verde, barreiras, indústria automotiva, validação de conteúdo, análise hierárquica do processo.*

RESUMEN

Este estudio identificó las barreras a la Gestión de la Cadena de Suministro Verde (GCSV) y analizó su grado de influencia, de acuerdo con la perspectiva de un proveedor de primer nivel (tier 1) de la industria automotriz brasileña. De las 43 barreras encontradas en la literatura, se han validado trece: apoyo e implicación (cinco), desempeño operacional (tres), desempeño económico (dos), desempeño ambiental (dos), y conocimiento e información (una). La validación ocurrió por medio de la percepción de especialistas técnicos y académicos familiarizados con los temas gestión ambiental y cadenas de suministro de diversos sectores. La jerarquía de las prioridades de las barreras se realizó a través de la aplicación del Proceso lítico Jerárquico (Analytic Hierarchy Process [AHP]), y los decisores fueron representantes de una industria del sector automotriz. La investigación mostró que las implicaciones de costo representan la barrera más influyente en la GCSV, desde el punto de vista de un proveedor de primer nivel del sector estudiado.

PALABRAS CLAVE | *Gestión de la cadena de suministro verde, barreras, industria automotriz, validación de contenido, proceso analítico jerárquico.*

INTRODUCTION

The automotive sector supply chain involves several supply levels and feature disparities among companies according to their position. This imbalance in the supply chain introduces critical aspects in terms of the economic, environmental, and operational performance of the upstream players in which most of the companies are constituted by small and medium enterprises, and small family business. Nonetheless, these are not isolated phenomena because such aspects affect every relationship along the chain (Zhu, Sarkis, & Geng, 2005).

The effects of such disparities tend to form a barrier to the implementation of supply chain management, which involves the introduction of instruments to adapt the processes and products to the environmental protection guidelines called Green Supply Chain Management (GSCM) practices, which include eco-design, recycling, remanufacturing, green purchasing, life-cycle evaluation, and reverse logistics (Leigh & Li, 2014; Srivastava, 2007).

Because different organizations interact in a supply chain, and it is impossible to eliminate all the barriers to GSCM simultaneously, the players in the chain tend to hierarchize the barriers and overcome them in according to their priorities (Govindan, Mathiyazhagan, Kannan, & Haq, 2014). Therefore, the objective of this study is to identify the barriers to GSCM and analyze their degree of influence from the perspective of a first-tier supplier in the Brazilian automotive industry. The remainder of this paper is structured into five sections. The next section discusses our theoretical framework, and the succeeding one presents the methodology used. A characterization of the researched economic sector is next discussed, with the second-to-last section presents our results. The final section presents the considerations and implications of the study.

THEORETICAL FRAMEWORK

Green Supply Chain Management (GSCM)

A supply chain involves several activities. It can be understood as a set of at least three entities directly involved in the upward and downward flow of products, services, financial resources and/or information, that is, from the raw material provider all the way to the customer. These include planning and control of all operations involving the supply, purchases, distribution logistics, and production of goods, from the extraction of raw material to the post-use disposal of the product (Seuring & Müller, 2008; Shibao, 2011).

GSCM integrates all the environmental considerations into supply chain management, including product design, outsourcing services, manufacturing processes, and delivery of the final product to consumers as well as product management at the life-cycle end (Srivastava, 2007). In terms of limitations, besides the integration of manufacturing processes and distribution, the control of GSCM ranges from the design to the product disposal stage (Sarkis, Zhu, & Lai, 2011).

GSCM activities are known by different names, including green operations; environmental practices, initiatives, or capabilities; and GSCM competencies, strategies, approaches, or tools (Jabbour, Arantes, & Jabbour, 2013; Srivastava, 2007). This study uses the term "GSCM practices" as defined by Vachon and Klassen (2006). Note that the literature presents studies related to different kinds of GSCM practices, and there is not a general agreement among authors on a unique model. However, the research converges when dealing with management activities relating to suppliers, product design, manufacturing, and reverse logistics (Jabbour et al., 2013).

Several aspects of GSCM require further clarification, including the imbalance between internal and external practices, the conflicting results of GSCM practices, and differing economic performance (Zhu et al., 2005). In fact, the lack of strong evidence to link GSCM implementation with an increase in any type of environmental, economic, or operational development represents a barrier to GSCM, as pointed out by Zhu et al. (2005).

Barriers to GSCM implementation

While there are several driving forces that lead organizations toward the implementation of GSCM and contribute to corporate sustainability, some factors challenge the efforts of companies to adopt environmentally sustainable practices, implying that the implementation of GSCM is a complex and wide-ranging task (Giunipero, Hooker, & Denslow, 2012; Haq & Mathiyazhagan, 2013).

The factors that oppose or create barriers to the implementation of GSCM are classified in different ways in the literature, as will be shown later.

METHODOLOGY

This study is categorized as applied and exploratory, and investigates the issue in the Brazilian context, implying that the study's findings can be applied to resolve specific problems (Prodanov & Freitas, 2013). This study was carried out in three

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phases using a mixed method to extract and combine the strengths of qualitative and quantitative strategies to better understand the research problems (Creswell, 2010). The first phase of the study reviews the related literature, while the next two phases focus on exploring the environmental factors in order to define and identify the barriers to GSCM (Martins & Theóphilo, 2009).

Phase 1: This phase first reviews the SciELO and Spell databases from 1999 to 2015 and the Scopus database from 1999 to 2014 extensively and systematically. The search terms used for the field titles, abstracts, and keywords consisted of two sets of words: (a) "barriers" "obstacles" "difficulties" "impediment" and "impracticable" and (b) "green supply chain management" and "environmental management in the supply chain".

The barriers to GSCM implementation extracted from the research papers that meet the selection criteria were classified under categories based on other studies, as detailed in Exhibit 1 below.

Exhibit 1. **Criteria for classifying the barriers to GSCM**

Classification type	Class	Justification for adoption	Studies that used the same classification
Extent of interaction with GSCM	Economic performance	Priority for organizations and one of the main reasons for implementing GSCM practices (Zhu, Sarkis, & Lai, 2012)	Govindan et al. (2014); Mathiyazhagan, Govindan, Nooru Haq and Geng, (2013); Muduli, Govindan, Barve, and Geng, (2013); Balasubramanian (2012)
	Environmental performance	Management of environmental aspects of an organization affects and is affected by various stakeholders (ABNT, 2004, 2005)	Balasubramanian (2012), Mathiyazhagan et al. (2013)
	Operational performance	GSCM practices influence the technical and technological processes of organizations (Zhu, Sarkis, & Lai, 2007).	Govindan et al. (2014); Mathiyazhagan et al. (2013); Muduli et al. (2013); Balasubramanian (2012)
	Knowledge and information	Skills and competences promote transformations in the organizational environment, and these are transmitted to the environment through multiple channels of interaction (World Economic Forum, 2013; Lee, 2015)	Govindan et al. (2014); Muduli, et al., (2013); Balasubramanian (2012)
	Support and involvement	The competitiveness of companies depends on the relationships maintained with their suppliers, and aspects such as interaction, commitment, trust, and reciprocity are fundamental requirements for GSCM (Chan, He, Chan, & Wang, 2012; Lee, 2015)	Govindan et al. (2014); Balasubramanian (2012)
Nature	Attitudinal	It refers to the posture of resistance, passivity, reactivity, or inactivity in relation to the environment, skepticism in relation to the benefits derived from GSCM practices (Kasim & Ismail, 2012; Mathiyazhagan, Govindan, & Nooru Haq, 2014)	Perron (2005)
	Resources	Related to the unavailability of human capital, as well as tangible and intangible means to operationalize GSCM practices (Giunipero et al., 2012)	
	Information	It refers to the restricted access to information or difficulty in interpreting and understanding the data (Daily & Huang, 2001)	
	Technique	Corresponds to the commitment of the processes due to lack of method or procedure (Barve & Muduli, 2013)	
Scope	Internal	Involves internal stakeholders, resources, and actions under the control of a single organization (Perron, 2005; Zhu, Sarkis, & Lai, 2012)	Balasubramanian, (2012); Walker & Jones (2012); Zhu et al. (2012).
	External	It covers the decisions of several players in the chain (Perron, 2005; Zhu et al., 2012)	

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Given the complex and subjective character of the barriers to GSCM implementation, their categorization was based on the similarity among their definitions, as in Balasubramanian (2012) and Haq and Mathiyazhagan (2013). In addition, from the plurality of the concepts and purposes of this study, the barriers to GSCM it was assumed simultaneously to have an internal and external scope and hold up to two different natures, as displayed in Exhibit 2.

Exhibit 2. **List of barriers to GSCM**

Barriers					
Type	Description		Nature	Scope	References
Economic performance	B1	Cost implications	Resources	External	Al Zaabi, Al Dhaheri, and Diabat (2013); Drohomeretski, Costa, and Lima (2014); Giunipero et al. (2012); Govindan et al. (2014); Luthra, Kumar, Kumar, and Haleem (2011); Mehrabi, Gharakhani, Jalalifar, and Rahmati (2012); Mollenkopf, Stolze, Tate, and Ueltschy (2010); Muduli and Barve (2013); Muduli et al. (2013); Solér, Bergstrom, and Shanahan, (2010); Walker and Jones (2012); Wycherley (1999).
	B2	Unavailability of cash flow	Resources attitudinal	Internal	Mathiyazhagan, Govindan, Nooru Haq, and Geng (2013); Mehrabi et al. (2012); Mudgal. Shankar, Talib, and Raj (2010); Muduli and Barve (2013); Walker, Di Sisto, and Mcbain (2008); Walker and Jones (2012)
	B3	High investment and low financial return	Resources	Internal	Barve and Muduli (2013); Govindan et al. (2014); Mathiyazhagan et al. (2013); Mollenkopf et al. (2010); Walker and Jones (2012); Wycherley (1999).
	B4	Unavailability of credit to finance green initiatives	Resources attitudinal	External	Govindan et al. (2014); Mathiyazhagan et al. (2013).
	B5	High cost of ecological packaging	Resources	External	Al Zaabi et al. (2013); Walker et al. (2008).
	B6	High cost of waste disposal	Resources technique	External	Al Zaabi et al. (2013); Govindan et al. (2014); Mathiyazhagan et al. (2013); Muduli et al. (2013).
	B7	Lack of competitiveness of organic products	Resources	External	Bala, Muñoz, Rieradevall, and Ysern (2008); Bovell-Benjamin, Hathorn, Ibrahim, Gichuhi, and Bromfield (2009); Kasim and Ismail (2012); Mosgaard, Riisgaard, and Huulgaard (2013).
Environmental performance	B8	Environmentally inappropriate strategic planning	Attitudinal	Internal	Al Zaabi et al. (2013); Barve and Muduli (2013); Giunipero et al. (2012); Govindan et al. (2014); Mehrabi et al. (2012); Mudgal et al. (2010); Walker et al. (2008).
	B9	Lack of metrics for internal performance evaluation	Information	Internal	Mathiyazhagan et al. (2013); Witczak et al. (2014).
	B10	Lack of metrics for performance evaluation common to chain members	Information	Internal External	Al Zaabi et al. (2013); Bala et al. (2008); Govindan et al. (2014); Mathiyazhagan et al. (2013); Mollenkopf et al. (2010); Mudgal et al. (2010).
	B11	Corporate restrictions regarding the product	Attitudinal	Internal	Govindan et al. (2014); Mathiyazhagan et al. (2013); Mudgal et al. (2010).
	B12	Competition and uncertainty in the market	Attitudinal information	External	Luthra et al. (2011); Mehrabi et al. (2012); Miao, Cai, and Xu (2012).
	B13	Decrease in the efficiency of GSCM	Attitudinal	Internal External	Govindan et al. (2014); Kasim and Ismail (2012); Mathiyazhagan et al. (2013); Mollenkopf et al. (2010); Muduli and Barve (2013); Walker and Jones (2012); Witczak et al. (2014); Wycherley (1999).
	B14	Inadequate business self-regulation	Attitudinal	Internal	Mehrabi et al. (2012); Walker et al. (2008).
	B15	Belief in the loss of competitive advantage	Attitudinal information	Internal	Mehrabi et al. (2012); Walker et al. (2008).
	B16	Fear of failure	Attitudinal information	Internal	Govindan et al. (2014); Mathiyazhagan et al. (2013)

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Exhibit 2. List of barriers to GSCM

Barriers					
Type	Description		Nature	Scope	References
Operational performance	B17	Resistance to innovations in technology, materials and processes	Attitudinal technique	Internal	Barve and Muduli (2013); Govindan et al. (2014); Luthra et al. (2011); Mathiyazhagan et al. (2013); Mehrabi et al. (2012); Muduli et al. (2013).
	B18	Lack of implementation of green practices	Attitudinal information	Internal External	Luthra et al. (2011); Mudgal et al. (2010); Mehrabi et al. (2012); Muduli and Barve (2013)
	B19	Disbelief in the performance and quality of green products	Attitudinal information	Internal	Bala et al. (2008); Mosgaard et al. (2013).
	B20	Lack of human resources	Resources	Internal	Govindan et al. (2014); Mathiyazhagan et al. (2013); Muduli et al. (2013); Witczak et al. (2014).
	B21	Lack of proper reverse logistics practices	Attitudinal technique	Internal External	Al Zaabi et al. (2013); Chen, Chen, Shen, Lo, and Chu (2014); Mathiyazhagan et al. (2013); Mudgal et al. (2010); Muduli et al. (2013); Sadrnia et al. (2013).
	B22	Low eco-efficiency due to complexities in product design	Information technique	Internal External	Al Zaabi et al. (2013); Govindan et al. (2014); Mathiyazhagan et al. (2013).
Knowledge and information	B23	Internal communication failures	Attitudinal information	Internal	Govindan et al. (2014); Mathiyazhagan et al. (2013); Muduli and Barve (2013).
	B24	Lack of implementation of information technologies (IT)	Information resources	Internal	Al Zaabi et al. (2013); Luthra et al. (2011); Mudgal et al. (2010).
	B25	Poor quality of human resources	Information resources	Internal	Barve and Muduli (2013); Luthra et al. (2011); Mathiyazhagan et al. (2013); Muduli and Barve (2013).
	B26	Lack of knowledge or technique	Information	Internal	Govindan et al. (2014); Mathiyazhagan et al. (2013); Mehrabi et al. (2012); Mosgaard et al. (2013); Muduli and Barve (2013); Muduli et al. (2013); Witczak et al. (2014); Thun and Muller (2010); Walker and Jones (2012
	B27	Lack of staff training	Attitudinal information	Internal	Al Zaabi et al. (2013); Govindan et al. (2014); Mathiyazhagan et al. (2013); Mudgal et al. (2010).
	B28	Difficulties in interpreting environmental and sustainable concepts	Attitudinal information	Internal	Al Zaabi et al. (2013); Giunipero et al. (2012); Solér et al. (2010); Walker et al. (2008); Walker and Jones (2012).
	B29	Environmental Labeling	Attitudinal information	Internal	Chen et al. (2014); Wycherley (1999).
	B30	Lack of information dissemination among chain members	Attitudinal information	External	Govindan et al. (2014); Mollenkopf et al. (2010); Muduli and Barve (2013); Muduli et al. (2013); Solér et al. (2010); Wycherley (1999).
	B31	Linguistic and cultural diversity	Attitudinal information	External	Setthasakko (2009); Walker and Jones (2012).

Continue

Exhibit 2. **List of barriers to GSCM** Conclusion

Barriers					
Type	Description		Nature	Scope	References
Support and involvement	B32	Lack of public policies and favorable government regulations	Attitudinal	External	Al Zaabi et al. (2013); Barve and Muduli (2013); Chen et al. (2014); Govindan et al. (2014); Kasim and Ismail (2012); Luthra et al. (2011); Mathiyazhagan et al. (2013); Mehrabi et al. (2012); Miao et al. (2012); Mosgaard et al. (2013); Mudgal et al. (2010); Muduli and Barve (2013); Muduli et al. (2013); Wycherley (1999).
	B33	Lack of corporate socio-environmental responsibility	Attitudinal	Internal	Govindan et al. (2014); Mathiyazhagan et al. (2013); Mudgal et al. (2010); Setthasakko (2009).
	B34	Lack of integration between members of the chain	Attitudinal	External	Mathiyazhagan et al. (2013); Miao et al. (2012); Mudgal et al. (2010).
	B35	Lack of commitment by the senior management	Attitudinal	Internal	Al Zaabi et al. (2013); Barve and Muduli (2013); Giunipero et al. (2012); Govindan et al. (2014); Luthra et al. (2011); Mathiyazhagan et al. (2013); Mehrabi et al. (2012); Mudgal et al. (2010); Muduli and Barve (2013); Muduli et al. (2013); Setthasakko (2009); Walker et al. (2008); Walker and Jones (2012); Witczak et al. (2014).
	B36	Lack of commitment of employees	Attitudinal	Internal	Barve and Muduli (2013); Muduli and Barve (2013); Muduli et al. (2013); Thun and Muller (2010); Walker et al. (2008); Walker and Jones (2012); Wycherley (1999).
	B37	Lack of involvement in environmental networks	Attitudinal	External	Govindan et al. (2014); Mathiyazhagan et al. (2013).
	B38	Lack of supplier commitment	Attitudinal	External	Drohomeretski et al. (2014); Govindan et al. (2014); Luthra et al. (2011); Mathiyazhagan et al. (2013); Miao et al. (2012); Mollenkopf et al. (2010); Mudgal et al. (2010); Walker et al. (2008); Walker and Jones (2012); Wycherley (1999).
	B39	Lack of client commitment	Attitudinal	External	Bala et al. (2008); Govindan et al. (2014); Kasim and Ismail (2012); Luthra et al. (2011); Mathiyazhagan et al. (2013); Mehrabi et al. (2012); Miao et al. (2012); Mosgaard et al. (2013); Mudgal et al. (2010); Muduli et al. (2013); Solér et al. (2010); Wycherley (1999).
	B40	Resistance to change	Attitudinal	Internal	Barve and Muduli (2013); Mudgal et al. (2010); Mathiyazhagan et al. (2013); Muduli et al. (2013).
	B41	Incompatibility of legal requirements among countries	Attitudinal	Internal	Giunipero et al. (2012); Thun and Muller (2010); Walker and Jones (2012).
	B42	Dependency among members of the chain	Attitudinal	External	Bala et al. (2008); Thun and Muller (2010).
	B43	Lack of integration with stakeholders	Attitudinal	External	Barve and Muduli (2013); Mehrabi et al. (2012); Muduli et al. (2013).

Phase 2: The barriers to GSCM compiled from the literature were presented as a questionnaire for validation by technical experts and academics according to the following standards: "essential" "useful, but not essential" and "not essential".

The study used the LinkedIn network to look for professionals having at least five years of experience in the area of consulting and certification of environmental management systems in small, medium, and large companies from at least two different economic sectors.

The academics were selected from postgraduate programs professors in Administration in the metropolitan area of the São Paulo city and certified by the National Association of Post graduation and Research in Administration (ANPAD) for student admission. The minimum criteria required for the selection are a doctorate degree and specialization in research fields related to environmental management and supply chain. The other requirements are the same as for the technical experts.

The content validity method followed the criteria proposed by Lawshe (1975), and reformulated by Ayre and Scally (2014); it recommends calculating the content validity ratio (CVR) from the number of experts evaluating the item as essential (ne) and the total number of respondents (N), excluding those who abstained from answering. Table 1 shows the CVR for some expert panels.

Table 1. **Criteria for validating content**

Total number of experts in the panel	Proportion of agreement (Essential item)	CVR (Exact values)	$N_{crítico}$ (Minimum number of experts in agreement)
17	0.765	0.529	13
18	0.722	0.444	13
19	0.737	0.474	14
20	0.750	0.500	15
21	0.714	0.429	15

Source: Ayre and Scally (2014, p. 85).

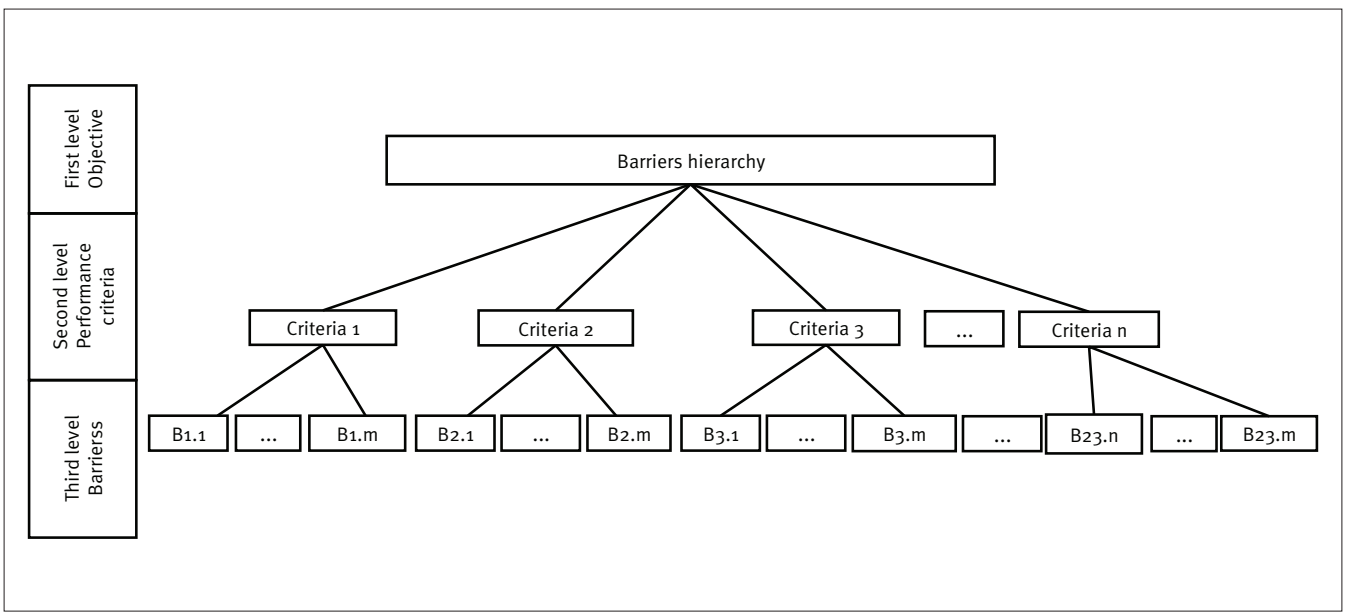
Fifty-three technical experts and 21 academics were contacted via email between August 24 and December 11, 2015. From this group, 14 technical experts and 6 academics were validated to participate, with response rates of 26.4% and 28.6%, respectively. A panel of 20 members required the consensus of at least 15 experts in order to validate each barrier to GSCM, as illustrated in Table 1.

Phase 3: The third and last phase of this research involved comparing the results obtained in the previous phases with the current position in the different departments of an organization. The scope of this research was limited to the automotive sector and defined, and, as a sample, to a first-tier supplier. This was represented by up to three collaborators located in strategic positions in different areas having direct contact with the players of the supply chain, such as purchasing department managers, logistics, quality, production, and development.

The study used the Analytic Hierarchy Process (AHP) method to analyze the degree of influence of each barrier to GSCM, following examples in the literature (Govindan et al., 2014; Salem, Salman, Najafi, & Moawad, 2010); moreover, this is a general theory of evaluation widely accepted by academics (Saaty & Vargas, 2012). The AHP method is generally divided into three stages: decomposition of the problem into a hierarchical structure (with objective, criteria and sub-criteria, and alternatives), construction of a comparison matrix between the criteria using the Saaty importance scale, and calculation of the priority vector (classification) for the alternatives (Saaty, 2008).

For the purpose of this study, this is the most suitable method, because it can be implemented partially. This is consistent with the model proposed in this work, which goes to the third level, as shown in Figure 1. Furthermore, this method can be easily developed in a spreadsheet, which would facilitate interaction with the decision makers. Another advantage is that the method allows a one-to-one comparison of the criteria, for a more focused analysis.

Figure 1. **AHP decision model adopted in this work**



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Since the AHP is an information and communication tool, each index of the comparative scale is given a numerical value: 1 for equal importance among the elements, 3 for a moderate difference, 5 for a significant difference, 7 when one element is much more important than the other, and 9 to show the extreme importance of one element over another. The values 2, 4, 6, and 8 are intermediaries between two decisions (Saaty, 2008).

Collective decisions arise from the combination of individual preferences for a concise and explicit purpose (Gomes, Gomes, & Almeida, 2009). From the different strategies documented in the literature for group decision making, and following the example in Aguarón, Escobar, and Moreno-Jiménez (2014), this study applied the AHP method integrally to each decision maker, after which the individual decisions were aggregated into a single decision using the geometric mean, a technique known as aggregation of individual priorities (AIP) (Costa & Belderrain, 2009; Cruz, 2011; Lai, Wong, & Cheung, 2002; Saaty & Peniwati, 2013).

The decision makers analyzed the problem and expressed their point of view and specific interests separately, and their decisions were verified in terms of the acceptable inconsistency patterns of the individual matrices, to obtain a consistency ratio (CR) lower than 0.1 (Saaty & Peniwati, 2013). In order to obtain a global picture of the difficulties faced by a given company, no weight was attributed to the decision of each company representative.

CONTEXTUALIZATION OF THE SUBJECT OF STUDY

The Brazilian automotive industrial complex consisted of 624 auto part manufacturing companies, including representative offices, and 31 vehicle, agricultural machinery, and road machinery manufacturers (National Association of Motor Vehicle Manufacturers [Anfavea], 2016). As in other sectors, the automotive industry's supply chain is organized in levels or tiers; that is, from the focal company—the assembler—toward the upstream suppliers and downstream customers (Castro, 2005).

The component, module, or pre-assembled subsystem suppliers are placed in the first upstream tier. Since these products are directly incorporated into the assembler production line, closer ties allow the focal company to have control over the consolidation of volumes and activities performed by the supplier. This occurs whether it is allocated within its own infrastructure, regardless of the assembler, the so-called single sourcing, or inserted in a delivery zone on the assembly plant itself or attached to it (Castro, 2005; Humphrey, Lecler, & Salerno, 2000; Martins, Souza, & Serio, 2011; Pires, 1998; Pires & Sacomano Neto, 2010; Salerno, Zilbovicius, Arbix, & Dias, 1998).

A certified environmental management system, waste management, and the adoption of green buildings (Lopes, Sacomano Neto, Silva, & Lopes, 2013; Pombo & Magrini, 2008) are some of the most commonly observed GSCM practices in the Brazilian automotive companies. However, the pressure to become energy efficient, minimize the environmental impact, and reduce oil dependence has driven the automotive industry to look for sustainable solutions (Vaz, Barros, & Castro, 2014).

This study chose the Alpha Company for analysis, given the ease of access and availability of information to carry out this research. Dedicated to the transformation of plastic material, with a production capacity of 65 tons per day, the company is consider as a large industry in accordance with The Brazilian Development Bank (BNDES, 2017) classification. Established as a first-tier supplier in the automotive supply chain, it relates with 12 light vehicle and truck assemblers downstream, and 90 suppliers upstream. Thus, they supply the domestic market with various products, such as tanks, cold start systems, and safety triangles.

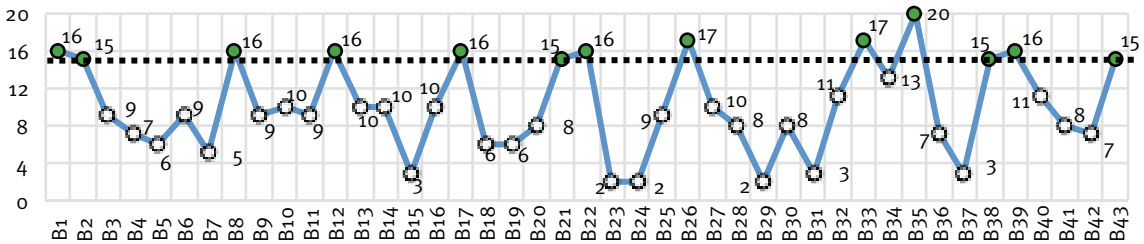
Over the process of hierarchizing the barriers to GSCM, the Alpha Company is represented by its Quality Engineering (decision maker 1), Production (decision maker 2), and Purchasing (decision maker 3) department managers. Decision makers 1 and 2 are qualified in Production Engineering, and decision maker 3 is qualified in Business Administration and Economics, and together they have an average experience of about 15 years.

RESULTS

As in other works dealing with the influence of the barriers to GSCM at the national level (Jabbour & Souza, 2015; Nascimento, Silva, Nunes, & Sellito, 2014), the conceptual framework of this study is based on studies carried out in the developed and developing countries.

As Figure 2 shows, a cut-off line of 15 evaluations from a panel of 20 specialists is required for a barrier to GSCM to be defined valid (Ayre & Scally, 2014). Only barrier B35, lack of commitment from top management, showed total consensus. From the barriers to GSCM implementation considered least impactful or irrelevant, B23, B24, and B29 were considered essential by 10% of the panel.

Figure 2. **Validation of the barriers to GSCM**



The total number of the valid barriers to GSCM in this study is 13; this is consistent with Zaabi, Dhaheri, and Diabat (2013), and places this study in an intermediate position among works analyzing the influence of four barriers to GSCM (Giunipero et al., 2012; Thun & Müller, 2010) and those investigating up to 26 barriers (Govindan et al., 2014; Mathiyazhagan, Govindan, Haq, & Geng, 2013). Table 2 compares the barriers to GSCM validated with regard to the aspect that they interact with.

Table 2. **Comparison of the validated barriers to GSCM**

Influence over:	Total number of barriers		Validated barriers	% of validation
	Qty	Description		
1 - Economic performance	7	B1, B2, B3, B4, B5, B6, B7	B1, B2	28.6
2 - Environmental performance	9	B8, B9, B10, B11, B12, B13, B14, B15, B16	B8, B12	22.2
3 - Operational performance	6	B17, B18, B19, B20, B21, B22	B17, B21, B22	50.0
4 - Knowledge and information	9	B23, B24, B25, B26, B27, B28, B29, B30, B31	B26	11.1
5 - Support and involvement	12	B32, B33, B34, B35, B36, B37, B38, B39, B40, B41, B42, B43	B33, B35, B38, B39, B43	41.7

Decision makers 2 and 3 exhibited a consistency ratio (CR) of less than 0.1 in their decisions (Saaty, 1991). Meanwhile, decision maker 1 showed a CR of 0.139, implying a need for reconsideration. After the decisions were made again, the CR value was confirmed to be equal to 0.091.

Table 3 shows the individual decisions on the extent to which the barriers influence GSCM.

Table 3. **Criteria priority**

Criteria		Decision maker 1		Decision maker 2		Decision maker 3	
EP	Economic performance	0.214	3rd	0.537	1st	0.232	2nd
EnP	Environmental performance	0.076	5th	0.079	4th	0.035	5th
OP	Operational performance	0.134	4th	0.169	2nd	0.107	3rd
KI	Knowledge and information	0.230	2nd	0.041	5th	0.095	4th
SI	Support and involvement	0.345	1st	0.174	3rd	0.531	1st

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Both Purchase and Quality managers agree that the barriers to GSCM are concentrated around the relationship among the players, mainly because the first-tier supplier is responsible for the automaker for the management of the suppliers at later tiers (Humphrey et al., 2000).

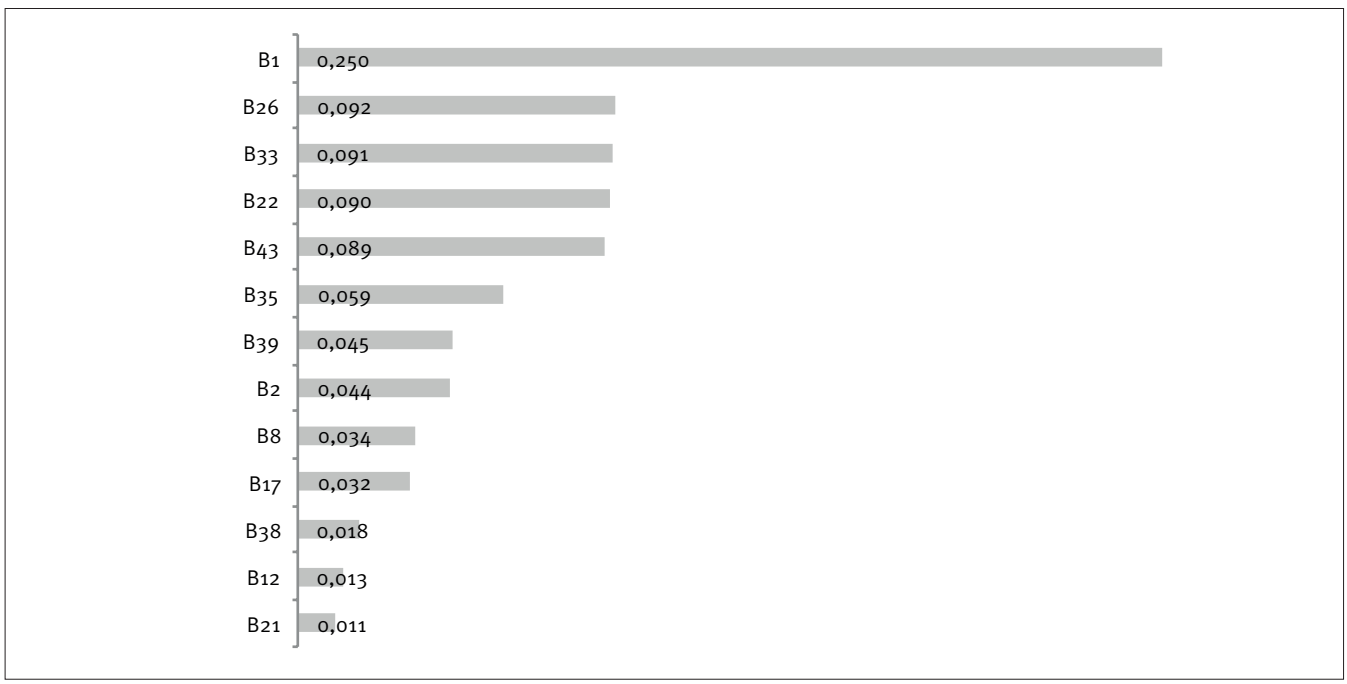
According to Vanalle and Salles (2011), the relationship among players, which is mediated through cooperation agreements, generally extends over the supply period of the product and impacts the final price of the car as well as other aspects such as quality, warranty, and image.

Decision maker 2, the production manager, finds the difficulties related to economic factors more critical for GSCM, despite the need to offer products at lower prices than their competitors and, at the same time, reduce production costs (Jabbour & Filhos, 2010). In general, the production strategies in the Brazilian automotive sector focus on the fulfillment of competitive goals relating to cost, quality, and flexibility (Vanalle, Salles, & Vieira, 2009).

For all the decision makers, the environmental performance barrier category was less significant, showing little doubt on the need to align their corporate goals with processes and products that are less aggressive to the environment. As Pombo and Magrini (2008) indicated, for more than a decade, the automotive sector had the largest number of companies with certified environmental management systems following NBR ISO 14001 (ABNT, 2004).

After aggregating the decision makers' individual priorities, the overall influence of the barriers to GSCM on a primary supplier of the automotive supply chain was obtained by determining the geometric mean, as shown in Figure 3.

Figure 3. **Influence of the barriers to GSCM**



The Cost Implications (B1) barrier was recognized as the primary challenge to implementing GSCM. This supports Nascimento et al. (2014), who identified four primary barriers to GSCM in the oil lubricant supply chain, of which three related to economic performance.

The priority index of B1 is 22 times more impactful than that of the lowest rated barrier, B21, lack of proper reverse logistics practices. This can be better understood by considering the vast body of the legislation and environmental policies, mainly at the state and federal levels, such as those for the collection and final disposal of solid waste like fluorescent lamps, batteries, lubricating oil, and tires.

Lack of technical knowledge, B26, was second in degree of priority. This highlights the need for organizations to sustain a position or department specialized in environmental issues dedicated to the diffusion of knowledge (Corazza, 2003). Jabbour, Teixeira, and Jabbour (2013) identified cases of co-evolution between the level of planned environmental training following the implementation of best practices and the environmental management level of Brazilian companies in various economic sectors.

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Socio-environmental responsibility lies not only with the top management, but also with the whole organization (Tachizawa & Andrade, 2008). According to the decision makers in Alpha Company, the lack of socio-environmental responsibility impedes GSCM, which is why B33 was treated as the third most important factor. In a study of the Indian automotive industry, Mudgal, Shankar, Talib, and Raj (2010) found an interdependence between the barriers to GSCM and the lack of socio-environmental responsibility and technical knowledge.

Barrier B22, low process eco-efficiency due to product design complications, shows a weight of 0.090, rendering it the fourth most pertinent barrier to GSCM. Although more modern vehicles consume less resources and are less polluting, it is difficult to translate legal requirements into technical criteria (Naveiro, Pacheco, & Medina, 2005).

Barrier B43, lack of integration with stakeholders, is in the fifth place, with a weight of 0.089. This can be explained by the difficulty of integrating various interests, such as the interests of regulatory bodies, the surrounding community, employees, and class associations (Seles & Jabbour, 2014; Wu, Ding, & Chen, 2012). For more reflections on barrier B43 in the automotive sector, see Gavirneni (2003).

Some results of this study could not find any comparison parameters with other works on this theme at the national level (Drohomeretski, Costa, & Lima, 2014; Jabbour & Souza, 2015; Nascimento et al., 2014) because they did not address several of the barriers to GSCM, such as B8, B33, and B35.

Lack of commitment of senior management (B35) was found to have high relevance during the second phase of the research, given that it was unanimously validated by technical and academic specialists. However, this barrier did not attain the same distinction for Alpha's decision makers. Note that Mudgal et al. (2010) found organizational management barriers to be the root cause of the problems in implementing GSCM in Indian manufacturing industries.

Supply chain management finds it increasingly important to know the barriers to GSCM implementation, primarily from the pressures and demands for better environmental practices by governments, significant segments of society in general, and internal and external stakeholders.

FINAL CONSIDERATIONS

The objective of this study is to identify the barriers to GSCM implementation and analyze their degree of influence, specifically from the perspective of a first-tier supplier in the Brazilian automotive industry. To accomplish this, through a specialized literature search, this study identified 43 barriers to GSCM and classified them according to their nature, scope, and extent of effect. From this total, 13 barriers were validated using the perception of technical and academic specialists familiar with environmental management and supply chains in various sectors of the national economy. Of these 13 barriers, 5 were related to supportive relationships and commitment among players in the chain. The remaining barriers were related to economic performance (two), environmental performance (two), operational performance (three), and knowledge and information (one).

The degree of influence of these barriers to GSCM in the Brazilian automotive industry was obtained by applying the AHP to three representatives of a first-tier supplier. The priorities were organized separately for each decision maker, with the goal to understand the extent to which the barriers impact each area of the company, such as purchasing, quality, and production. At the end of the process, the barriers to GSCM were ranked by taking the geometric mean of the provided ratings.

The cost implications barrier (B1) led the ranking of GSCM impediments, with a weight 22 times more than the 13th barrier, B21. The decline in sales experienced by the Brazilian automotive industry since 2009 and the political and economic instability which the country currently faces may have had a notable influence on the situation of the company surveyed, which in turn might have been reflected in priority allocation.

This research used a consistent method, assuming that it can be replicated in supply chains in other sectors. This could follow when managers are aware of the potential barriers, especially when faced with the pressures and demands exerted by internal and external stakeholders and the society in general in favor of better environmental practices.

The scope of this academic study was relatively limited due to the research method adopted and its execution. As far as sampling is concerned, the barriers were validated by considering a 95% confidence level and a five-point interval, according to the CVR indices calculated as recommended by Ayre and Scally (2014). However, if more experts had been consulted, the range of validated barriers could have been larger.

This study addressed a frontier topic, and its results and conclusions are exploratory in nature and restricted to the company studied. However, it has contributed to the literature by identifying the main barriers to the integration of environmental management in the automotive supply chain. The results presented can be a starting point for action plans to overcome the barriers to GSCM implementation.

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This study opens up diverse research possibilities. Other companies can replicate the pattern of this research to delineate the barriers to their GSCM implementation in various supply chains. Furthermore, this research model can be extended to other supply levels by expanding the extent of research and diversifying the statistical analytic techniques so as to obtain more conclusive results regarding the Brazilian automotive sector.

REFERENCES

Aguarón, J., Escobar, M. T., & Moreno-Jiménez, J. M. (2014). The precise consistency consensus matrix in a local AHP-group decision making context. *Annals of Operations Research, 245*(1-2), 245-259. doi:10.1007/s10479-014-1576-8.

Al Zaabi, S., Al Dhaheri, N. & Diabat, A. (2013). Analysis of interaction between the barriers for the implementation of sustainable supply chain management. *International Journal of Advanced Manufacturing Technology, 68*(1-4), 895-905.

Associação Brasileira de Normas Técnicas. (2004). *NBR ISO 14001: Sistemas da gestão ambiental: Requisitos com orientações para uso*. Rio de Janeiro, RJ: ABNT.

Associação Nacional dos Fabricantes de Veículos Automotores. (2016). *Anuário da indústria automobilística brasileira*. Retrieved from http://www.anfavea.com.br/anuario.html

Ayre, C., & Scally, A. J. (2014). Critical values for Lawshe's content validity ratio: Revisiting the original methods of calculation. *Measurement and Evaluation in Counseling and Development*, *47*(1), 79-86. doi:10.1177/0748175613513808

Bala, A., Muñoz, P., Rieradevall, J., & Ysern, P. (2008). Experiences with greening suppliers. The Universitat Autònoma de Barcelona. *Journal of Cleaner Production*, *16*(15), 1610-1619. doi:10.1016/j.jclepro.2008.04.015

Balasubramanian, S. (2012). A hierarchical framework of barriers to green supply chain management in the construction sector. *Journal of Sustainable Development*, *5*(10), 15-27. doi:10.5539/jsd.v5n10p15

Banco Nacional de Desenvolvimento Econômico e Social. (2017). *Classificação de porte dos clientes*. Retrieved from http://www.bndes.gov.br/wps/portal/site/home/financiamento/guia/quem-pode-ser-cliente/

Barve, A., & Muduli, K. (2013). Modelling the challenges of green supply chain management practices in Indian mining industries. *Journal of Manufacturing Technology Management*, *24*(8), 1102-1122. doi:10.1108/JMTM-09-2011-0087

Bovell-Benjamin, A. C., Hathorn, C. S., Ibrahim, S., Gichuhi, P. N., & Bromfield, E. M. (2009). Healthy food choices and physical activity opportunities in two contrasting Alabama cities. *Health & Place*, *15*(2), 429-438. doi:10.1016/j.healthplace.2008.08.001

Castro, R. L. (2005). *Planejamento e controle da produção e estoques: Um survey com fornecedores da cadeia automobilística brasileira* (Masters dissertation). Universidade de São Paulo, São Paulo, SP.

Chan, R. Y. K., He, H., Chan, H. K., & Wang, W. Y. C. (2012). Environmental orientation and corporate performance: The mediation mechanism of green supply chain management and moderating effect of competitive intensity. *Industrial Marketing Management*, *41*(4), 621-630. doi:10.1016/j.indmarman.2012.04.009

Chen, S. M. S. M., Chen, Y-T., Shen, Y-H., Lo, S-T., & Chu, S-S. (2014). Green supply chain management as a conceptual framework for Taiwan textile industry. *Research Journal of Applied Sciences, Engineering and Technology, 7*(12), 2432-2436. doi:10.19026/ rjaset.7.548

Corazza, R. I. (2003). Gestão ambiental e mudanças da estrutura organizacional. *RAE-eletrônica*, *2*(2), 1676-5648. doi:10.1590/S1676-56482003000200006

Costa, T. C., & Belderrain, M. C. N. (2009). Decisão em grupo em métodos multicritério de apoio à decisão. *XV Encontro de Iniciação Cientifica e Pós-Graduação do ITA*. São José dos Campos, SP.

Creswell, J. W. (2010). *Projeto de pesquisa: Métodos qualitativo, quantitativo e misto* (3ª ed.). Porto Alegre, RS: Artmed.

Cruz, M. H. (2011). *Utilização de uma metodologia de apoio à decisão na análise de outsourcing em uma empresa metalúrgica* (Masters dissertation). Universidade Estadual de Campinas, Campinas, SP).

Daily, B. F., & Huang, S. (2001). Achieving sustainability through attention to human resource factors in environmental management. *International Journal of Operations & Production Management*, *21*(12), 1539-1552. doi:10.1108/01443570110410892

Drohomeretski, E., Costa, S. G, & Lima, E. P. (2014). Green supply chain management: Drivers, barriers and practices within the Brazilian automotive industry. *Journal of Manufacturing Technology Management*, *25*(8), 1105-1134. doi:10.1108/JMTM-06-2014-0084

Gavirneni, S. (2003). Supply chain management at a chip tester manufacturer. In T. P. Harrison, H. L. Lee, & J. J. Neale (Eds.), *The practice of supply chain management: Where theory and application converge* (pp. 277-293). Norwell, USA: Kluwer Academic Publishing.

Giunipero, L. C., Hooker, R. E., & Denslow, D. (2012). Purchasing and supply management sustainability: Drivers and barriers. *Journal of Purchasing and Supply Management, 18*(4), 258-269. doi:10.1016/j.pursup.2012.06.003

Gomes, L. F. A. M., Gomes, C. F. S., & Almeida, A. T. (2009). *Tomada de decisão gerencial: Enfoque multicritério* (3ª ed.). São Paulo, SP: Atlas.

Govindan, K., Mathiyazhagan, K., Kannan, D., & Haq, A. N. (2014). Barriers analysis for green supply chain management implementation in Indian industries using analytic hierarchy process. *International Journal of Production Economics*, *147*(Part B), 555-568. doi:10.1016/j.ijpe.2013.08.018

Haq, A. N., & Mathiyazhagan, K. (2013). Comparative study of green supply chain: Barrier analysis. *IV International Conference on Mechanical, Production and Automobile Engineering*. Dubai, United Arab Emirates.

Humphrey, J., Lecler, Y., & Salerno, M. S. (2000). *Global strategies and local realities: The auto industry in emerging markets*. London, UK: Macmillan.

Jabbour, A. B. L. S., & Filhos, A. G. A. (2010). Tendências da área de pesquisa em estratégia de produção. *Revista Eletrônica Sistemas & Gestão*, *4*(3), 238-262. doi:10.7177/sg.2009.V4N3A4

Jabbour, A. B. L. S., Arantes, A. F., & Jabbour, C. J. C. (2013). Gestão ambiental em cadeias de suprimentos: Perspectivas atuais e futuras de pesquisa. *Interciencia*, *38*(2), 104-111.

Jabbour, A. B. L. S., & Souza, C. L. (2015). Oportunidades e desafios para lidar com as barreiras à adoção de práticas de green supply chain management: Guidelines à luz de um estudo de múltiplos casos no Brasil. *Gestão & Produção*, *22*(2), 295-310. doi:10.1590/0104-530X871-13

Jabbour, C. J. C., Teixeira, A. A., & Jabbour, A. B. L. S. (2013). Treinamento ambiental em organizações com certificação ISO 14001: Estudo de múltiplos casos e identificação de coevolução com a gestão ambiental. *Produção*, *23*(1), 80-94. doi:10.1590/S0103-65132012005000047

Kasim, A., & Ismail, A. (2012). Environmentally friendly practices among restaurants: Drivers and barriers to change. *Journal of Sustainable Tourism*, *20*(4), 551-570. doi:10.1080/09669582.2011.621540

Lai, V. S., Wong, B. K., & Cheung, W. (2002). Group decision making in a multiple criteria environment: A case using the AHP in software selection. *European Journal of Operational Research*, *137*(1), 134-144. doi:10.1016/S0377-2217(01)00084-4

Lawshe, C. H. (1975). A quantitative approach to content validity. *Personnel Psychology*, *28*(4), 563-575. doi:10.1111/j.1744-6570.1975.tb01393.x

Lee, S. Y. (2015). The effects of green supply chain management on the supplier's performance through social capital accumulation. *Supply Chain Management: An International Journal*, *20*(1), 42-55. doi:10.1108/SCM-01-2014-0009

Leigh, M., & Li, X. (2014). Industrial ecology, industrial symbiosis and supply chain environmental sustainability: A case study of a large UK distributor. *Journal of Cleaner Production*, *106*, 623-643. doi:10.1016/j.jclepro.2014.09.022

Lopes, L. J., Sacomano Neto, M., Silva, E. M., & Lopes, F. C. C. (2013). Influência das práticas do green supply chain management no desempenho ambiental das empresas do setor automotivo brasileiro. *XXXVII Encontro da Associação Nacional de Pós-Graduação e Pesquisa em Administração*. Rio de Janeiro, RJ.

Luthra, S., Kumar, V., Kumar, S., & Haleem, A. (2011). Barriers to implement green supply chain management in automobile industry using interpretive structural modeling technique: An Indian perspective. *Journal of Industrial Engineering and Management*, *4*(2), 231-257. doi:10.3926/jiem..v4n2.p231-257

Martins, G. A., & Theóphilo, C. R. (2009). *Metodologia da investigação científica para ciências sociais aplicadas* (2ª ed.). São Paulo, SP: Atlas.

Martins, R. S., Souza, O. V, Filho, & Serio, L. C. (2011). Práticas colaborativas entre camadas na cadeia automobilística brasileira. *XIV Simpósio de Administração da Produção; Logística e Operações Internacionais*. São Paulo, SP.

Mathiyazhagan, K., Govindan, K., & Haq, A. N. (2014). Pressure analysis for green supply chain management implementation in Indian industries using analytic hierarchy process. *International Journal of Production Research*, *52*(1), 188-202. doi:10.1080/00207543.2013.831190

Mathiyazhagan, K., Govindan, K., Haq, A. N., & Geng, Y. (2013). An ISM approach for the barrier analysis in implementing green supply chain management. *Journal of Cleaner Production*, *47*, 283-297. doi:10.1016/j.jclepro.2012.10.042

Mehrabi, J., Gharakhani, D., Jalalifar, S., & Rahmati, H. (2012). Barriers to green supply chain management in the petrochemical sector. *Life Science Journal*, *9*(4), 3438-3442.

Miao, Z., Cai, S., & Xu, D. (2012). Exploring the antecedents of logistics social responsibility: A focus on Chinese firms. *International Journal Production Economics*, *140*(1), 18-27. doi:10.1016/j.ijpe.2011.05.030:

Mollenkopf, D., Stolze, H., Tate, W. L., & Ueltschy, M. (2010). Green, lean, and global supply chains. *International Journal of Physical Distribution & Logistics Management*, *40*(1/2), 14-41. doi:10.1108/09600031011018028

Mosgaard, M., Riisgaard, H., & Huulgaard, R. D. (2013). Greening non-product-related procurement: When policy meets reality. *Journal of Cleaner Production*, *39*, 137-145. doi:10.1016/j.jclepro.2012.08.018

Mudgal, R. K., Shankar, R., Talib, P., & Raj, T. (2010). Modelling the barriers of green supply chain practices: An Indian perspective. *International Journal of Logistics Systems and Management*, *7*(1), 81-107. doi:10.1504/IJLSM.2010.033891

Muduli, K., & Barve, A. (2013). Establishment of a sustainable development framework in small scale mining supply chains in India. *International Journal of Intelligent Enterprise*, *2*(1), 84-100. doi:10.1504/IJIE.2013.057340

Muduli, K., Govindan, K., Barve, A., & Geng, Y. (2013). Barriers to green supply chain management in Indian mining industries: A graph theoretic approach. *Journal of Cleaner Production*, *47*, 335-344. doi:10.1016/j.jclepro.2012.10.030

Nascimento, A. P., Silva, F. P., Nunes, A. A. B., & Sellito, M. A. (2014). Barreiras para implementação da gestão verde da cadeia de suprimento em uma distribuidora de óleo lubrificante. *Revista Eletrônica em Gestão, Educação e Tecnologia Ambiental*, *18*(2), 718-728. doi:10.5902/2236117013125

Naveiro, R. M., Pacheco, E. B. A. V., & Medina, H. D. V. (2005). Ecodesign: O desenvolvimento de projeto de produto orientado para reciclagem. *V Congresso Brasileiro de Gestão de Desenvolvimento de Produto*. Belo Horizonte, MG.

Perron, G. M. (2005). *Barriers to environmental performance improvements in Canadian SMEs*. Dalhousie University, Halifax, Canada.

Pires, S. R. I. (1998). Gestão da cadeia de suprimentos e o modelo de consórcio modular. *Revista de Administração da Universidade de São Paulo*, *33*(3), 5-15.

Pires, S. R. I., & Sacomano Neto, M. (2010). Características estruturais, relacionais e gerenciais na cadeia de suprimentos de um condomínio industrial na indústria automobilística. *Produção*, *20*(2), 172-185. doi:10.1590/S0103-65132010005000032

Pombo, F. R., & Magrini, A. (2008). Panorama de aplicação da norma ISO 14001 no Brasil. *Gestão & Produção*, *15*(1), 1-10. doi:10.1590/S0104-530X2008000100002

Prodanov, C. C., & Freitas, E. C. (2013). *Metodologia do trabalho científico: Métodos e técnicas da pesquisa e do trabalho acadêmico* (2ª ed.). Novo Hamburgo, RS: Universidade FEEVALE.

Saaty, T. L. (1991). Some mathematical concepts of the analytic hierarchy process. *Behaviormetrika*, *18*(29), 1-9. doi:10.2333/bhmk.18.29_1

Saaty, T. L. (2008). Decision making with the analytic hierarchy process. *International Journal of Services Sciences*, *1*(1), 83-98. doi:10.1504/IJSSci.2008.01759

Saaty, T. L., & Peniwati, K. (2013). *Group decision making: Drawing out and reconciling differences*. Pittsburgh, EUA: RWS Publications. Saaty, T. L., & Vargas, L. G. (2012). *Models, methods, concepts e applications of the hierarchy analysis process* (2nd ed.). New York, USA: Springer Science & Business Media.

Sadrnia, A., Ismail, N., Zulkifli, N., Ariffin, M. K. A., Nezamabadi-Pour, H., & Mirabi, H. (2013). A multi objective optimization model in automotive supply chain networks. *Mathematical Problems in Engineering*, *2013*, 1-10. doi:10.1155/2013/823876doi.org/10.1155/201.

Salem, O., Salman, B., Najafi, M., & Moawad, A. (2010). Use of trenchless technologies for a comprehensive asset management of culverts and drainage structures. *Pipelines 2010: Climbing New Peaks to Infrastructure Reliability – Renew, Rehab, and Reinvest*. Retrieved from https://ascelibrary.org/doi/abs/10.1061/41138(386)102.

Salerno, M. S., Zilbovicius, M., Arbix, G., & Dias, A. V. C. (1998). Mudanças e persistências no padrão de relações entre montadoras e autopeças no Brasil. *Revista de Administração*, *33*(3), 16-28.

Sarkis, J., Zhu, Q., & Lai, K. H. (2011). An organizational theoretic review of green supply chain management literature. *International Journal of Production Economics*, *130*(1), 1-15. doi:10.1016/j.ijpe.2010.11.010

Seles, B. M. R. P., & Jabbour, A. B. L. S. (2014). O papel dos stakeholders no contexto da green supply chain management: Uma revisão sistemática. *XXXIV Encontro Nacional de Engenharia de Produção*. Curitiba, PR.

Setthasakko, W. (2009). Barriers to implementing corporate environmental responsibility in Thailand: A qualitative approach. *International Journal of Organizational Analysis*, *17*(3), 169-183. doi:10.1108/19348830910974905

Seuring, S., & Müller, M. (2008). From a literature review to a conceptual framework for sustainable supply chain management. *Journal of Cleaner Production*, *16*(15), 1699-1710. doi:10.1016/j.jclepro.2008.04.020

Shibao, F. Y. (2011). *Cadeia de suprimentos verde: Um estudo nas indústrias químicas do Brasil* (Doctoral thesis). Universidade Presbiteriana Mackenzie, São Paulo, SP).

Solér, C., Bergström, K., & Shanahan, H. (2010). Green supply chains and the missing link between environmental information and practice. *Business Strategy and the Environment*, *19*(1), 14-25. doi:10.1002/bse.655

Srivastava, S. K. (2007). Green supply chain management: A state-of-the-art literature review. *International Journal of Management Reviews*, *9*(1), 53-80. doi:10.1111/j.1468-2370.2007.00202.x

Tachizawa, T., & Andrade, R. O. B. (2008). *Gestão socioambiental: Estratégias na nova era da sustentabilidade*. Rio de Janeiro, RJ: Elsevier.

Thun, J. H., & Müller, A. (2010). An empirical analysis of green supply chain management in the German automotive industry. *Business Strategy and the Environment*, *19*(1), 119-132. doi:10.1002/bse.642

Vachon, S., & Klassen, R. D. (2006). Extending green practices across the supply chain integration: The impact of upstream and downstream integration. *International Journal of Operations & Production Management*, *26*(7), 795-821. doi:10.1108/01443570610672248

Vanalle, R. M., & Salles, J. A. A. (2011). Relação entre montadoras e fornecedores: Modelos teóricos e estudos de caso na indústria automobilística brasileira. *Gestão e Produção*, *18*(2), 237-250.

Vanalle, R. M, Salles, J. A. A., & Vieira, M., Junior. (2009). Strategies of production in the automobile industry: A multi-case study in Spain and Brazil. *Brazilian Journal of Operations and Production Management*, *6*(2), 101-124.

Vaz, L. F. H., Barros, D. C., & Castro, B. H. R. (2014). *Veículos híbridos e elétricos: Sugestões de políticas públicas para o segmento*. Rio de Janeiro, RJ: BNDES Setorial.

Walker, H., & Jones, N. (2012). Sustainable supply chain management across the UK private sector. *Supply Chain Management: An International Journal*, *17*(1), 15-28. doi:10.1108/13598541211212177

Walker, H., Sisto, L. Di, & McBain, D. (2008). Drivers and barriers to environmental supply chain management practices: Lessons from the public and private sectors. *Journal of Purchasing & Supply Management*, *14*(1), 69-85. doi:10.1016/j.pursup.2008.01.007

Witczak, J., Kasprzak, J., Klos, Z., Kurczewski, P., Lewandowska, A., & Lewicki, R. (2014). Life cycle thinking in small and medium enterprises: The results of research on the implementation of life cycle tools in Polish SMEs-part 2: LCA related aspects. *International Journal of Life Cycle Assessment*, *19*(4), 891-900. doi:10.1007/s11367-013-0687-9

World Economic Forum. (2013). *The human capital report 2013*. Genève, Suisse. Retrieved from http://reports.weforum.org/human-capital-index-2013/

Wu, G. C., Ding, J. H., & Chen, P. S. (2012). The effects of GSCM drivers and institutional pressures on GSCM practices in Taiwan's textile and apparel industry. *International Journal of Production Economics*, *135*(2), 618-636. doi:10.1016/j.ijpe.2011.05.023

Wycherley, I. (1999). Greening supply chains: The case of The Body Shop International. Business *Strategy and the Environment, 8*(2), 120-127.doi:10.1002/(SICI)1099-0836(199903/04)8:2<120::AID-BSE188>3.0.CO;2-X

Zaabi, S. Al, Dhaheri, N. Al, & Diabat, A. (2013). Analysis of interaction between the barriers for the implementation of sustainable supply chain management. *International Journal of Advanced Manufacturing Technology, 68*(1-4), 895-905. doi:10.1007/s00170-013-4951-8

Zhu, Q., Sarkis, J., & Geng, Y. (2005). Green supply chain management in China: Pressures, practices and performance. *International Journal of Operations & Production Management*, *25*(5), 449-468. doi:10.1108/01443570510593148

Zhu, Q., Sarkis, J., & Lai, K. H. (2007). Initiatives and outcomes of green supply chain management implementation by Chinese manufacturers. *Journal of Environmental Management*, *85*(1), 179-189. doi:10.1016/j.jenvman.2006.09.003

Zhu, Q., Sarkis, J., & Lai, K. H. (2012). Examining the effects of green supply chain management practices and their mediations on performance improvements. *International Journal of Production Research*, *50*(5), 1377-1394. doi:10.1080/00207543.2011.571937