
Green supply chain management: mapping the territory

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Abstract: The objective of this paper is to identify the main definitions, related practices and to point out future directions in green supply chain management (GSCM). After a literature review and systematisation of the published articles in this field, it was possible to identify: a) the main research objectives of analysed papers; b) the research methods adopted; c) the predominantly analysed industrial sectors; d) the GSCM practices considered by the researchers. Results are presented in each of these analytical perspectives. The main findings are: 1) there are various classifications, nomenclatures and types of GSCM practices, but the most commonly used by studies in GSCM are cleaner production, product design, reverse logistic and green purchasing; 2) from the highlighted definitions, the tonic is to adapt operating activities and incorporate the supply chain management philosophy (integration/collaboration) to environmental concerns (impact reduction) in relations between links in the chain. These results can be useful for those interested in environmental management as well as supply chain management, considering the growing interest in GSCM. We also propose a research agenda on this subject. This is one of the most recent literature review and systematisation on green supply chain management.

Keywords: green supply chain management; GSCM; definition; practices; literature review and systematisation.

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1 Introduction

Environmental management that deals with the incorporation of objectives and environmental strategies with the broader strategies of the organisation (Haden et al., 2009) has gone through several phases in a business context. It has been considered a necessary evil that focuses only on compliance with legislation in a reactive manner, until reaching a more contemporary phase, where it tends to be considered a source of competitive advantage, transformed into a differential in products, brand image and resource savings with a proactive perspective (Sarkis, 1998).

As a consequence of the advances in environmental management, nowadays, environmental concern tends to transcend the organisation level, unfolding into the supply chain (Olugu et al., 2010). In other words, suppliers of raw materials and components, logistics providers, distributors/retailers and clients are being involved in a search for a reduction in consumption, as well as remanufacturing and recycling/reuse of natural resources (Sarkis and Rasheed, 1995). Environmental management should thus be integrated to the links in the value chain, including product project, purchasing, production, packaging, logistics and distribution activities (Handfield et al., 1997).

As a result of this new context, the green supply chain management (GSCM) theme has been discussed since the mid-1990s. According to Srivastava (2007), GSCM has been gaining interest among researchers and practitioners in operations and supply chain management. As a consequence, the author affirms the definition of GSCM is rooted in environmental management literature, as well as in supply chain management, since it is a multidisciplinary and emerging theme.

In general, the most discussed themes in literature about GSCM are:

- 1 support of an environmental management system (EMS) to facilitate GSCM actions (Darnall et al., 2008; Testa and Iraldo, 2010; González et al., 2008; Arimura et al., 2011)
- 2 discussion on the importance of collaboration in the supply chain to support environmental protection actions in the other links (Vachon and Klassen, 2008; Yang et al., 2010)
- 3 adoption of GSCM practices (Zhu and Sarkis, 2006; Zhu et al., 2007b, 2008c; Walker et al., 2008; Lee, 2008; Thun and Muller, 2010)
- 4 motivating/inhibiting factors for adopting GSCM (Zhang et al., 2008; Holt and Ghobadian, 2009; Thun and Muller, 2010; Diabat and Govindan, 2010; Arimura et al., 2011).

Some papers aimed at systematising GSCM literature, such as: Srivastava (2007), who conducted a bibliographic study aimed at presenting an encompassing and integrated vision of literature published on all aspects and facets of GSCM, with reverse logistics as a focus; Fortes (2009), who conducted a brief of history of the last 20 years, discussing green operations, green design, green manufacturing, reverse logistics and waste management; Toke et al. (2010), who present some definitions for GSCM and discuss issues and practices geared towards purchasing and in-bound logistics, production, distribution (outbound logistics and marketing), and reverse logistics; and Sarkis et al. (2011), who elaborated a literature review to provide an overall perspective of a series of organisational theories that are applicable in GSCM's nascent literature.

But what can still be explored? What are the main tendencies and convergences of current literature on GSCM? Considering the theme's multidisciplinary nature, is there greater predominance for operations management (supply chain management) or environmental management?

As a result of the questions raised, the objectives of this paper are:

- identify convergences of the current stage of literature development on GSCM, including the discussion on GSC practices, to indicate tendencies for future studies
- identify and discuss the main definitions of GSCM.

This paper conducted a sweep of literature on GSCM using the Scopus database in order to identify the area's main papers, their objectives, research methods, object of study and results achieved to analyse and achieve the objectives proposed in this paper.

The next sections of this paper present the main definitions attributed to the term, GSCM practices, studies already conducted on the theme (literature review); then, in Section 3 (research method), the systematisation method and the criteria for paper selection and analysis; in Section 4, results and discussions, reviewed articles are organised to identify convergences and underscore the main results; and finally, in Section 5, final considerations, indicating guidelines for new studies to expand knowledge of this current theme of growing interest.

2 Literature review

2.1 GSCM definitions

Academic and practical interest in studying GSCM has been growing as GSCM practices emerge with new knowledge for obtaining improved operational performances (Sarkis et al., 2011).

GSCM is a multidisciplinary field since it integrates various areas of knowledge which are necessary for its implementation, expanding environmental management to the supply chain level between suppliers, manufacturers and clients (Thun and Muller, 2010). Thus, some authors defined 'green supply chain' in different ways, such as:

- Beamon (1999) defined GSCM as an extension of the supply chain that includes activities that reduce environmental impacts by using product reutilisation and remanufacturing adequately.
- Bowen et al. (2001) defined GSCM as purchasing company plans and activities that integrate environmental issues with supply chain management to improve supplier and client environmental performance.
- Vachon and Klassen (2008) believe that by integrating the supplier and client, the manufacturing process could obtain an effective solution in face of environmental changes.
- Zhu and Sarkis (2006) say GSCM encompasses all supply chain activities related to ecological and economic issues for transforming materials, from the initial stage of raw materials to the final user. Therefore, GSCM is the integration of these activities, improving supply chain relations to achieve a sustainable economy and environmental competitive advantage.
- Srivastava (2007) defined GSCM as an integration of environmental issues in supply chain management that includes product design, selection of materials, processing, delivery to the final consumer and product life cycle management.
- Lee (2008) defined GSCM as programmes to highlight the transfer and dissemination of environmental management throughout the supply chain through relationships between purchasing companies and their suppliers.
- Blanchard (2010) refers to GSCM as the alignment of manufacturing, distribution, transport and remanufacturing/recycling processes, with the objective of reducing a company's carbon sequestration.
- Zheng (2010) affirms that GSCM combines supplier, manufacturer, seller and user together to realise green design, green purchase, green manufacturing, green logistics and green consumption.
- Yeh and Chuang (2011) say that GSCM refers to management between suppliers, their products and environment, that is to say, the environment protection principle is brought into the suppliers' management system.
- Sarkis et al. (2011) define GSCM as the integration of environmental concerns in inter-organisational practices of supply chain management, including reverse logistics.

The highlighted definitions comply with the perspective of adapting operational activities of product design (ecodesign), purchasing (requirements for suppliers), production (reuse, and remanufacturing) and transportation and distribution (reverse logistics), which are part of supply chain management to the perspective of business environmental management; and incorporate environmental concern (impact reduction) to supply chain management philosophy (integration/collaboration) in relations between chain links. Thus, greater bias is seen for operational aspects than for environmental aspects (conservation, preservation, etc.) in current definitions of GSCM.

The objective of the next section is to present and briefly discuss GSCM's main practices.

2.2 GSCM practices

Lee (2008) considers GSCM initiatives programmes to transfer and disseminate environmental management throughout the supply chain, using the relations between buyers and suppliers, aimed at improving the suppliers' environmental performance through the buyers' influence.

In theory, GSCM has several terms and classifications for GSCM practices. There are authors who name GSCM practices using the term practices (Zhu and Sarkis, 2006; Vachon and Klassen, 2008; Zhu et al., 2007a, 2007b; Chien and Shih, 2007; Darnall et al., 2008; Zhu et al., 2008a, 2008b, 2008c; Thun and Muller, 2010; Zheng, 2010), others as initiatives (Lee, 2008; Wooi and Zailani, 2010; Eltayeb et al., 2010b), others as capability (Shang et al., 2010) and still others as approach (Hsu and Hu, 2008).

The types of practices are also diversified. The list of practices below is considered in the main papers selected from the Scopus database.

Zhu and Sarkis (2006), and Zhu et al. (2007a, 2007b, 2008b, 2008c), use the same GSCM practices later validated by Zhu et al. (2008a):

- a internal environmental management
- b green purchases
- c cooperation with consumers
- d eco-design
- e recovery of investment, for example, through the sale of residue or reuse.

Vachon and Klassen (2008) consider two major GSCM practices: collaboration and environmental monitoring.

Srivastava (2007) proposes verifying the context of the GSCM theme based on a literature review, pointing out four major practices:

- a green design
- b green operations
- c reverse logistics
- d waste management.

Chien and Shih (2007) use 11 GSCM practices in their research:

- a green purchases
- b elaborate a control list of hazardous environmental substances
- c profile of raw materials with prohibited substances
- d table to evaluate environmental management at suppliers
- e data for green product certification
- f audit mechanisms for green management
- g green production practices
- h green design
- i manufacturing of green products
- j recovery and reuse of used products
- l standardisation of green products.

Hsu and Hu (2008) selected 20 approaches and using statistical techniques, they grouped them into four factors that represent them:

- a supplier management
- b product recycling
- c organisational involvement
- d life cycle management.

Darnall et al. (2008) consider the following to be GSCM practices in their study:

- a evaluate the supplier's environmental performances
- b require suppliers to carry out environmental measures
- c trace waste cost
- d inform buyers of ways to reduce environmental impact.

Lee (2008) considered four initiatives related to GSCM:

- a select suppliers with environmental criteria
- b require an EMS from suppliers
- c have an interest in GSCM
- d provide training, education and technical environmental assistance.

Thun and Muller (2010) adopted the following GSCM practices:

- a reduction of packaging material and waste with suppliers
- b reduction of packaging material and waste with clients
- c reusable packaging system with suppliers
- d reusable packaging system with clients

- e selection of suppliers based on environmental criteria
- f requirement of environmental certificate
- g sharing ecological responsibilities with suppliers
- h joint development and use of environmental technologies
- i awarding of suppliers based on eco-programmes.

Wooi and Zailani (2010) consider the following as GSCM initiatives: design for environment, green purchases and reverse logistics.

Zheng (2010) consider the following as GSCM practices:

- a environmental implementation
- b positive environmental direction
- c environmental information management
- d global environmental management
- e life cycle management
- f environmental efficacy test
- g supplier environmental capability
- h eco-design
- i evaluation of environmental risk
- j compliance with environmental laws
- l environmental auditing.

Shang et al. (2010) stipulated 45 variables to represent GSCM practices, and based on a factorial and a cluster analysis, six factors represent them:

- a green manufacturing and packaging
- b environmental participation
- c green marketing
- d green supplier
- e green stock
- f green eco-design.

Eltayeb et al. (2010b) nominated the following as GSCM initiatives: eco-design, green purchasing and reverse logistics.

As a result, there is a perceived lack of unanimity in terms of practices (actions, programmes, initiatives) that represent GSCM. However, there is a tendency for GSCM practices to involve:

- supplier management (selection criteria, control/monitoring, collaboration)
- product design (eco-design, life cycle analysis, collaboration with the client)

- manufacturing management (technology, packaging)
- reverse logistics (recycling).

2.3 *Main evidence of state-of-the-art in GSCM*

For more than a decade now, the discussion concerning GSCM has been on the agenda of diverse researchers. There are various objectives, objects of study and research methods. The next paragraphs briefly discuss the main papers on GSCM published in journals indexed in the Scopus database, with an emphasis on the main results and implications for state-of-the-art in GSCM.

Handfield et al. (1997) conducted a study with environmental managers from furniture companies and the results suggest that to be successful environmental management strategies should be integrated at every stage of the value chain, which includes all the processes that encompass product design, purchasing, manufacturing and assembly, packaging, logistics and distribution.

Van Hoek (1999) proposed activities and evaluation measures for the main links in the supply chain to support environmental actions throughout a supply chain.

Sarkis (2003) elaborated a structure to assist in decision making regarding GSCM.

Based on a survey with US companies, Vachon and Klassen (2008) propose extending the perspective of collaboration of supply chain management theory to environmental management in operations.

Zhu and Sarkis (2006) studied three different Chinese industrial sectors and verified there are differences in the degree of GSCM adoption in different sectors as a result of the motivations and pressures unto which these sectors are submitted; the electro-electronic sector stood out among those studied.

Vachon and Klassen (2007) developed a study with companies from Canada and the USA that focused on the impact of supply chain activities in selecting environmental technologies: pollution prevention, control of pollution and management systems. As a result, they found that the allocation of a greater proportion of environmental investment for preventing pollution was positively tied to technology integrated with suppliers. However, control of pollution was driven by the integration of the supply chain with clients.

Zhu et al. (2007a) confirmed theoretical presuppositions that different types of industry also have different levels of GSCM implementation and results. The electro-electronic sector presents better results in GSCM than other studied sectors in China.

Zhu et al. (2007b) studied GSCM pressures and motivations, initiatives and performance of the automotive chain after an empirical analysis of 89 automotive companies in China. Results show that Chinese supply chains have experienced high and growing regulatory and market pressures, and at the same time, they have strong internal motivations for adopting GSCM practices.

Chien and Shih (2007) conducted interviews and survey quantitative research with electro-electronic companies in Thailand. They ascertained that manufacturers of original equipment and manufacturers in original projects adopted green purchase practices and green manufacturing practices in response to the current wave of international environmental issues, and as a result, they obtained environmental and financial performances.

Srivastava (2007) conducted a bibliographic study with the objective of presenting an encompassing and integrated view of literature published about all GSCM's aspects and facets, with the perspective of reverse logistics as a focus to facilitate future studies, practice and research.

Darnall et al. (2008) reveal empirical evidence that companies that adopt an EMS also more frequently implement GSCM practices. Therefore, those who adopt an EMS have a strong chance of improving the environment not only internally, but throughout the network of suppliers and clients.

Nawrocka (2008a) conducted interviews with environmental managers at companies in Poland and Sweden to explore an EMS's potential not only as an internal environmental management tool, but also for communication, development and control of their suppliers' environmental requirements.

Nawrocka (2008b) investigated the use of an EMS to initiate and control environmental improvements in the context of cooperation by the supply chain. It also analysed how environmental demands are reaching small companies in the electronic supply chain in light of recent legal alterations with the application of the RoHS directive.

Zhu et al. (2008c) conducted a survey with Chinese companies and identified that company size can affect the level of GSCM adoption.

Zhu et al. (2008a) gathered data from 341 Chinese manufacturers to empirically investigate the construction of a scale to evaluate the implementation of GSCM practices among manufacturers.

Zhu et al. (2008b) investigated the correlation of two main factors, 'organisational learning' and 'management support', with the degree of GSCM practice adoption at China's manufacturers, where their inbound and outbound logistics activities are potential polluters of the environment.

Based on a study with Thailand's electro-electronic companies, Hsu and Hu (2008) suggest companies could emphasise supplier performance management as a means to implement GSCM. That, after creating an environmental database for products, asking for a product testing report and support from top management for the more important approaches.

González et al. (2008) analysed Spanish automotive companies and reached the conclusion that companies with EMS require their suppliers to adopt environmental practices and thus the environmental concern disseminates downstream the supply chain.

Vachon and Klassen (2008) investigated US companies to examine the relationship between environmental collaboration in the supply chain (environmental planning and joint objectives) and operational performance.

Côté et al. (2008) studied three supply chains at small and medium sized companies to verify opportunities to improve environmental performance at small and medium sized companies, emphasising the reduction of greenhouse gases and solid wastes.

Walker et al. (2008) conducted an exploratory study based on interviews with seven different public and private sector organisations. This study explores the factors that drive or hamper organisations in implementing GSCM initiatives.

Lee (2008) investigated the important factors that influence the participation of small and mid-sized suppliers in GSCM initiatives.

Holt and Ghobadian (2009) evaluated the extension and nature of environmental actions in UK manufacturing sector supply chains and the factors that influence the range and depth of these actions.

Sharfman et al. (2009) conducted a two-phase survey, the first being empirical, with large market leaders, and the second theoretical, and they determined that confidence between companies, and uncertainty and proactive environmental management have a more direct effect on how companies engage GSCM in a cooperative manner.

Nawrocka et al. (2009) used interviews, surveys and focal groups with companies in Sweden to determine that ISO 14001 certification plays a facilitator role in environmental activities between consumers and suppliers; that a close relationship with a limited number of suppliers is beneficial for successful project results, as a facilitator for environmental work; and the environmental audit is a reliable tool for accompanying suppliers.

Thun and Muller (2010) conducted an empirical study with German automotive companies to discover the motivations, objectives and barriers for integrating ecological issues in inter-organisational processes.

Solér et al. (2010) conducted a case study with Swiss food companies and realised there is dependence between the perception of environmental costs and the perception of environmental demands by informed consumers, where this difference is a barrier to GSCM practices.

Wooi and Zailani (2010) conducted a study with small and mid-sized companies from Malaysia to discover the barriers that affect the low adoption of GSCM initiatives.

Zheng (2010) analysed GSCM performance between Chinese and foreign companies. Based on the successful practice of GSCM management at Chinese and foreign companies and the real situation in China, the author presents some suggestions about spreading GSCM throughout China.

Yang et al. (2010) conducted a survey with electro-electronic companies located in China and Taiwan and they verified that the study's statistical results suggest companies with closer partnerships with suppliers and solid continuous improvement practices are more likely to develop a proactive environmental management programme, which in turn increase competitive advantage through cost reductions and improvements in quality and process/product innovations.

Testa and Iraldo (2010) conducted a survey with seven different countries, totalling a database of 4,000 manufacturers to evaluate the determining factors and the motivations to implement GSCM and they ascertained that GSCM contributed towards improvements in environmental performance.

Shang et al. (2010) proposed presenting a taxonomy for GSCM capability for Taiwan's electronic companies and verifying the relationship between GSCM capability and company performance.

Diabat and Govindan (2010) developed a model for determining factors that affect GSCM implementation using an interpretive structural model.

Eltayeb et al. (2010b) evaluated the real environment and the economic and intangible results stemming from the adoption of GSCM initiatives.

Sarkis et al. (2011) elaborated a literature review to provide an overall perspective of a series of organisational theories that are applicable in GSCM's nascent literature. The review focuses on studies that used GSCM from the perspective of organisational theory to sustain their studies, especially in relation to the adoption and dissemination of GSCM practices.

Arimura et al. (2011) investigated the impact of ISO 14001 certification on GSCM and ascertained that installation with an ISO 14001 certified EMS have 40% more chances to evaluate the environmental performance of suppliers and are 50% more likely to require suppliers to commit to specific environmental practices.

Organising and systematising the proposals from the highlighted papers, it is possible list four major areas of interest in GSCM:

- 1 study of GSCM practices, their impact on organisational/operational/environmental performance and factors that affect the adoption of GSCM practices (industrial sector and company size)
- 2 identification of motivations and barriers to GSCM
- 3 analysis of impacts from adopting an EMS to put GSCM into effect
- 4 importance of collaboration in the supply chain to disseminate GSCM actions/initiatives/practices.

Taking into account these discussions shown in Section 2, a more detailed analysis was conducted of GSCM literature to identify convergence of the current stage of literature development on GSCM, including the discussion of GCS practices to indicate tendencies for future studies.

The next section presents the method chosen to systematise selected papers to identify research objectives, research methods, objects of study and results achieved.

3 Research method

The research procedure adopted in this paper was based on the classification method defined by Lage Junior and Godinho Filho (2010), adapting empirical-analytical analysis to conduct a sweep of literature that refers to the key word 'green supply chain/GSCM' in the Scopus database.

In order to achieve the objective of this paper, a bibliometric analysis was conducted on 36 papers, giving priority to those papers accessed most and the most recent publication between 2000 and 2011.

According to Cardoso et al. (2005), the bibliographic analysis aims at studying bibliographic references and publications as a basic instrument for evaluating scientific production in a specific area of knowledge and through quantitative synthesis, generating results for measuring and supporting decision-making.

After selecting the articles, a study was conducted on the content of the publications, highlighting the papers' main research objectives, the adopted research methods, the analysed industrial sectors and the measured results in the studies. It was thus possible to analyse the data in a quantitative manner and systematise them to indicate research convergences.

This study used the Lage Junior and Godinho Filho (2010) classification method, which is addressed below, as per the order established by the authors, and adapted to this paper's reality. The phases are:

- Phase 1: Conduct a literature review of the ‘GSCM’ theme.
- Phase 2: Develop a classification chart in accordance with the frequency of occurrence of the theme.
- Phase 3: Use the classification chart to summarise which information you intend to extract from papers on GSCM.
- Phase 4: Organise the literature review using the classification method.
- Phase 5: Quantitatively analyse the review and make suggestions for future research.

After a study of the papers, the basic variables for paper classification were chosen. These variables are:

- a the objective of the researched paper
- b the research method adopted
- c the industrial sector analysed
- d the results determined by the research.

Table 1 Objectives presented in the papers

<i>Code</i>	<i>Research objective</i>
BP	Identify the best practices adopted.
OB	Identify and analyse the opportunities/barriers in your business and environmental activities.
DS	Identify and analyse the drivers/stakeholders and understand what they imply in GSCM.
SW	Identify and analyse the strengths/weaknesses stemming from adopted practices.
PC	Identify and analyse the relationships of partnerships/collaborations established between agents
UP	Identify and analyse the practices adopted upstream of the chain.
DW	Identify and analyse the practices adopted downstream of the chain.
IS	Analysed the ‘practices adopted aimed at increasing sales.
IM	Analyse the competitive and environmental strategies that aim at increasing sales abroad through the internationalisation of the market.
CA	Analyse and understand the practices adopted for companies to achieve competitive advantages.
RM	Analyse and understand the practices adopted so companies can acquire a reputation in the market.
OT	Use organisational theory as a tool for investigating the adoption, dissemination and results of GSCM practices.
RS	Adopt a modelling method to evaluate results obtained from GSCM practices.
EI	Investigate and analyse the relationship between characteristics in the supply chain and environmental practices adopted.
SP	Investigate, study and analyse GSCM practices.
SS	Check whether the adoption of ISO 14001/EMS certification has generated an impact on GSCM.

Table 2 Industrial sector

<i>Code</i>	<i>Sector</i>
01	Electro/electronics
02	Textile
03	Food
04	Hygiene/health/beauty
05	Automotive
06	Civil construction
07	Chemical/oil
08	Energy generation
09	Raw material
10	Mining
11	Metallurgy
12	Others

Table 3 Results determined in the papers

<i>Code</i>	<i>Results</i>
A	Obtain best operational performance
B	Obtain best environmental performance
C	Obtain best economic/financial performance
D	Obtain greater market/niche share
E	Obtain competitive advantage
F	Increase sales
G	Acquire reputation in the market/image
H	Conduct differentiation strategy
I	Obtain customer satisfaction
J	Achieve reduction in residues, resources, materials
K	Obtain dependence between links
I	Integrate environmental policies/practices in other functional areas
M	Increase final consumer visibility
N	Improve eco-efficient management
O	Obtain more efficient auditing
P	Increase environmental demand
Q	Conduct environmental innovation
R	Acquire social responsibility
S	Conduct vertical integration

Parameter (A) has two codes: the first represents how many different objectives are addressed in the paper, which may vary between 1 and 16 objectives in a single paper; and the second identifies the objectives, represented by two letters. Table 1 shows the most common research objectives (general objective and specific objectives) identified in this papers.

Category (B) divides paper methodology into two classes: practical, through case studies and surveys; and theoretical, through literature reviews and modelling/simulation. And it is presented with two letters, one capital and one small, as can be seen below:

- ‘T’ – theoretical, which can be ‘r’ (review of literature) or ‘m’ (modelling/simulation)
- ‘P’ – practical, which can be ‘c’ (case study) or ‘s’ – (survey).

Category (C) addresses the industrial sectors studied in the papers. The code can be single number, as shown in Table 2. However, some papers will have a hyphen (-). That means no information exists or it was not explicitly mentioned.

And finally, parameter (D) presents the results of the papers (broken down/detailed) and each has a code with a letter (Table 3).

Besides the classification of these data, the GSCM practices each study addressed were also identified regardless of the frequency with which the practice is cited in papers, to thus conduct the proper analyses that refer to the objectives of this paper. The code is presented in Table 4.

Table 4 The abbreviation for the practices

<i>Code</i>	<i>Practice</i>
GP	Green purchasing
GS	Green supplier
GK	Green stock
CP	Cleaner production
SC	Standard Certification (ISO 14001)
CC	Collaborate with customers
CS	Collaborate with suppliers
GT	Green technology
LC	Product life cycle
PD	Product design
RP	Reengineering of the product
EL	Eco-label
OP	Organic product
GE	Green energy
SR	Social responsibility
ER	Environmental responsibility
RL	Reverse logistic
ET	Eco-training
GM	Green marketing
EM	Eco-management

The next section shows the tables systematising the literature as per the classification criteria reported in this section, and the quantitative analyses as per the Lage Junior and Godinho Filho (2010) method.

4 Results and discussions

Table 5 presents the organisation of literature mapping on GSCM in accordance with the objective criteria shown in analysed papers, their research methods, sectors focused and results.

Table 5 Literature review's overview

<i>Author (year)</i>	<i>(A)</i>	<i>(B)</i>	<i>(C)</i>	<i>(D)</i>
Zhu et al. (2010)	3 (IM, OB, CA)	Ps	01, 05, 07, 11	A, B, C, D, E.
Tomomi (2010)	4 (OB, CA, RM, SP)	Pc	02, 06	A, B, C, D, G, H, I, J, N, R.
Sharfman et al. (2009)	2 (DS, PC)	Ps, Pc	01, 02, 03, 05, 07, 12	A, B.
Sarkis et al. (2011)	2 (OB, OT)	Tr	-	B, C, Q.
Bai and Sarkis (2010)	2 (UP, RS)	Ps, Tm	-	A, B, C, N
Thun and Muller (2010)	5 (BP, OB, DS, UP, SP)	Ps	05	A, B, C, E, J, K, L, N, R.
Solér et al. (2010)	4 (OB, SW, PC, EI)	Pc	03	B, C, E, I, J, M, P.
Chien and Shih (2007)	2 (DS, SP)	Tr	01	B, C, D, J, O.
González et al. (2008)	4 (UP, IM, SP, SS)	Ps	05	A, B, N, O, P.
Holt and Ghobadian (2009)	2 (DS, SP)	Ps	01, 07, 12	A, B, C.
Lee (2008)	4 (DS, SW, PC, SP)	Ps	-	A, B, C, Q, R.,
Zhu et al. (2008a)	1 (SP)	Ps	01, 07, 08, 12.	A, B, C, J, O.
Fortes (2009)	2 (DS, SP)	Tr	01	A, B, J, R.
Eltayeb et al. (2010b)	2 (DS, SP)	Ps	01, 07, 10, 11	A, B, C, D, G, I, J.
Diabat and Govindan (2010)	5 (DS, SW, PC, RS, SP)	Tm	10	A, B, C, J, N.
Olugu et al. (2010)	3 (UP, DW, SP)	Ps	05	A, C, I, J, O.
Zhu et al. (2008b)	4 (UP, DW, IS, SP)	Ps	05, 01, 07, 03, 08, 02, 12	A, C, F, G, N, O.
Walker et al. (2008)	3 (OB, DS, SP)	Pc	04, 01, 03, 12	A, B, C, E, J.
Linton et al. (2007)	2 (OB, DS)	Tr	-	A, B, C, E.
Eltayeb et al. (2010a)	2 (DS, SS)	Ps	-	A, B, C, J, O, R.
Shang et al. (2010)	1 (SP)	Ps	01	A, D, F, G, I.
Zhu et al. (2007a)	1 (SP)	Ps	01, 05, 07, 08	A, B, C, J, N, O.
Arimura et al. (2011)	3 (EI, SP, SS)	Ps	-	A, B, C, G.
Balkau and Sonnemann (2010)	3 (DS, SW, PC)	Pc	01, 03, 04, 10	A, E, G.
Sarkis (2003)	4 (BP, DS, SP, RS)	Tm	-	A, E.

Table 5 Literature review's overview (continued)

<i>Author (year)</i>	<i>(A)</i>	<i>(B)</i>	<i>(C)</i>	<i>(D)</i>
Vachon and Mao (2008)	4 (SW, PC, RS, EI)	Tm	-	A, B, Q, R.
Zhang et al. (2008)	1 (DS)	Ps	07	B, O, Q.
Zhu et al. (2007b)	2 (BP, DS)	Ps, Pc	05	A, B, C.
Yeh and Chuang (2011)	2 (PC, RS)	Tm	-	A, B, C, D, G, J.
Hsu and Hu (2008)	2 (RS, SP)	Tm	01	A, B, G, O.
Wooi and Zailani (2010)	2 (BP, OB)	Ps	09, 10, 12	A, B.
Srivastava (2007)	4 (BP, OB, DS, RS, SP)	Tr	01, 03, 04, 05, 07.	A, B.
Testa and Iraldo (2010)	3 (OB, SW, CA)	Ps	01, 02, 05, 07, 09, 10, 11, 12.	B, C, D, E, G, Q.
Darnall et al. (2008)	4 (OB, DS, PC, EI)	Ps	-	A, B, C, D, G, I, J, O.
Nawrocka (2008b)	6 (OB, DS, PC, UP, SP, SS)	Pc	01	A, B, C, E, G, J, K, L, O, Q.
González-Torre et al. (2010)	2 (OB, DS)	Ts	05	A, B, C, E, Q

Sixteen different types of research objectives were identified, according to the frequency of occurrences in proposals for studied articles, considering that a paper can have more than one declared or implicit objective. From the set of papers under analysis, the objective that stands out is to 'investigate, study and analyse GSC practices' with 55%, or of the 36 papers evaluated, 20 have that objective as a study proposal. Another objective that stands out is 'identify and analyse the drivers/stakeholders and understand what they imply in GSCM', which occurs in 53%. In an intermediate situation, we have the 'identify and analyse the opportunities/barriers in your business and environmental activities', with a frequency of 36%. The 'GSCM practices' theme stands out among the research objectives, since it is from adopting actual actions on GSCM that one can understand the theme and thus generate new research insights, such as verify barriers and motivations for organisational and operational changes to adopt GCS practices. In other words, one can eventually point to a relationship of a certain hierarchy and of consequences in relation to the general objectives of the academic studies in GSCM.

The most common research method in GSCM is the practical with the use of survey data collection techniques (55% frequency). The second most common is the practical case study (19%). The least used approach is 'theoretical paper', whether through literature review or modelling (16%). Therefore, the importance of this paper, since it is relevant to discuss conceptual bases and point to tendencies for future research.

Table 6 GSCM practices adopted in the papers

<i>Author (year)</i>	<i>Practices</i>
Zhu et al. (2010)	GP, CC, RL
Tomomi (2010)	RP, EL, OP, SC, GE, SR.
Sharfman et al. (2007)	CC, LC
Sarkis et al. (2011)	CP, CC, GT, PD, RL
Bai and Sarkis (2010)	GS, CP, GT, LC, PD
Thun and Muller (2009)	GP, GS, CP, CC, SR, ET
Solér et al. (2010)	CP, LC, PD
Chien and Shih (2007)	GP, GS, CP, LC, PD, RL, GM
González et al. (2008)	CP, SC, GT, PD, EM.
Holt and Ghobadian (2009)	GP, CP, SC, RP, GE, SR, ET
Lee (2008)	GP, GS, CP, CC, RP, ET.
Zhu et al. (2008a)	GP, CP, SC, CC, CS, PD.
Fortes (2009)	CP, LC, PD, RL.
Eltayeb et al. (2010b)	GP, GS, CP, SC, CC, PD, RL.
Diabat and Govindan (2010)	CP, SC, CC, CS, PD, RL
Olugu et al. (2010)	SC, LC, PD, EL, RL
Zhu et al. (2008b)	GP, GS, CP, SC, CC, CS, PD, RP, GM.
Walker et al. (2008)	GP, RL.
Linton et al. (2007)	CP, LC, PD, RL.
Eltayeb et al. (2010a)	GP, CP, SC, LC, EL, SR, RL, ER.
Shang et al. (2010)	GP, GS, CP, PD, RL, GM, GK.
Zhu et al. (2007a)	GP, CP, SC, CC, CS, PD, RL.
Arimura et al. (2011)	SC, GT.
Balkau and Sonnemann (2010)	GP, LC, PD.
Sarkis (2003)	GP, CP, GT, LC, RL.
Vachon and Mao (2008)	CP, SC, EL, GE, SR, ER, RL, GM.
Zhang et al. (2008)	CP, SC, CC, RL, ET.
Zhu et al. (2007b)	GP, CC, PD.
Yeh and Chuang (2011)	CP, SC, PD, RL.
Hsu and Hu (2008)	GP, CS, PD, RL, ET.
Wooi and Zailani (2010)	GP, PD, RL.
Srivastava (2007)	GP, CP, PD, RL.
Testa and Iraldo (2010)	SC, CC, CS, LC
Darnall et al. (2008)	SC, CC, CS, LC, PD, ET.
Nawrocka (2008b)	GP, GS, CP, SC, CS, GT, PD, ET.
González-Torre et al. (2010)	CP, GT, RL, ET.

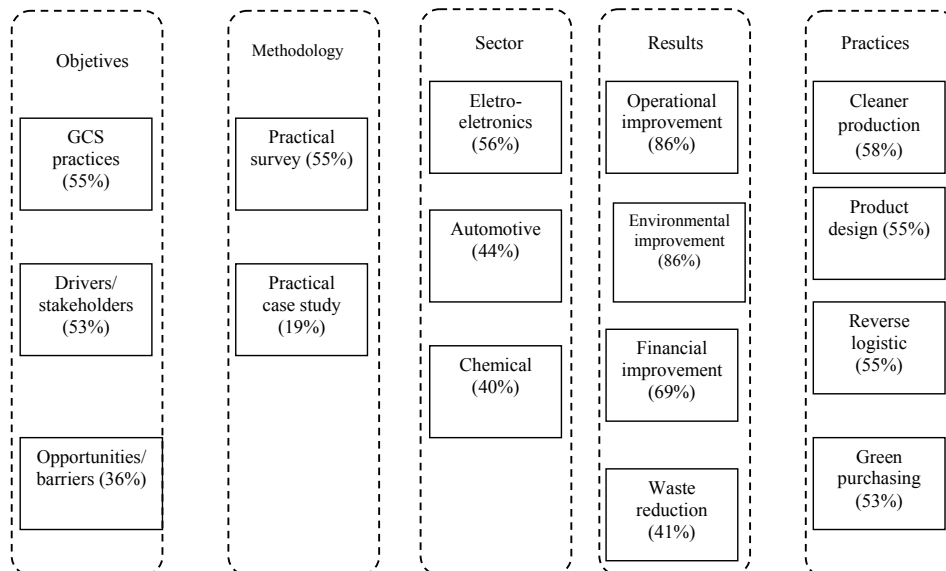
The electro-electronic sector is the most studied industrial sector in evaluated articles about GSCM. The other two sectors that stand out are the automotive and chemical, occurring 44% and 40%, respectively. In some countries, the electro-electronic sector, as in the case of China and Taiwan, which are major exporters of parts for this sector, is potentially interesting for study since the reality of the sector in face of adopted GSCM practices is different (special) because it also takes into account regulation/legislation of purchasing countries. The automotive sector is emblematic when dealing with pioneer actions in the manufacturing industry and the chemical sector, and one that needs to be most concerned with GSCM because it is generally a sector associated with the generation of significant environmental impacts and consequently interested in new tendencies in environmental management.

Research results show that the main results achieved with GSCM are 'better operating performance' and 'better environmental performance', occurring 86% each. The other results achieved are 'better economic/financial performance' with 69% and 'residue, resource and material reductions' (41%).

It is interesting to observe that, like any other theme, the great objective behind change in an organisation is to obtain superior operating performance. It is also interesting to observe that obtaining superior performance in relation to environmental management is result gauged by companies, when studying GSCM, revealing the importance of bias in environmental management concepts. This can be corroborated with the 'achieve a reduction in residues, resources and materials' result. However, operational and financial results still preponderate compared to environmental results.

Although not one the paper's objectives, it is necessary to underscore the authors Qinghua Zhu, Joseph Sarkis and Kee-hung Lai as some of the most dedicated to GSCM, especially Sarkis, who is the author or co-author of 28% of researched papers.

Figure 1 Summary of the main research results



Besides the organisation of selected papers in accordance with commented criteria (A, B, C and D), the types of GSCM practices considered in these papers were also classified. Table 6 shows the results obtained.

The most common GSCM practices are 'cleaner production', occurring 58% of the time, followed by 55% for 'product design' and 'reverse logistic' practices, and 53% for 'green purchasing'. In other words, although there is a different set of GSCM practice categories, the most common, in a literature review of selected and evaluated papers, are related to process, product and supply, in that order; a classification similar to that of Srivastava (2007).

Figure 1 summarises the main results of literature systematisation, following the methodology proposed by Lage Junior and Godinho Filho (2010).

Therefore, GSC practices are an important focus in current research guidelines about GSCM; practical research, especially surveys and the use of advanced statistical techniques are the main methodological approach used; the electro-electronic sector is a recurring object of study; and the main results of studies are that GSC practices have a positive impact in terms of operations and the environment.

5 Conclusions

The objective of this paper was to identify convergences of the current stage of literature development on GSCM, including the discussion on GSC practices, to indicate tendencies for future studies. After a sweep of literature using the keyword 'green supply chain/GSCM' in the Scopus database, 36 papers were selected, and a bibliometric analysis was conducted highlighting the main research objectives, research method, analysed industrial sector and the main results measured.

The Lage Junior and Godinho Filho (2010) systematisation method was adopted, which permitted identifying and classifying standards found in literature for selected papers. The main results obtained in terms of convergences are that GSC practices are an important focus in current research guidelines about GSCM; practical research, especially surveys and the use of advanced statistical techniques are the main methodological approach used; the electro-electronic sector is a recurring object of study; and the main results of studies are that GSC practices have a positive impact in terms of operations and the environment.

There are various classifications, nomenclatures and types of GSCM practices, but the most commonly used by studies in GSCM are cleaner production, product design, reverse logistic and green purchasing. That means GSCM practices are directed towards adapting value chain activities from a supply chain for business environmental management aspects.

Taking into account the definitions highlighted in the literature review section and the results from the bibliometric analysis, the conceptual scenario is seen as having a bias towards operational aspects from supply chain management to environmental aspects (conservation, preservation, etc.). In general, from the highlighted definitions, the tonic is to adapt operating activities and incorporate the supply chain management philosophy (integration/collaboration) to environmental concerns (impact reduction) in relations between links in the chain.

Some future research propositions can be formulated, taking into account the previously highlighted convergences:

- a verify which means and mechanisms can be adopted to support upstream dissemination of GSCM practices
- b verify which means and mechanisms can be adopted to support downstream dissemination of GSCM practices
- c identify and describe aspects of specific legislation/regulations in certain countries, with a recognised proactive environmental attitude (e.g., Iceland, Switzerland, etc.), to verify how these countries legal aspects affect supply chain behaviour at companies from sectors that potentially cause environmental impacts (ex: chemical, extractive, etc.)
- d study and compare the adoption of GSCM practices in the electro-electronic sector of different countries to check whether cultural aspects and legislation interfere in the degree of practice adoption
- e relate information sharing aspects (type of information and information systems) that support GSCM dissemination
- f verify the difference between downstream and upstream collaboration for adapting value chain activities in the incorporation of GSCM
- g confirm the constructs of GSCM practices; among others.

This study has limitations in its contributions since it was restricted to conducting a sweep of literature using only the Scopus database and delimited 'green supply chain' as the keyword for the search.

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