Green Supply Chain Management

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Green or sustainable supply chain management (SSCM) involves integrating environmental and economic objectives into the management of the operation strategy of the supply chain. Such integration helps reduce the carbon footprint while increasing financial return and profitability. A wider concept is SSCM, which aims to maximize profitability and, at the same time, reduce the environmental impact and improve the social well-being of the various involved stakeholders.

green supply chain management | green practices | green strategy | green innovation | green operations

1. Introduction

Bowen et al. [1], p. 176, define GSCM as the “Integration of the company’s purchase plans with the environmental activities in SCM, to improve the environmental performance of suppliers and customers.” GSCM also includes concerns about product design, use, reuse, disassembly, and final disposal [2], as well as warehousing, transportation, supplier development to meet green requirements in purchasing, and stimulus for the adoption of environmental certifications such as ISO 14000 [2][3]. Zhu and Sarkis [4] conceptualize GSCM as the integration of environmental thinking with operations management in the SC, starting with the product design and passing through the selection of raw materials, manufacturing processes, transportation and delivery, and the final consumer arriving at the final destination after use. Large and Thomsen [5] states that GSCM includes the design process, raw material selection, green procurement, the green manufacturing process, green distribution, and reverse logistics.

This study poses the following research question: How do you organize green practices observed in GSCM in a model formed by dimensions and categories of analysis? In answer, this work highlights key factors that should be analyzed by GSCM models. Secondary purposes are to (i) review green management models and practices published from 2003 to 2019; (ii) propose a conceptual framework for managing green practices in GSCM, and (iii) propose directions for future research to amplify the application of the framework. These are the key issues of the study.

Green practices are operations that seek to reduce or eliminate negative impacts on the environment [6]. Greening is typically associated with the implementation of green practices in SCs [7][8], which requires multidimensional models and approaches [9]. This study approaches GSCM as a multidimensional problem. The model framework

relies on dimensions supported by analytical categories [10], evolves from other models, and covers a larger set of dimensions and categories when compared to other models already proposed. Our framework details 64 green practices. These are the key factors addressed by this study. This number allows for more extensive analysis when compared with the models existing in the literature [6][11][12]. The models retrieved from the literature do not support more than 25 green practices, and this is the main novelty of our study.

Moreover, the framework provides support to identify environmental weaknesses and to assess and prioritize corrective actions in SCs. Green practices are considered at the level of the SC, covering internal practices and upstream and downstream relationships [13][14] as well as creating room for systemic possibilities [15] and systemic methods [16]. The key motivation of the study is the construction of a consistent tree-like structure or framework organizing key green practices that could facilitate many kinds of stakeholders (practitioners, managers, and scholars) who need to handle environmental concerns in managing supply chains.

2. Methodology and the Sample of Articles

Kassarjian [17] provides the following definition for a systematic literature review: “Systematic reviews aim to address problems by identifying, critically evaluating, and integrating the findings of all relevant, high-quality individual studies addressing one or more research questions.” Bearing such a definition in mind, our review pursues two objectives: Summarize recent research retrieving and interpreting similarities, themes, and issues on GSCM and contribute to the conceptual development of the theme and the future formation of a theory [18]. From a methodological perspective, the systematic literature review includes qualitative and quantitative aspects combined to evaluate structural and content standards. Therefore, the methodology used in this study follows the steps below [18]: − definition of the unit of research (models for structuring GSCM issues); − delimitation of the search: (i) only articles in English in peer-reviewed scientific journals published between 2010 and 2020; (ii) the use of Science Direct (www.sciencedirect.com accessed on 16 June 2021) and Emerald (www.emeraldinsight.com accessed on 16 June 2021) databases; and (iii) four journals outside databases (Chemical Engineering Transactions , International Journal of Applied Science and Engineering Research , Journal of Sustainable Development , and Journal of Operations and Supply Chain Management); − collection of articles according to the keyword green supply chain management, combined with green operation, green practices, and green performance; − reading and selection of articles: the rough sample was entirely reviewed and a final, refined sample was identified; − complete review of the final sample and description of the structural elements of the articles: bibliometric description of authors, journals, and studies; − content analysis of the retrieved GSCM models for the identification of dimensions and categories of analysis; − evaluation of the content of the articles of the final sample; and − identification of similarities of dimensions and construction of the structure for the conceptual framework.

In the content analysis, we assessed models and classified green practices in GSCM according to dimensions and categories of analysis. Three external experts, two scholars from research institutes with experience in supply chain management and one scholar with previous experience in supply chains as a practitioner in the industry, participated in the analysis. The participation of specialists minimizes interpretation risks and subjectivities [18]. Finally, we constructed and proposed a conceptual framework for the management of green practices in SC.

3. Conceptual Framework and Green Practices

The information provided by the articles helped to define the framework categories. Subsequently, invited specialists reviewed the main concepts underlying the categories and aggregated similar ones (e.g., green design and eco-innovation were jointly framed as eco-design). The systematic review of the literature provided information and data, but the specialists' review guided and grounded the construction of the conceptual framework. Categories were organized considering their relationship with the dimensions and their relations and interactions within the SC (upstream, internal activities in the focal company, and upstream level). The specialists, together with the researchers, also classified 64 green practices retrieved from the literature in accordance with the categories.

The strategic dimension includes 6 categories and 18 documented practices. **Table 1** shows the practices allocated in the categories of the dimension and suitable references that provide empirical evidence of the application.

Table 1 Green practices in the categories of the strategic dimension.

Green Practices	Activities	Reference
Environmental plans and goals	Environmental plans and objectives of the company that integrate the strategies of the organization and the supply chain.	[19][20][21]
Environmental risk management	Adopting tools to assess, monitor, and mitigate environmental risks.	[20][22]
Environmental certification —ISO 14001	ISO 14001 supports the reduction of the consumption of raw material and waste and improves the quality of the products/services produced for customers.	[23][6][24]
Environmental audit program	Monitoring national environmental compliance and audit programs.	[4][25][24] [26]
Monitoring	Monitoring the environmental performance of suppliers, including the second level.	[6][18][25] [24]
Environmental accidents	Developing actions to reduce environmental accidents.	[22]
Benchmarking	Sharing best practices with other members of the supply chain.	[25][24]
Support and education	Supporting and training actions in the development of technologies that improve environmental performance and operation, and the adoption of environmental certifications.	[18][24][27]
Joint ventures	The purchasing company works closely with its suppliers and establishes common teams and long-term joint programs to develop green innovations and solutions.	[27][28]
Eco-labeling	Eco-labeling for the identification of environmentally friendly products.	[29][30]

Green Practices	Activities	Reference
Green packaging	Actions that facilitate the recycling, reuse, and/or return of packaging.	[6][31]
Cooperation with suppliers and customers and cleaner production	Valuing activities that result in eco-efficient processes.	[12][22]
Decreased consumption of hazardous and toxic materials	Developing practices associated with lower consumption of hazardous and toxic materials.	[31][32]
Customer cooperation about environmental concerns	Actions that value compliance with legislation, eco-efficiency, and the improvement of products and processes.	[30]
Flow of information	Interconnected structures and systems that ensure the flow of information among supply chain stakeholders, ensuring competitive priorities related to company operations, quality, and customer satisfaction.	[6][18][33]
Sale of scrap, excessive inventory, and obsolete equipment	Evaluating the processes considering the possibility of the sale, recycling, and/or reuse of scrap, sale of inventory, and obsolete equipment, transforming surplus or idle resources into revenue.	[26][21][32]

Green innovation supports environmental sustainability by promoting changes to processes with less environmental impact [34][35]. Product and process innovations are involved in energy saving, pollution prevention, waste recycling, green or corporate product design, and environmental management [23]. **Table 12** shows the practices allocated in the categories of the dimension and suitable references that provide empirical evidence of the application.

Table 2 Green practices in the categories of the innovation dimension.

Green Practices	Activities	References
Design of products	Design that prevents or minimizes the use of hazardous and toxic products.	[18][31][21]
Design of products for reuse, recycling, or recovery of material and parts	Designing modular products and easy-to-disassemble options that help to repair, recycle, and remanufacture end-of-life returns.	[23][15][31][36] [21]
Design for resource efficiency	Designing consumption-reducing products and energy.	[37][15][27][21] [32]
Control structures	Developing automated or error-proof control systems for defective parts or products.	[38][23]
Compliance with quality	Adopting a standardized set of inspection criteria and quality	[23]

Green Practices	Activities	References
standards	standards.	
Process design	Designing processes that minimize or eliminate unnecessary movements, waste, and scrap.	[13][39]
Lean principles	Analyzing the processes to identify activities and operations considered unnecessary and that do not add value to the final product.	[38][23]
Definition of components and raw materials	Actions that reduce the consumption of material in production, use of materials that generate less pollution or waste, use of non-toxic materials, and use of recycled or recyclable materials.	[15][40]
Definition of product components	Developing components with materials that can be recycled and derived from renewable sources.	[18][40]
Product characteristics	Simplifying product characteristics, reducing weight and raw material consumption.	[34][40]
Energy use	Using energy-efficient equipment and developing new processes, materials, and technologies.	[37][41][34][42]
Waste	Minimizing waste generated in the production process, reusing waste, and ensuring acceptable limits of hazardous substances (compliance with emission limits).	[43][40][44][33]
Commitment of senior managers	Leadership, commitment, and understanding of managers concerning the importance of GSCM to the organization and the chain.	[13][8][45][25] [26]
Support for mid-level managers	Manager education on green practices for the supply chain.	[13][45][46]
Organizational strategy	Implementing GSCM in organizational strategy and integrating corporate policies.	[8][18][46]
Multifunctional cooperation	Developing multifunctional groups with different expertise working in the analysis and evaluation of green practices.	[28]
Number of patents	Research and development capability of innovations, facilitating new patents.	[8][47]
ISO 14001 certification	Companies that implement ISO 14001 are likely to improve their internal environment through their network of suppliers and customers.	[23][25][48]
Updating of company websites on environmental issues	Using websites to disseminate environmental reports and practices.	[49][50][28]

Green Practices	Activities	References
Adopting resource and energy conservation arguments in marketing	Developing tools and technologies to make lifestyles more sustainable and encourage social change.	[28][22]
Attracting customers with green initiatives and eco-services	Developing actions that influence consumers and industrial buyers through advertising that reflects the company's commitment to the environment.	[49][28]
Providing customers with environmentally friendly service information	Developing services and practices that may result in actions that contribute to the environment.	[28][22]
Spending more budget on green advertising	Investment incorporates complementary actions since companies gain a competitive advantage.	[49][47]
Products with environmental characteristics	Alignment of the product development process with the consumer market and environmental issues.	[51][40][47]
Environmental management tools	Developing environmental management tools for the supply chain to subsidize evaluation, monitoring, and the environmental quality of products and the cost of waste among the chain members.	[18][25][24][52]
R&D capability	Infrastructure for R&D.	[21][48][22]
Design capability	Capability to rapidly develop new designs.	[21][22][32]

Environmental costs, production, logistics, processes, purchasing, and the reverse logistics process characterize SC green operations. **Table 3** shows the practices allocated to the categories of this dimension and suitable references that provide empirical evidence of the application.

Table 3. Green practices in the categories of the operations dimension.

Green Practices	Activities	Reference
Specifications for suppliers	Providing project specifications to suppliers that include environmental requirements for purchases.	[21][32]
Green packaging	Requiring suppliers to use environmentally friendly packaging (reusable, degradable, and non-hazardous).	[13][53]
Supplier selection	Using environmental criteria to select suppliers.	[47][32]
Supplier audits	Conducting audits to assess suppliers' internal environmental management.	[13]
Evaluation of second-level suppliers	Assessing the environmental management of second-tier suppliers	[13][18][53]

Green Practices	Activities	Reference
Quality of internal service	Using standards and criteria to monitor the internal quality of operations and services.	[36][47]
Cleaner production	Developing methods and practical tools that protect human and environmental health to support sustainable development.	[43][36][48][32]
Inventory management	Adopting methods and tools that allow inventory management.	[45][54]
Internal green production plan	Planning the production, manufacturing, and resource allocation modules to apply environmental strategies.	[54][47]
Warehousing and green building	Developing warehouse spaces conducive to environmental activities.	[31][26]
Packaging and documentation	Enabling the use of packaging that can be reused, collecting packaging, and optimizing the return journey of transport structures.	[31][40]
Product distribution	Optimizing the schedule and routing of deliveries of materials and components to the customer.	[34][40][36]
Remarketing	Developing markets for remanufactured products.	[23][28]
Returnable packaging	Encouraging the return of packaging for reuse and recycling.	[6][7][14][53]
Inspection and classification	Classifying waste from production and consumption to facilitate subsequent activities.	[43][32]
List of substances	Mapping the list of hazardous, toxic, and noxious substances for monitoring and control purposes.	[21]
Use of filters	Using emission and discharge control filters.	[21]
Solid waste	Developing actions that support the reduction of solid waste.	[6][28]
Carbon management	Developing plans and goals for reducing greenhouse gases.	[44]
Water and energy consumption	Reducing water and energy consumption in operations.	[43][25]
Risk prevention systems	Employment risk prevention systems and environmental accidents/emergencies.	[6][55]
Hazardous and toxic materials	Decreasing consumption of hazardous/noxious/toxic materials.	[6]

4. Final Remarks, Implications, and Directions for Future Research

This study proposes a comprehensive conceptual framework that bridges the gap related to the need for effective models for GSCM. The conceptual framework considers dimensions, categories, and green practices identified in the literature. The proposed model can contribute to the literature given that empirical studies mostly select a limited number of dimensions to evaluate supply chain green practices.

Although the article analyzes green practices in SC retrieved from the systematic review of the literature, the study did not consider other elements such as pressure and incentives that influence green practices and their results. Predominantly, green practices in SC will be more or less effective according to the presence or absence of enablers or moderators such as pressure and incentives.

The sample size of articles, 43 articles, is the main limitation of this study. A secondary limitation is the number of dimensions, practices, and categories identified. This number can increase with the social dimension, which will imply using other keywords besides the current “green supply chain management.”

From the study, we derive future research directions. As quantitative models to GSCM analysis use a limited number of dimensions, further research should introduce new dimensions. Examples of new dimensions are corporate social responsibility and networking operations. The proposed conceptual framework requires empirical studies on the dimensions and categories in GSCM through the implementation of case studies. Another area in which studies are needed is more surveys in entire industries. An example is the agro-food SC, since such an industry has a significant impact on the international economic and environmental scenario [56]. Over time, there have been a limited number of studies evaluating the adoption of green practices in agro-food SC [11][57][56], mainly regarding production [58], warehousing, and transportation [59]. Similar studies could be applied to research on emerging markets [60], e-business [61], e-commerce [62], and renewable energy industries [63].

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