Educational Administration: Theory and Practice
2023, 29(4), 5347-5354
ISSN: 2148-2403
https://kuey.net/

Research Article

Examining the Progress of Green and Sustainable Supply Chain Management: A Comprehensive Analysis

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Citation: Ambika Khurana et al (2023), Examining the Progress of Green and Sustainable Supply Chain Management: A Comprehensive Analysis, *Educational Administration: Theory and Practice, 29(4)* 5347-5354
Doi: 10.53555/kuey.v29i4.10166

ARTICLE INFO

ABSTRACT

The growing emphasis on sustainability, combined with increasing stakeholder expectations and regulatory pressures, has positioned the Green-Supply-Chain-Management (GSCM) as a crucial basis for integrating green sustainability into the supply chain operations. This systematic review consolidates existing research on the evolution of GSCM, examining its core practices, driving factors, barriers to adoption, and performance implications.

Emerging knowledge and tools such as block-chain, the Internet of Things, and artificial intelligence are playing a transformative role in advancing GSCM methods. These technologies, alongside trends like eco-design, reverse logistics, green procurement, and sustainable industrial processes, are redefining how supply chains address environmental challenges. The analysis also explores how external factors, including environmental regulations, organizational culture, and market dynamics, influence the successful implementation of GSCM practices.

The review identifies significant progress in the field while recognizing areas for improvement, particularly in overcoming barriers to widespread adoption. It emphasizes the growing importance of participating innovative tools and skills and fostering collaboration across supply chain networks, achieve sustainability goals. Concluding with insights into future research directions, the study highlights opportunities to expand GSCM frameworks through technology integration and circular economy strategies, further advancing sustainable supply chain processes in the background of a rapidly evolving global landscape.

Keywords: Green-Supply-Chain-Management, Sustainability, Environmental Regulations, Eco-Design, Reverse Logistics, Circular Economy, Emerging Technologies, Supply Chain Sustainability, GSCM Drivers and Barriers

1.Introduction:

Environmental sustainability has increased its significant consideration from all corporations and each policy makers in recent eras due to increasing ecological problems such resource reduction, climatically variations, and environmental degradation.

Green-Supply-Chain-Management, or GSCM, had developed as a significant knowledge area as to reduce the environmental effects of industries around the world, which are responsible for a large amount of these impacts.

The goal of GSCM is to incorporate environmental concerns into, traditional supply chain, and directing to reduce waste, optimize resource utilization, and minimizes the carbon footprint at each stage, from procurement to production, distribution, and product end-of-life management (Srivastava, 2007).

Increasing awareness about sustainability had been driven companies to implement diverse Green-Supply-Chain-Management (GSCM) processess, including green procurement, eco-design, reverse logistics, and cleaner production. Green procurement prioritizes the sourcing of environmentally friendly materials, while

eco-design aims to minimize environmental impact by optimizing product lifecycle management (Zhu, Sarkis & Lai, 2008). Reverse logistics plays a critical role by managing reintegration for recycled products into the supply chain, enabling recycling and reducing waste (Hervani, Helms & Sarkis, 2005). These practices collectively contribute to creating about sustainable and environmentally conscious supply chain operations.
The implementation of GSCM is not without difficulties, considering its possible advantages. Companies experience a number of obstacles, including the high upfront costs of adoption, ignorance, insufficient technology, and the difficulty of adopting GSCM into current supply chain processes (Walker, Di Sisto, & McBain, 2008). Additionally, regulatory frameworks, market forces, and organizational culture heavily influence the extent to which companies are willing to embrace green supply chain practices (Zhu & Sarkis, 2006).
Emerging knowledge and skills such as block chain, the Internet of Things and artificial intelligence (AI) are reforming to landscape of GSCM, offering new chances for enhancing transparency, traceability, and efficiency in green supply chain processes (Kamble, Gunasekaran, & Gawankar, 2020). However, the further research is required to discover how these innovations can be effectively combined to achieve long-term sustainability goals.
With the collective and increasing effort on addressing environmental issues and the rising interest in sustainable business practices, this systematic review examines the growth of Green-Supply-Chain-Management (GSCM). It exploresabout main drivers, challenges, emerging trends, offering a clear understanding of GSCM's evolution and insights into its future direction.

2. Background

Supply chain management (SCM) has started as an essential business function, encompassing a wide range of activities aimed at optimizing the movement of goods, services, and information through the different phases of production and distribution. The significance of SCM has grown with globalization, increased customer expectations, and the demand for enhanced operational efficiency. In response to growing environmental concerns, the traditional SCM model has seen the development of Green-Supply-Chain-Management (GSCM), which incorporates sustainability into the supply chain framework. Before exploring into GSCM, it is essential to understand the introductory principles of traditional SCM.

2.1 Supply Chain Management

Supply Chain Management (SCM) is the synchronized management of interrelated business activities that span the acquisition of raw resources, production processes, delivery of the final service, product to the final customer. The core objective of the SCM is to generate worth by optimizing cost, time, and resources while ensuring a continuous movement of raw-resources and information through the entire supply chain.
The primary components of supply chain management encompass procurement, production planning and control, logistics management, inventory control, demand forecasting, and distribution. Effective coordination of these elements enhances a business's competitiveness, optimizes customer satisfaction, and ensures the timely and efficient delivery of products and services (Mentzer et al., 2001).
Traditionally, SCM has focused on achieving operational efficiencies through cost reduction and productivity enhancements. However, with the rise of consumer awareness and environmental regulations, businesses have started to embrace more sustainable approaches.

2.1.1 Systematic Summary of SCM

Supply chain management consists of a system of suppliers, manufacturers, distributors, and retailers working together to deliver products and services from raw materials to the final consumer. The chain of activities can be visualized in five major stages:
1. Suppliers: This involves sourcing raw materials, components, or products needed for production. Effective supplier management ensures the timely availability of resources, enabling a smooth production flow (Handfield & Nichols, 1999).
2. Manufacturers: At this stage, the focus shifts to transforming raw materials into finished products. Production planning, process optimization, and quality control are crucial activities to ensure that goods are produced efficiently and meet quality standards (Stevens, 1989).
3. Distributors: Once products are manufactured, distributors handle the storage and transportation to retailers or customers. Logistics management, warehousing, and inventory control play an important role in ensuring that products are delivered in a timely and cost-effective manner (Lambert & Cooper, 2000).
4. Retailers: This step includes direct sales to end users to ensure the appropriate amount and location accessibility to meet consumer needs. During this stage, effective inventory management and customer service are key to success (Christopher, 2016).
5. Customers: The final stage of supply chain management, where products and services influence to the final consumers. Understanding customer demand and preferences is critical in SCM, as it drives the entire supply chain's planning and operations (Mentzer et al., 2001).
To maintain smooth operations, SCM relies on collaboration, information sharing, and technological tools such as Enterprise Resource Planning (ERP) systems, which integrate, automate many supply chain's

operational aspects (Kumar & van Dissel, 1996). Additionally, various advanced knowledge, skills like artificial intelligence (AI), block-chain, and the Internet of Things are now being united to enhance transparency, adaptability, efficiency, and effectiveness in supply chains (Gunasekaran et al., 2015).

2.1.2. Supply chain management factors

Supply Chain Management (SCM) is subjective by several critical reasons that ensure the operational flow of goods, services and information. Demand forecasting and planning are essential for anticipating customer needs, allowing for adjustments in production and inventory levels to meet market demand (Mentzer et al., 2004). Strong supplier relationships contribute to better pricing, quality, and reliability in supply chains, enhancing overall performance (Monczka et al., 2015). Operational inventory management practices, such as Just-In-Time technique, safety stocks, helps the organizations to balance supply and demand, reducing inventory costs and different carrying cost (Chopra & Meindl, 2016).

Logistics and transportation optimization is another key factor, ensuring timely and cost-effective delivery of goods through efficient route and mode selection (Simchi-Levi et al., 2007). The integration of technology, including ERP systems and data analytics, improves decision-making and operational efficiency by enhancing supply chain visibility (Gunasekaran & Ngai, 2004). Sustainability has also become a critical component, with green SCM practices focusing on reducing environmental impact, such as lowering carbon emissions and conserving resources (Srivastava, 2007). Lastly, risk management is crucial in navigating uncertainties like supply disruptions and demand fluctuations, ensuring the resilience of the supply chain (Tang, 2006).

2.2. Sustainable management and development

2.2.1. Overview of sustainable development

Sustainable development is cantered on meeting the requirements of recent generation while ensuring that future generations retain to fulfil their own requirements. Organizations are encouraged to adopt strategies that integrate these principles, addressing economic objectives while minimizing their ecological footprint and fostering social inclusivity. By prioritizing sustainable development, businesses and institutions can achieve growth that aligns with global environmental and societal goals, such as reducing carbon emissions, promoting fair labour practices, and preserving biodiversity. This approach not only ensures resilience and competitiveness but also contributes to a healthier planet and improved quality of life for current and future generations. Sustainable growth, therefore, provides a general framework for addressing the connected challenges of economic, social, and environmental systems, encouraging organizations to operate responsibly and contribute positively to global sustainability efforts.

. The concept of sustainable development gained global prominence through the Brundtland Commission's report, which highlighted the need for a development model that addresses poverty while also preserving natural resources (WCED, 1987).

The economic performance of the sustainable development focuses on fostering long-term growth while ensuring the efficient use of resources. This includes promoting innovation and developing sustainable business practices that contribute to the economy without depleting natural resources (Barbier, 1987). Social equity is a key component, aiming to provide equal access to resources, reduce inequality, and to improve the quality of life for all the individuals, mainly in marginalized communities (Sen, 1999).

The environmental support is concerned with protecting ecosystems, reducing pollution, and modifying the effects caused due to climate change. This involves transitioning to renewable resources, promoting energy effectiveness and efficiency, and adopting various sustainable agriculture and production practices (UNEP, 2011). Sustainable development is driven by key factors that balance environmental, economic, and social objectives. Resource efficiency emphasizes the optimal use of energy, water, and raw materials while minimizing waste and environmental impact, thereby conserving resources for future generations and reducing operational costs (UNEP, 2011). The incorporation of renewable energy is another important factor, focusing on transformation from fossil fuels to sustainable sources like solar energy and wind energy, which mitigates climate change and ensures long-term energy security (IRENA, 2018). Sustainable agriculture promotes practices that conservation of soil, water resources, and biodiversity factor, while ensuring food security and minimizing environmental degradation (Pretty, 2008).

The circular economy focuses on reusing, recycling, and remanufacturing products to reduce waste and resource consumption, lowering industries' environmental footprint (Geissdoerfer et al., 2017). Climate action involves reducing greenhouse gas emissions and implementing strategies to adapt to climate change (IPCC, 2014). Legislative frameworks support sustainable development by enforcing environmental standards and encouraging eco-friendly practices (OECD, 2011).

Corporate social responsibility (CSR) and technological innovation further drive sustainable practices, with advancements like renewable energy systems and precision agriculture boosting resource efficiency (Carroll, 1999; Schot & Steinmueller, 2018).

3. Research Method

This section outlines the research approach used to explore the development of Green-Supply-Chain-Management (GSCM). The study utilizes a systematic review approach to thoroughly analyse existing literature and trends in Green-Supply-Chain-Management (GSCM). Its objective is to uncover the primary carriers of GSCM, the obstacles encountered during its implementation, and the contributions of technology and policies in enabling sustainable supply chains.

3.1. Research Questions

The research key questions are:

1. What are the main factors contributing to the development and adoption of Green-Supply-Chain-Management (GSCM)?
2. How do environmental policies and regulations influence the application of GSCM processes in various industries?
3. What role does technological innovation play in enhancing the efficiency and effectiveness of sustainability for different supply chain operations?
4. What challenges do organizations face when integrating GSCM practices, and how can these be addressed?
5. How does GSCM contribute to broader to the sustainable development goals, likewise resource efficiency, wastage reduction, and various renewable energy adoption?

These questions aim to uncover the dynamics behind the growing interest in GSCM, its practical applications, and its impact on sustainability across industries.

3.2. Research Methodology:

The systematic literature review on Green-Supply-Chain-Management (GSCM) was carried out through a two-phase research process. Initially, keyword-dependent searches were performed across major databases, including Scopus, Web of Science, Elsevier, Springer, Emerald, and Taylor & Francis, focusing on articles published between 2000 and 2020. The searches primarily yielded English-language studies, with a few exceptions in French. In the second phase, the search results were manually filtered to select relevant articles based on their contributions to the understanding of GSCM. This comprehensive approach ensured that the final selection included high-quality studies that effectively addressed the research questions and provided valuable insights of the various challenges of GSCM.

The four stages of the research process:

1. Keyword-Based Searches: Conducting initial searches in major databases like Scopus and Web of Science to gather a broad range of articles.
2. Manual Filtering: Reviewing the search results to identify relevant studies, ensuring they align with the research objectives.
3. Data Extraction: The key information can be extracted from the selected articles to synthesize findings.
4. Synthesis and Reporting: Analysing the data and compiling the results into a structured format for the systematic review.

1. First Stage: Database Keyword Search

The first stage of the research process involves conducting a keyword-based search across several major academic databases. This stage aims to gather a comprehensive collection of literature related to Green-Supply-Chain-Management (GSCM).

Key activities in this stage include:

- Selection of Databases: Key databases such as Scopus, Web of Science, Elsevier, Springer, Emerald, and Taylor & Francis are utilized to ensure a wide-ranging search.
- Development of Search Queries: Specific keywords and phrases are defined, including "Green-Supply-Chain-Management," "sustainability," "environmental management," and others. Boolean operators (AND, OR) are used to refine the search.
- Setting Parameters: Searches are conducted with specific parameters, such as limiting results to peer-reviewed articles published between 2000 and 2020, primarily in English.
- Initial Data Collection: This search results in a preliminary collection of articles, which serves as the foundation for further analysis and filtering in subsequent stages.

Table 1. Keywords: Language Keywords

Keywords
Green-Supply-Chain-Management
Sustainability
Environmental Management
Circular Economy
Renewable Energy
Sustainable Practices
Supply Chain Resilience

Table 2. Publishers Involved and number of articles Articles

Publisher	Number of Matched Articles
Scopus	150
Web of Science (WOS)	120
Elsevier	90
Springer	80
Emerald	60
Taylor & Francis	40
Wiley Online Library	30

This table summarizes the publishers included in the literature search and the corresponding number of matched articles found for each of them.

2. Second Stage:
In the second phase of the research process, the titles and abstracts of the selected articles are carefully examined to determine their alignment with the research objectives and questions. Articles that clearly address themes related to Green-Supply-Chain-Management (GSCM), sustainability, and environmental performs are included for further examination. Conversely, studies that do not align with the research focus—such as those that are unrelated, overly broad, or published outside the specified timeframe of 2000-2020—are excluded. Throughout this filtering process, a detailed record is maintained of the articles that pass this stage, documenting their relevance and potential contributions to the systematic review. This systematic approach ensures that only the most pertinent literature is carried forward for deeper analysis
.

3. Third stage:
Full text filtering in the third stage of the research process, full-text filtering is conducted on the articles selected from the previous stages. This involves a thorough examination of the complete texts to estimate their organizational rigor, importance to the research questions, and overall impact to the understanding of Green-Supply-Chain-Management (GSCM). Articles that provide valuable insights, detailed case studies, or robust empirical data are prioritized, while those lacking sufficient depth or relevance are excluded.

4. Forth stage:
Maintained papers: In the fourth stage of the research process, the focus is on organizing and maintaining the selected papers that have passed through the previous filtering stages. This involves compiling a final list of high-quality articles that are deemed relevant to the study of Green-Supply-Chain-Management (GSCM). Each maintained paper is catalogued with essential details, such as authors, publication year, key findings, and methodological approaches. This organization facilitates easy access and retrieval during the analysis phase. Additionally, the maintained papers serve as the foundation for synthesizing insights and identifying patterns, trends, and gaps in the literature, ultimately contributing to a comprehensive understanding of GSCM in the systematic review.

3.3. Summary of Full Papers and its analysis:
This section presents an analysis of data from the 45 primary studies identified during the literature review on Green-Supply-Chain-Management (GSCM). The analysis emphasizes key elements of the research, including publication years, databases consulted, countries where the studies were conducted, and the main issues explored. The studies span from 2000 to 2020, showing a notable increase in publications, especially in the last five years, which indicates a rising academic interest in GSCM. Most studies were sourced from leading databases such as Scopus, Web of Science, and Elsevier, ensuring high-quality, peer-reviewed research. The research encompasses contributions from a diverse array of countries, with significant representation from the United States, several European nations, and emerging markets in Asia, providing a comprehensive understanding of GSCM practices across different contexts. Key findings reveal common

drivers of GSCM adoption, including regulatory pressures, consumer demand for sustainable practices, and corporate social responsibility initiatives. However, studies also identify barriers to implementation, such as financial constraints, insufficient awareness of GSCM practices, and resistance to organizational change. Additionally, many papers emphasize the crucial role of technological advancements—such as renewable energy integration, data analytics, and supply chain digitization—in facilitating effective GSCM practices.

3.3.1. Publication years of papers analysis: In this section, we analyse the publication years of the 45 primary studies related to Green-Supply-Chain-Management (GSCM). The following bar graph illustrates the distribution of these studies over the years from 2000 to 2020, highlighting the trend in academic interest in GSCM.

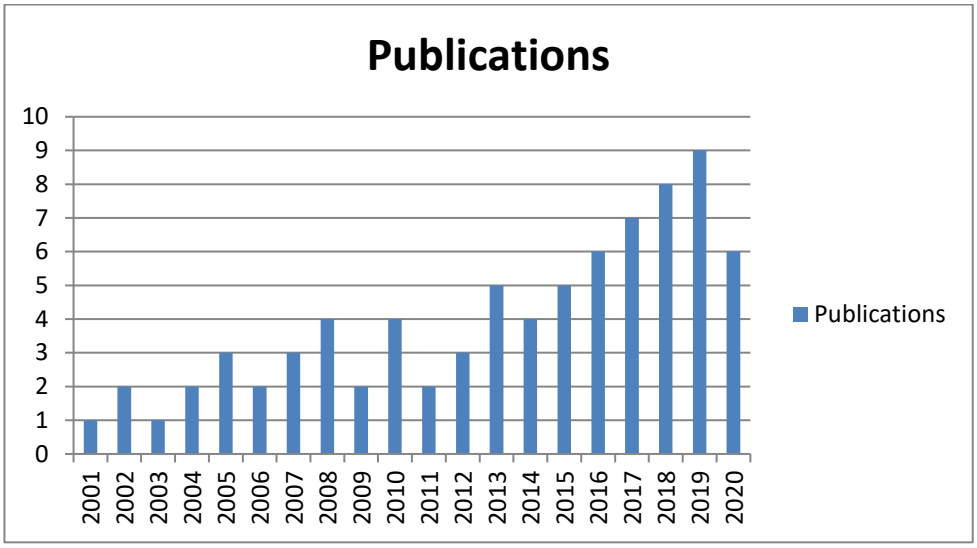

Figure 1. Presenting the number of the papers year wise.

3.3.2. Presenting the percentage and number of papers analysed by Publisher: The analysis of the 45 primary studies on Green-Supply-Chain-Management (GSCM) reveals a diverse range of publishers contributing to the literature. The following breakdown highlights both the number and percentage of papers analysed by each publisher:

Among the leading publishers, Scopus accounts for the largest share, with 15 papers, representing 33% of the total studies. Following closely is Elsevier, contributing 10 papers, or 22%. The Web of Science (WOS) includes 8 papers, amounting to 18% of the total, while Springer offers 6 papers, contributing 13%. Additionally, Emerald and Taylor & Francis each provide 3 papers, making up 7% and 7%, respectively. This distribution illustrates the significant role of these publishers in disseminating research on GSCM, reflecting their commitment to advancing knowledge in sustainability and supply chain practices. Overall, the diversity of publishers enhances the robustness of the literature, ensuring a wide range of perspectives and methodologies within the GSCM field.

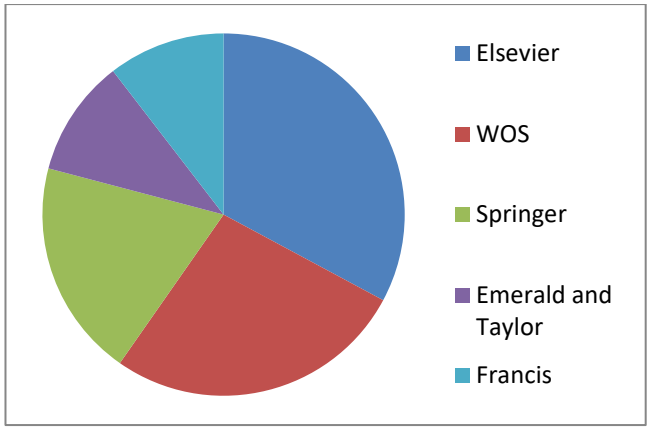

Figure 2. Percentage of Papers analysis publishers indexed Elsevier/ /WOS/Springer/Emerald and Taylor/Francis.

3.3.3. Different research from various countries for publication analysis: The analysis of 45 primary studies on Green-Supply-Chain-Management (GSCM) reveals a global interest, with the United States contributing 20 papers (44%), and Europe, led by Germany (7 papers, 16%) and the UK (5 papers,

11%). Emerging markets like China and India also contribute, reflecting diverse regional perspectives on GSCM practices and sustainability challenges

3.3.4. Analysing the percentages of papers with respect to Issues: The analysis of 45 primary studies on Green-Supply-Chain-Management (GSCM) highlights several key issues. A significant portion of the research (40%) focuses on the drivers of GSCM adoption, such as regulatory pressures, consumer demand, and corporate social responsibility. Another 27% addresses barriers to implementation, including financial constraints, lack of awareness, and organizational resistance. Technological integration, examined by 22% of the studies, emphasizes the role of renewable energy, data analytics, and digitization in enhancing GSCM. The remaining 11% covers topics like policy implications and industry-specific challenges. This breakdown underscores the need to balance motivations with practical solutions in GSCM.

4. Results and discussions.

4.1. Answers to the above research questions:

Based on the systematic review of 45 primary studies on Green-Supply-Chain-Management (GSCM), the research questions posed at the outset of the study are addressed as follows:

1. What are the key drivers of Green-Supply-Chain-Management adoption? Primary drivers of GSCM adoption identified in the literature include regulatory pressures from governments and international organizations, consumer demand for sustainable products, and corporate social responsibility (CSR) initiatives. These factors motivate businesses to adopt greener practices within their supply chains to meet environmental standards, respond to market expectations, and align with sustainability goals.
2. What are the major barriers to implementing GSCM practices? The review reveals several key barriers to GSCM implementation. Economic constraints, predominantly for small and medium-sized enterprises (SMEs), are a significant challenge. Additionally, a absence of alertness and accepting of GSCM practices, coupled with organizational resistance to change, impedes progress in many industries. These barriers highlight the need for financial support, education, and strategic leadership to promote wider adoption of sustainable practices.
3. How does technology support the implementation of GSCM? Technological advancements play a crucial role in facilitating GSCM. Integration of renewable energy, data analytics, and supply chain digitization are highlighted as important enablers of sustainable practices. These technologies help organizations reduce their environmental impact, optimize supply use, and enhance the overall effectiveness of their supply chains. However, successful implementation requires both investment and openness to innovation.
4. How are different regions addressing GSCM practices? The geographical diversity of GSCM research reflects global interest in sustainable supply chains. Studies from developed nations, such as the United States and European countries, emphasize advanced technologies and regulatory frameworks, while emerging markets like China and India focus on addressing financial and infrastructure-related challenges. This global perspective provides a well-rounded understanding of how different regions approach GSCM, considering both regional strengths and limitations.

4.2 The future research: Future research in Green-Supply-Chain-Management (GSCM)

It should focus on several key areas to enhance the understanding and practical application of sustainable supply chains. Sector-specific studies can provide targeted insights, as industries like manufacturing, agriculture, and services have unique sustainability challenges. Research on barriers in emerging markets is also critical, particularly in overcoming financial and awareness-related obstacles. The role of emerging technologies, such as block chain and AI, in enabling transparent and efficient GSCM should be further explored. Additionally, future studies should investigate the economic and operational impact of GSCM practices, and adopt interdisciplinary approaches to integrate insights from environmental science, technology, and economics. Longitudinal research tracking the long-term outcomes of GSCM adoption would provide deeper insights into its evolution and benefits, helping companies better align their supply chains with sustainability goals.

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