

A Comprehensive Literature Review on Green Supply Chain Management: Recent Advances and Potential Research Directions

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Abstract

Organisations are attempting to make their supply chain eco-friendly due to rising carbon emissions and unsustainable use of natural resources. In this context, this study seeks to give an up-to-date literature review on green supply chain management (GSCM) from 2011 to December 2021. Initially, 375 articles were collected from the Web of Science (WoS) database for metadata analysis. In metadata analysis, the descriptive statistics of research trends of GSCM; most contributing authors, countries/regions and institutions; and most prominent journals, keywords and subject areas are discussed in detail. Later, 50 scholarly publications were selected according to their citations for content analysis. Based on their contents, the papers were classified into four categories: GSCM practices and performances, mathematical techniques, drivers and barriers of GSCM, and general articles related to GSCM. According to the in-depth analysis, most of the publications are theoretical works that contribute to the theory-building of GSCM. Likewise, mathematical techniques are gaining appeal among researchers, whereas research on drivers and barriers is limited. In articles regarding GSCM practices and performance, the structural equation modelling methodology was often employed. The results and future research directions presented may assist beginners in exploring new GSCM research domains.

Keywords: Green supply chain management; Literature review; Metadata analysis; GSCM practices and performances; Drivers and barriers; Mathematical techniques.

1. Introduction

Due to increased environmental degradation and pollution caused by industrial wastes, people's quality of life is deteriorating dramatically (Ososanmi et al., 2022). Industries are often held accountable for their unanticipated and irresponsible initiatives toward sustainability (Tseng et al., 2019). As a result, organisations are under legislative, competitive, and stakeholder pressure to balance their environmental and economic performances (Malviya and Kant, 2015; Lotfi et al., 2021b). Organisations are trying their best to engage in green operations to enhance their economic and environmental performances to gain a competitive advantage in the marketplace and meet customer demands (Yan et al., (2021), Ren et al., (2006)). Integrating green practices into an organisation's supply chain activities can help to reduce the industry's escalating environmental damage (Najmi et al., 2020; Lotfi et al., 2021e). In this context, the notion of green supply chain management (GSCM) might be helpful. GSCM is primarily concerned with incorporating economic and environmental goals into managing the supply chain's operation strategy (Herrmann et al., 2021). GSCM accounts for an organisation's whole sourcing, production, packaging, transportation, and marketing processes from an environmental aspect (Ali et al., 2022; Mohammed et al., 2021). As a result, by using GSCM practices, organisations can boost their supply chain's environmental capabilities (Fakhrzad and Lotfi, 2018) and guarantee that all environmental regulations are satisfied (Bhatia and Gangwani, 2021).

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After the 1990s, the notion of GSCM took formal shape as a distinct field (Ramírez-Granados et al., 2014). However, owing to the increasing unsustainable use of natural resources and global warming, it acquired appeal among many research experts around 2000 (Fahimnia et al., 2015). GSCM is regarded as a comprehensive method that includes environmental considerations in the supply chain. However, no formal definition of GSCM exists in the literature. Tseng et al. (2019) attempted to give a unified definition of GSCM by synthesising the 22 definitions provided by various research experts. The authors described GSCM as “The integration of environmental management system into the supply chain process including collaboration with customers, suppliers, and logistics service providers to share information and knowledge with an aim to improve environmental performance”. An effective GSCM can provide organisations with various advantages, including cost reduction, improved market share and sales, stakeholder satisfaction, and long-term consumer engagement (Khalili and Alinezhad, (2018), Tarasewicz, (2016)).

As GSCM is currently the research hotspot due to rising environmental pollution, various authors have presented different literature reviews on various aspects of GSCM. Initially, the first state-of-the-art literature review was presented by Srivastava, 2007. Later, some authors focused on GSCM in terms of renewable resources (Gawusu et al., 2022), while others focused on GSCM in terms of an uncertain environment (Chen et al., 2021). Similarly, some authors focused on methodology (Soda et al., 2016; Banasik et al., 2018; Tuni et al., 2018), while others focused on the broader aspect of GSCM (Tseng et al., (2019); Rungklin and Srimai, (2019), Liu et al., (2018)). Likewise, Lotfi et al. (2021d) suggested a feasible supply chain network layout based on cryptocurrencies and blockchain technology. To summarise, most prior studies concentrated on a specific facet of GSCM, providing readers with expertise in that single domain. As a result, there is a need to convey information about GSCM in various aspects, as the GSCM literature grows rapidly, supporting the need to present the most recent trends and research directions to the current body of literature. Furthermore, limited studies analysed the GSCM literature regarding metadata analysis and insights of the top 50 most cited research publications based on GSCM from 2011 to December 2021. To fulfil the gap which the prior studies have not addressed, this paper provides a comprehensive literature review regarding GSCM based on metadata analysis and content analysis of highly cited research articles. Based on these analyses, research gaps and prospective research directions for future research are offered. The rationale for choosing the top 50 most cited research publications is that it will rapidly provide a guideline for novices to understand the study fields extensively accepted by various scholars and those that still need more investigation. As a result, the following research questions are attempted to be answered in this study:

- What is the latest development trend in GSCM related research articles?
- What are the names of the most influential authors and journals?
- What are the top prolific countries/regions and institutions which published most articles related to GSCM?
- Which articles are highly acknowledged by the research scholars?
- What are the four main classifications of highly acknowledged articles based on the content analysis?

The data was retrieved from the ISI Web of Science database from 2011 to December 2021. For metadata analysis, 375 publications were collected from the ISI Web of Science (WoS) database. The metadata analysis includes the descriptive statistics of research trends of GSCM; most contributing authors, countries/regions and institutions; and most dominant journals, keywords and subject areas. Later, the most influential 50 papers were classified into four main categories to provide insights regarding GSCM. The four main categories include (1) GSCM practices and performances; (2) Mathematical techniques; (3) Drivers and barriers of GSCM; (4) General articles related to GSCM. Finally, the research gaps for future directions are highlighted based on the acquired findings. The main contributions of this study are as follows: (1) This study provides an up-to-date and easy to understand comprehensive literature review regarding GSCM from 2011 to December 2021; (2) Top 50 highly influential publications are classified into four main categories to provide quick insight to the beginners; (3) The proposed study highlights some findings that differ from other studies. This study will assist researchers interested in the GSCM by giving thorough insights and future research directions.

The remainder of the paper is organised as follows. The suggested methodology and sample articles are defined in Section 2. Section 3 discusses the GSCM’s metadata analysis. Insights of the GSCM literature based on its four categories are presented in section 4. Section 5 presents a detailed discussion of the obtained results. Section 6 provides the conclusion, limitations and research directions for future research initiatives.

2. Methodology and sample articles

In order to retrieve the data from credible sources, this paper adopted the systematic process defined by Herrmann et al. (2021), Sharma et al. (2021) and Tseng et al. (2019). The systematic literature review begins with locating, critically analysing, and integrating relevant papers to meet one or more research issues (Kassarjian, 1977). Keeping that concept in mind, the primary goals of this study are twofold: (1) Highlights GSCM trends using metadata analysis; (2) Categorises highly significant articles to give recommendations for future research. Figure 1 depicts the overall flowchart of the proposed methodology to help understand the proposed approach. The suggested methodology’s steps are as follows:

Step 1: Data was gathered from the Web of Science database, containing scientific publications from well-known publishers, including Elsevier, Springer, Emerald, Wiley, and Taylor & Francis.

Step 2: The proposed study primarily employed the keywords “Green supply chain management” OR “GSCM” to locate relevant material. The search was limited to titles to find the most relevant papers linked to GSCM.

Step 3: Furthermore, the search was restricted to articles published between 2011 and December 2021, with peer-reviewed papers published in English being considered for further analysis.

Step 4: 375 articles were obtained for metadata analysis based on the preceding steps. Only 50 of the most highly acknowledged papers among 375 are chosen to provide an in-depth insight into the GSCM literature.

Note: The ISI Web of Science database was used to gather all of the data for analysis on January 25, 2022.

3. Metadata analysis of GSCM

This section presents the metadata analysis of 375 articles retrieved from the most reliable data source, the ISI Web of Science. In order to understand the emerging trend of GSCM, the metadata analysis mainly analysed the number of publications related to GSCM concerning each year; most contributing authors, countries/regions and institutions; and most dominant journals, keywords and subject areas. However, one paper is counted multiple times in doing the metadata analysis because of multiple authors. For example: if two authors coauthor one article from two different institutes, each author gets one publication credit, and the same goes for their institutions and countries.

3.1. Publications related to GSCM per year

This section illustrates the rising trend of GSCM-related papers. Figure 2 depicts the exponential growth of GSCM-related research publications from 2011 to December 2021. According to figure 2, 2018 ranked first among all years with 49 publications in which many authors addressed the rising environmental issues related to supply chain management. The number of publications declined marginally in 2020, maybe due to the escalating pandemic situation. However, the number of publications begins to climb again in 2021, indicating that GSCM is still a primary concern for many research scholars due to the substantial increase in the unsustainable use of natural resources and growing industrial pollution.

3.2. The subject areas of the publications related to GSCM

Various disciplines endorsed the concept of GSCM as a result of expanding consumer environmental awareness and strict governmental laws and regulations enforced to deal with escalating environmental challenges. Figure 3 shows that the environmental science field provides the most papers to the GSCM literature, accounting for 17% of the total publications. Following that, green sustainable science and technology came in second place with a 14% total contribution. At the same time, management discipline placed third with a 12% contribution, demonstrating the growing environmental concern in the managerial strategies of the various organisations. As the implementation of GSCM practices can improve the organisation's environmental and economic performances, numerous disciplines embraced the idea of GSCM, demonstrating that the notion of GSCM is not limited to a single domain but has applications in multiple domains.

3.3. Most contributing authors

This sub-section highlights the ten most prolific authors who have made substantial contributions to the GSCM literature. Table 1 presents the names of the most contributing authors and their publications. According to table 1, Govindan K and Zhu QH, both authors ranked 1st by publishing an equal number of articles (14 each out of 375) related to GSCM, having a cumulative percentage of 7.466. Similarly, Sarkis J and Jabbour CJC retain the ranking of 2nd and 3rd by publishing 11 and 10 articles, respectively. In contrast, Lai KH and Liu JJ ranked least among the prolific authors.

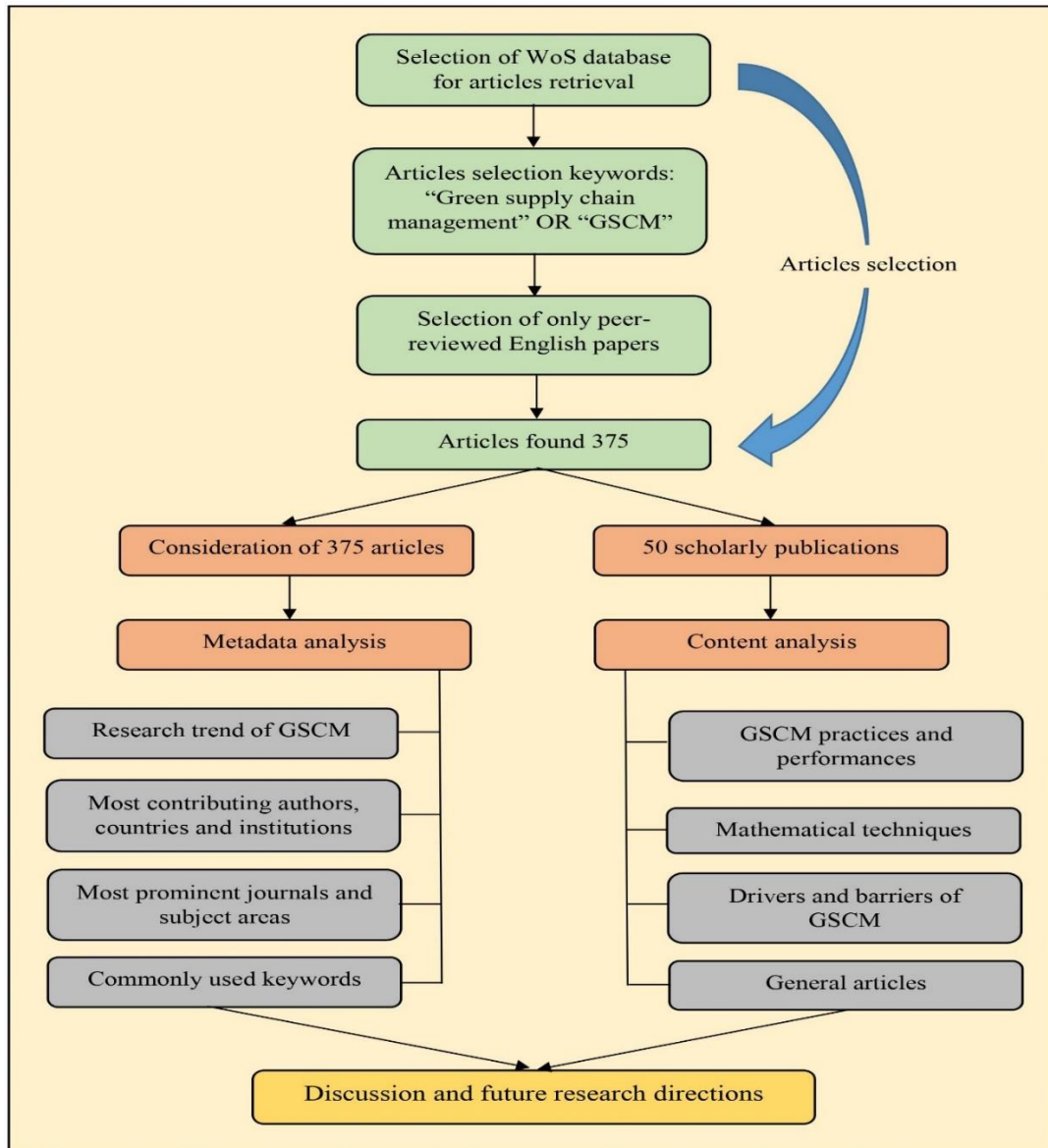


Figure 1. Overall flowchart of the proposed methodology

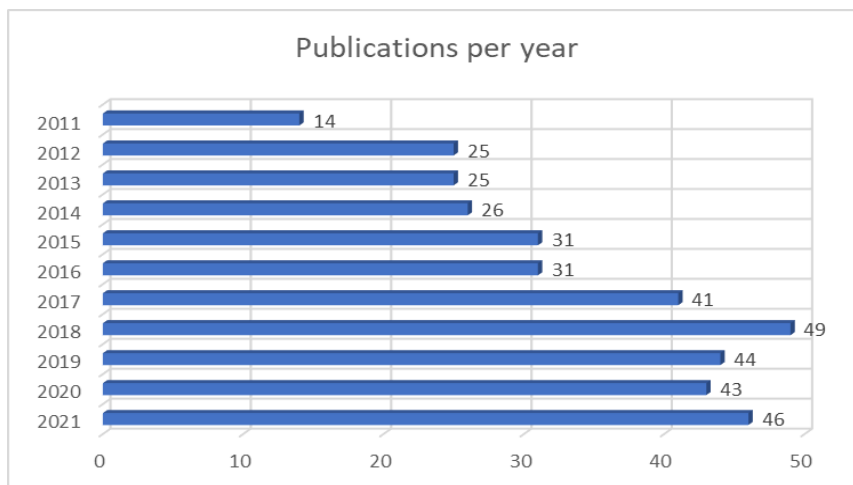


Figure 2. Number of publications per year

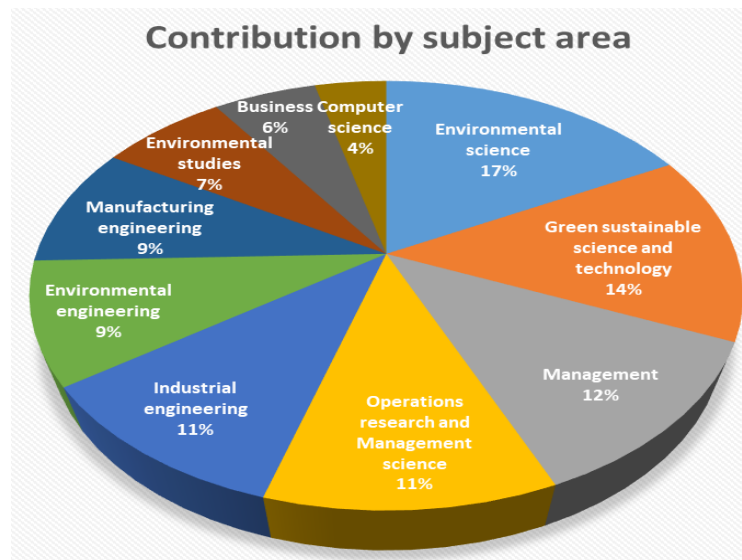


Figure 3. Contribution to the GSCM literature by different subject areas

Table 1. Ten most contributing authors related to GSCM literature

Rank	Author	No. of publications	Contribution percentage out of 375 articles
1	Govindan K	14	3.733
1	Zhu QH	14	3.733
2	Sarkis J	11	2.933
3	Jabbour CJC	10	2.667
4	Jabbour ABLD	9	2.4
5	Mathiyazhagan K	7	1.867
6	Ali SM	6	1.6
6	Geng Y	6	1.6
7	Lai KH	5	1.333
7	Liu JJ	5	1.333

3.4. Contributions by different countries/regions

This section highlights the most contributing countries/regions. Looking at figure 4, China took the lead among all the countries by publishing the highest number of articles related to GSCM. After that, the USA and India followed the lead by publishing 48 and 46 articles, respectively. In contrast, Italy ranked last among all the countries with an overall contribution of 14 articles. It is worth noticing that China, USA and India together contributed a lot to the GSCM literature (around 60% of the total contribution), which shows their awareness of rising environmental concerns because all these countries produce a significant number of the world's pollution due to their increase in the usage of fossil fuels. Note: As a single article contains multiple authors from different countries/regions, each country has given equal publication credit in this regard. For example, if an article contains two authors from two different countries, each gets one credit.

3.5. Contributions by different institutions

Table 2 depicts the most contributing institutions to the GSCM literature. According to table 2, India's National Institute of Technology published many articles on GSCM. This institute constitutes an overall contribution of 4.267% (16 articles) to the GSCM literature. Following the lead, the University of Southern Denmark took second place among the most prolific institutions. Interestingly, the total publications from the University of Southern Denmark are precisely the same as the number of publications written by Govindan K (mentioned in table 1), who belongs to the same institute. This implies that all of the institute's publications are written by a sole author. In contrast, Islamic Azad University ranks last with 6 publications.

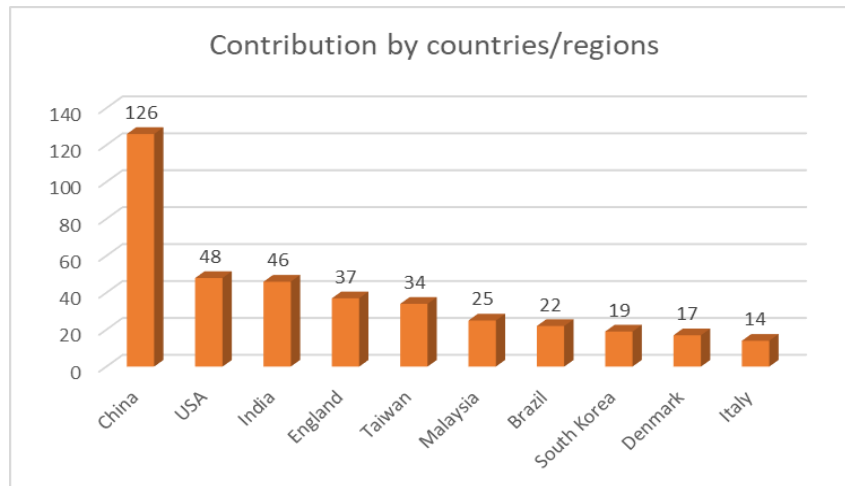


Figure 4. Ten most contributing countries/regions

Table 2. Ten most contributing institutions related to GSCM literature

Rank	Institution	No. of publications	Contribution percentage out of 375 articles
1	National Institute of Technology	16	4.267
2	University of Southern Denmark	14	3.733
3	Dalian University of Technology	12	3.2
4	Universidade Estadual Paulista	11	2.933
5	Chinese Academy of Sciences	8	2.133
5	Hong Kong Polytechnic University	8	2.133
6	Clark University	7	1.867
6	Indian Institute of Technology	7	1.867
6	Shanghai Jiao Tong University	7	1.867
7	Islamic Azad University	6	1.6

3.6. Contributions by influential journals

This section focuses on the most prominent journals contributing considerably to the GSCM literature. Table 3 shows that the Journal of Cleaner Production published more papers (45) on GSCM, contributing about 12% out of 375 articles. Sustainability is the second most popular journal, accounting for around 7.2% with 27 articles. However, this journal's impact factor is more diminutive than other highly prominent journals, showing that the articles published in this journal received fewer citations than others. Similarly, Supply Chain Management: An International Journal produces the fewest GSCM-related publications. However, the impact factor of this journal is fairly good (9.012), making this journal worthwhile to publish.

3.7. Most commonly used keywords in the GSCM literature

This section uses the VOSviewer tool to identify the most frequently used keywords in the GSCM literature. Table 4 presents the most commonly used keywords along with their occurrences. Here, the number of articles in which two keywords appear together is referred to as the total link strength. The greater the value of total link strength, the stronger the connection between the two keywords. Figure 5 demonstrates the nodes and linkages between these nodes to comprehend the idea better. The node's size represents the occurrences of the keywords. Therefore, the greater the node's size, the more frequent the occurrence of that specific keyword. According to table 4, "Green supply chain management", "Performance", "Impact", and "Sustainability" are the most commonly used keywords used in the GSCM literature with the strongest link strengths. Note: It is challenging to represent each node and its linkage with other nodes in Figure 5. However, the reader can easily visualise these things in the VOSviewer tool, which is freely available online.

Table 3. Ten most prominent journals on GSCM

Rank	Journal	No. of publications	Impact factor (2020)	Contribution percentage out of 375 articles
1	Journal of Cleaner Production	45	9.297	12
2	Sustainability	27	3.251	7.2
3	Production Planning & Control	12	7.044	3.2
4	International Journal of Production Research	11	8.568	2.933
5	Business Strategy and the Environment	10	10.302	2.667
5	International Journal of Production Economics	10	7.885	2.667
5	Journal of Manufacturing Technology Management	10	7.547	2.667
5	Resources Conservation and Recycling	10	10.204	2.667
6	International Journal of Logistics Research and Applications	9	3.821	2.4
6	Supply Chain Management: An International Journal	9	9.012	2.4

Table 4. Ten most commonly used keywords in the GSCM literature

Keyword	Occurrences	Total link strength
Green supply chain management	193	1898
Performance	122	1218
Impact	106	1263
Sustainability	90	1082
Environmental-management	65	813
Implementation	64	753
Model	63	662
Framework	59	699
Drivers	58	674
Environmental performance	52	577

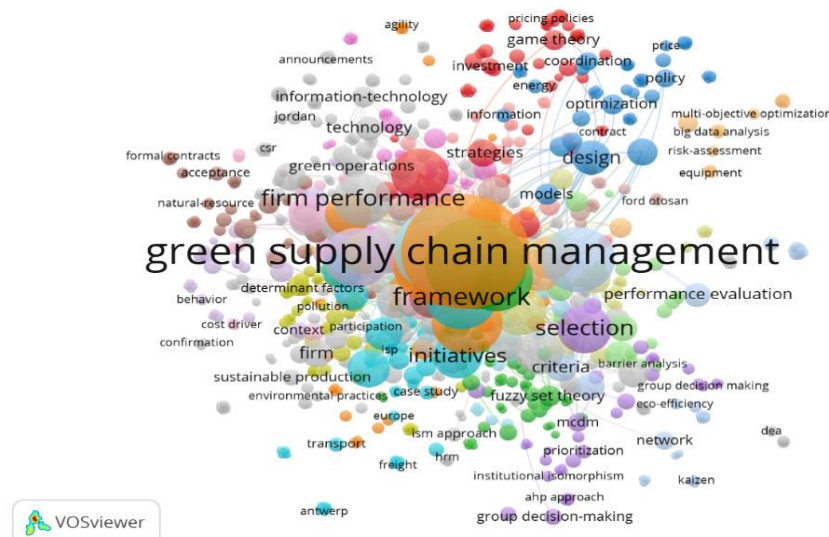


Figure 5. Network visualisation of commonly used keywords

4. Insights of GSCM literature

The top fifty scholarly articles will be discussed in this section, mainly retrieved from the ISI Web of Science database based on their citations. The details of the scholarly articles and their number of citations are presented in table 5. The main reason for selecting the top fifty highly cited articles is that it will give the academician an overview of which research domains related to GSCM were highly acknowledged by the researchers and which still need further

investigation. This section is divided into four main sub-categories: (1) GSCM practices and performances; (2) Mathematical techniques; (3) Drivers and barriers of GSCM; (4) General articles related to GSCM.

Table 5. Top 50 highly cited articles related to GSCM (accessed on January 25, 2022)

No.	Authors	Publication year	Main focus of the article	Total citations
1	Sarkis et al.	2011	Classified the GSCM literature into nine organisational theories that were only focused on the analysis of GSCM theory adoption, dissemination, and results to identify research possibilities and directions.	998
2	Fahimnia et al.	2015	Bibliometric analysis of over 1000 published articles on GSCM was conducted to identify areas of existing research and prospective avenues for research consideration.	588
3	Green et al.	2012	Conducted empirical research on the effects of GSCM techniques on organisational performance.	547
4	Diabat and Govindan	2011	Identified numerous drivers for GSCM adoption with the aid of literature analysis and discussions with industry professionals.	480
5	Zhu et al.	2013	Developed and experimentally tested the theoretical model on various sorts of institutional constraints driving manufacturing businesses to adopt GSCM practices.	424
6	Kannan et al.	2014	Proposed multi-criteria decision-making methodology for the selection of green suppliers based on GSCM parameters in the electronics industry.	373
7	Govindan et al.	2014	Identified the main challenges for the adoption of GSCM practices.	362
8	Mathiyazhagan et al.	2013	Barrier identification to GSCM deployment in the automobile component manufacturing business so that industrial specialists may remove them on time.	340
9	Lin	2013	Investigated the most dominant criteria of the GSCM practices with the help of a decision-making technique.	318
10	Hsu et al.	2013	Utilised the DEMATEL method to recognise the prominent criteria of carbon management in green supply chains.	308
11	Zhu et al.	2012a	Evaluated the mediation relationships between external and internal practices of GSCM with the assistance of a survey conducted from Chinese manufacturers.	260
12	Swami and Shah	2013	Considered the collaboration of producer and retailer in a vertical supply chain to make their operations eco-friendly.	244
13	Sarkis	2012	Provided a framework for understanding the connection between several research streams concerning GSCM, primarily consisting of nine non-exclusive interconnected boundaries and five resource flows.	225
14	Jabbour and Jabbour	2016	Proposed framework to give insights into how green human resource management (GHRM) may help GSCM in terms of decreasing obstacles.	215
15	Chan et al.	2012	Surveyed multiple foreign-invested firms in China to mediate relationships between several elements.	215
16	Rostamzadeh et al.	2015	Assessed the adoption of GSCM approaches among Malaysian laptop manufacturing company practitioners under uncertain situations.	213
17	Tseng and Chiu	2013	Utilised the decision-making approach to assess the green suppliers' performance based on environmental and non-environmental GSCM parameters.	212
18	Zhu et al.	2012b	Identified and distinguished GSCM adopters based on environmental, operational, and economic performances.	206
19	Wu et al.	2012	Examined the influence of GSCM drivers and institutional forces on GSCM practices.	204
20	Tian et al.	2014	Proposed hybrid models to monitor subsidy policies to encourage the dissemination of GSCM in China, as well as an analysis of the connection between the government, firms, and consumers.	182
21	Mitra and Datta	2014	Investigated the implementation of GSCM techniques in Indian manufacturing businesses.	181
22	Yang et al.	2013	Empirically explored the impact of GSCM on corporate green performance and business competitiveness.	180

23	Geng et al.	2017	Provided a meta-analysis of empirical data from Asian developing economies to better understand the correlation between GSCM practices and business performance in the manufacturing sector.	176
24	Shi et al.	2012	Provided literature that describes GSCM from a natural resource perspective, as well as performance measurements and institutional factors.	169
25	Mirhedayatian et al.	2014	Evaluated the GSCM in the presence of dual-role components, unwanted outcomes, and ambiguous data.	162
26	Lee et al.	2012	Investigated the influence of GSCM on the firm performance of small and medium-sized organisations that operate as vendors to major client firms in the electronics sector.	155
27	Tseng et al.	2019	Presented a thorough literature assessment on GSCM up to 2017 to analyse the various research streams.	154
28	Liou et al.	2016	Utilised the combination of decision-making approaches for internal organisation development and green suppliers' selection.	154
29	Cabral et al.	2012	Proposed a decision-making framework for measuring the success of an automaker's supply chain based on lean, agile, resilient and green characteristics.	143
30	Muduli et al.	2013a	Identified the impediments to GSCM implementation in the mining industry.	138
31	Arimura et al.	2011	Studied the implications of ISO 14001 certification on the propagation of GSCM practices.	136
32	Laosirihongthong et al.	2013	Examined the employment of pro-active and reactive strategies in the execution of GSCM and their influence on overall company performance.	135
33	Chin et al.	2015	Scrutinized a large body of literature to develop a credible conceptual model to explain the relationship between different factors.	134
34	Muduli et al.	2013b	Identified and assessed the dynamic behavioural elements influencing GSCM deployment.	132
35	Luthra et al.	2016	Investigated the influence of critical success factors (CSFs) in implementing GSCM for long-term sustainability.	131
36	Hoejmose et al.	2012	Evaluated the deployment of GSCM strategies in B2B markets.	131
37	Zaid et al.	2018	Investigated the effect of GHRM and GSCM practices on the company's sustainability performance.	129
38	Zhu et al.	2011	Conducted a thorough survey to analyse the GSCM existence in Chinese manufacturing corporations.	129
39	Vanalle et al.	2017	Investigated the GSCM pressures, practices, and performances among Brazilian automotive supply chain vendors.	127
40	Zhao et al.	2017	Proposed an empirical optimised model for GSCM by utilising a big data analytic methodology.	127
41	Oliveira et al.	2018	Conducted the systematic literature review of GSCM from 2006 to 2016 to highlight the research implications.	123
42	Luthra et al.	2015a	Detected and modelled the CSFs for executing the GSCM towards sustainability in the Indian industry.	122
43	Teixeira et al.	2016	Targeted several Brazilian ISO 14001 certified organisations to investigate the association between various elements.	121
44	Luthra et al.	2015b	Identified and analysed the CSFs using an exhaustive literature review and discussions with experts to effectively highlight the accomplishment of environmental sustainability in the Indian car sector supply chains.	121
45	Mathiyazhagan et al.	2014	Identified and prioritised different pressures for GSCM implementation.	118
46	Laari et al.	2016	Mainly focused on organisational performance and customer-driven GSCM in Finnish manufacturing enterprises.	113
47	Tseng	2011	Proposed an integrated approach for green supplier selection under data uncertainty.	109
48	Abdel-Baset et al.	2019	Evaluated the GSCM practices with the help of a decision-making approach.	106
49	Yu et al.	2014	Surveyed several automobile industries in China to investigate the association between certain components.	104
50	Khan et al.	2018	Collected panel data from different countries to investigate the connection between GSCM, economic development and the environment.	103

Note: The details of all the articles are present in the references. Moreover, further information regarding the reviewed factors and solution methods are demonstrated in the sub-sections provided below.

4.1. GSCM practices and performances

This section categorises the studies, which primarily entail finding and assessing the GSCM-related practices and their impact on the company's performance. Similarly, papers that address the connection between GSCM practices and performances are also included in this section. In this regard, Green et al. (2012) gathered data from 159 manufacturing industry managers to empirically assess the influence of GSCM practices on performance. Their suggested research finds that the environmental and economic performances of the organisation can be enhanced by using GSCM practices since they have a favourable influence on the firm's operational performance. Zhu et al. (2012a) conducted a survey and gathered data from 396 Chinese manufacturing enterprises to provide three models illustrating the mediation connection between external and internal GSCM practices. Similarly, Shi et al. (2012) attempted to assist managers in assessing their strengths and weaknesses for using GSCM practices in their industrial operations to promote the notion of sustainable industrial growth.

To analyse the collected data effectively with the help of mathematical techniques, various authors adopted various techniques to present more precise results. In this context, Mitra and Datta (2014) investigated the impact of GSCM practices in a developing country's manufacturing sectors to determine the effects of such practices on company performance. The authors used factor analysis and structural equation modelling to analyse the obtained data properly. Similarly, Vanalle et al. (2017) used partial least squares structural equation modelling to evaluate Brazilian automotive suppliers' GSCM pressures, practices, and performances. Laosirihongthong et al. (2013) studied the adoption of proactive and re-active GSCM practices in 190 ISO 14001 certified Thai firms. The authors employed factor analysis and multivariate linear regression to examine the influence of GSCM practices on economic, environmental, and intangible performances while keeping business strategy as the organisation's primary emphasis. Yu et al. (2014) utilised structural equation modelling to study the linkage between three aspects of integrated GSCM (internal GSCM, GSCM with consumers, and GSCM with suppliers) and several dimensions of operational performance (cost, quality, delivery and flexibility). Similarly, Laari et al. (2016) studied 126 Chinese automotive businesses to determine the direct and indirect relationship between customer-driven GSCM practices and environmental and financial performances. The authors analysed the data with the help of structural equation modelling. Zaid et al. (2018) used partial least squares structural equation modelling to analyse data from 121 Palestinian enterprises to examine the influence of green human resource management and GSCM practices on the sustainability performance of companies.

Surprisingly, most highly cited studies related to GSCM practices and performances employed structural equation modelling to analyse the provided data. As a result, future research may use alternative mathematical strategies to analyse data by using techniques to address data uncertainty successfully. Figure 6 displays the most often utilised GSCM practices and performances described in the literature.

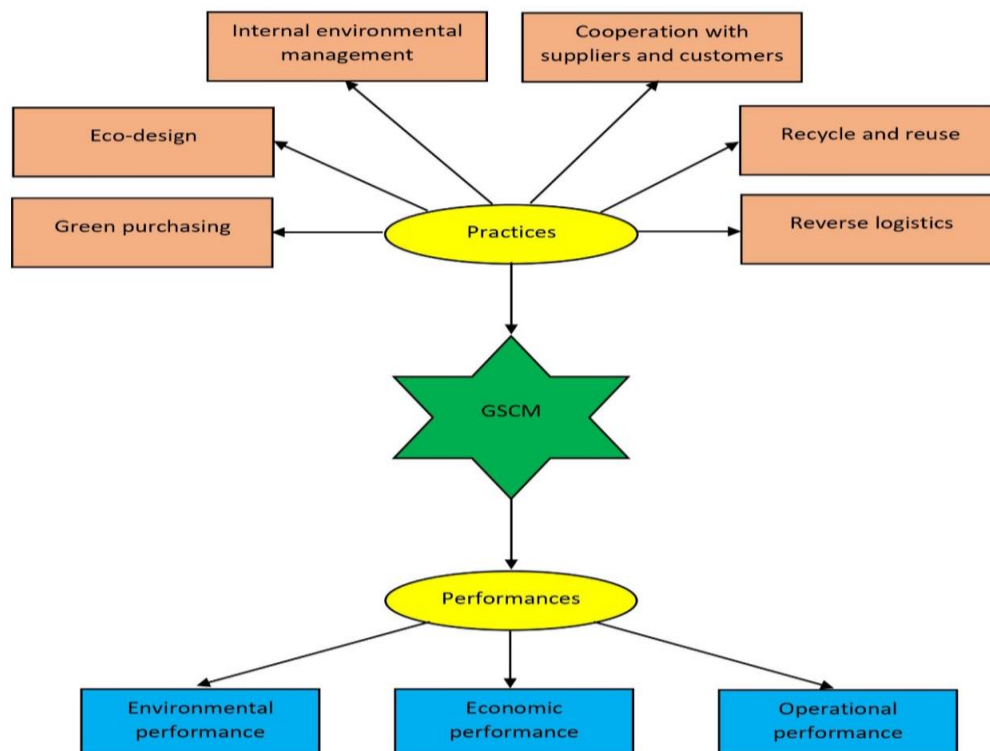


Figure 6. Practices and performances related to GSCM

4.2. Mathematical techniques

Many research scholars have adopted mathematical techniques to evaluate the qualitative and quantitative criteria in the GSCM literature (Lotfi et al., 2021a; Lotfi et al., 2021c; Lotfi et al., 2022). In this regard, Kannan et al. (2014) employed the fuzzy TOPSIS (technique for order preference by similarity to ideal solution) method to select the Brazilian electronics company's green suppliers based on GSCM practices. Likewise, Lin (2013) evaluated the GSCM practices using the fuzzy DEMATEL (decision making trial and evaluation laboratory) technique. Hsu et al. (2013) used the DEMATEL method to identify the influential criteria related to carbon management with an agenda to improve the overall performance of suppliers based on carbon management. The authors concluded that carbon management training and carbon information management systems are the two most significant criteria for choosing suppliers with carbon management skills. In order to tackle the data uncertainty due to tangible and intangible factors, Rostamzadeh et al. (2015) used the fuzzy VIKOR method to evaluate the GSCM practices in Malaysian laptop manufacturing firms. Yang et al. (2013) utilised the combination of fuzzy set theory and network data envelopment analysis to evaluate the GSCM under the conditions of dual-role components, ambiguous information and undesirable output. In this regard, the authors collected the data from ten Iranian soft drinks manufacturing companies. Zhao et al. (2017) suggested a multi-objective optimisation model with the primary goals of minimising costs, carbon emissions, and hazardous materials' inherent risk. To effectively evaluate the GSCM practices in the petroleum industry of Egypt and manufacturing organisation of China, Abdel-Baset et al. (2019) utilised the neutrosophic set with a robust ranking technique. Mathiyazhagan et al. (2014) identified and prioritised the pressures to implement the GSCM in the Indian industries with the help of the analytic hierarchy process (AHP) method. Tian et al. (2014) employed a system dynamic model based on evolutionary game theory to monitor subsidy schemes to increase GSCM adoption among Chinese manufacturers and examine the relationship between the government, businesses, and consumers. It is worth noticing that many research scholars used mathematical techniques to analyse qualitative and quantitative data efficiently. Some authors employed fuzzy set theory to cope with the data uncertainty element. Table 6 summarises the main mathematical techniques used in different studies related to GSCM.

Table 6. The mathematical techniques used in the scholarly articles related to GSCM

No.	Technique	Reference
1	TOPSIS/ Fuzzy TOPSIS	Kannan et al., 2014.
2	DEMATEL/ Fuzzy DEMATEL	Lin, 2013; Hsu et al., 2013; Liou et al., 2016.
3	VIKOR/ Fuzzy VIKOR	Rostamzadeh et al., 2015.
4	FST	Tseng and Chiu, 2013; Mirhedayatian et al., 2014; Tseng, 2011.
5	GRA	Tseng and Chiu, 2013.
6	DEA/ network DEA	Mirhedayatian et al., 2014; Wong and Wong, 2008
7	ANP	Liou et al., 2016; Cabral et al., 2012.
8	COPRAS-G	Liou et al., 2016.
9	AHP	Mathiyazhagan et al., 2014; Singh, 2013; Govindan et al., 2014.
10	SEM	Green et al., 2012; Mitra and Datta, 2014; Yang et al., 2013; Lee et al., 2012; Yu et al., 2014.
11	ISM	Mathiyazhagan et al., 2013; Muduli et al., 2013b; Luthra et al., 2015a.
12	GTMA	Muduli et al., 2013a.
13	PLS-SEM	Zaid et al., 2018; Vanalle et al., 2017.
14	IRP	Luthra et al., 2015b.

Where TOPSIS = Technique for order preference by similarity to ideal solution, DEMATEL = Decision making trial and evaluation laboratory, VIKOR = Vlsekriterijumska Optimizacija I Kompromisno Resenje, FST = Fuzzy set theory, GRA = Grey relational analysis, DEA = Data envelopment analysis, ANP = Analytic network process, COPRAS-G = Complex proportional assessment of alternatives with grey relations, AHP = Analytic hierarchy process, SEM = Structural equation modelling, ISM = Interpretive structural modelling, GTMA = Graph theoretic and matrix approach, PLS-SEM = Partial least squares structural equation modelling, and IRP = Interpretive ranking process

4.3. Drivers and barriers of GSCM

This section covers articles that examine the drivers and barriers to GSCM adoption. In this context, drivers or pressures relate to the variables that primarily assist businesses in successfully implementing GSCM practices (Soni and kodali, 2010). Barriers, on the other hand, are the variables that primarily impede the application of GSCM practices in any business (Tseng et al., 2019). The drivers assist organisations in efficiently implementing GSCM practices to improve environmental, economic, and operational performances (Vernadat et al., 2013). In this regard, Diabat and Govindan (2011) identified the key drivers of a manufacturing firm in southern India with the help of a comprehensive literature review and industrial experts. Wu et al. (2012) used the hierarchical moderated regression analysis to explore the effect of GSCM drivers and institutional pressures on GSCM practices in Taiwan's apparel industry. Based on sample analysis

collected from 396 Chinese manufacturers, Zhu et al. (2013) discovered that institutional pressures drove manufacturing organisations to embrace internal GSCM practices that link to adopting external GSCM practices.

On the other hand, Muduli et al. (2013a) identified the barriers which cause hindrance to GSCM adoption in Indian mining industries in the form of factors and sub-factors. Later, the authors used the graph theoretic and matrix approach (GTMA) to assess the negative impact of the identified impediments on GSCM implementation. Govindan et al. (2014) used the AHP technique to identify and prioritise the 47 hurdles to GSCM implementation in the Indian industry. Among 47 barriers, the intricacy of monitoring suppliers' environmental practices, deficiency of innovative technology, materials, and processes, and lack of adequate environmental controls were highlighted as the three most essential impediments. Mathiyazhagan et al. (2013) examined the 26 barriers in auto component manufacturing industries with the help of extensive literature, interviews and surveys. The authors attempted to assist industrial specialists by emphasising the most prevalent hurdles so that the practitioners could take precautionary measures on time. Figure 7 depicts some of the frequent drivers and barriers found in research studies concerning GSCM.

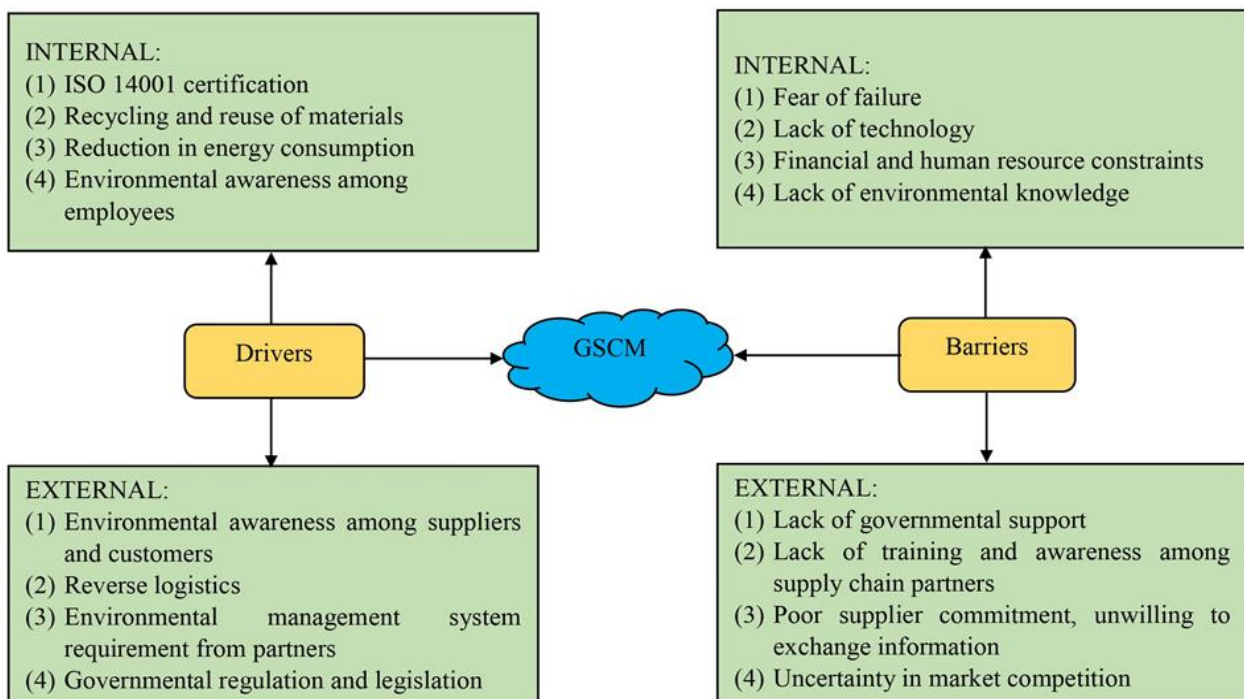


Figure 7. Drivers and barriers common in GSCM literature

4.4. General articles related to GSCM

This section discusses all the remaining articles that do not fall in the aforementioned three categories. This section mainly comprises of literature reviews (Sarkis et al., 2011; Oliveira et al., 2018), bibliometric/metadata analysis (Fahimnia et al., 2015; Geng et al., 2017), theory-building of GSCM (Swami and Shah, 2013; Sarkis, 2012; Luthra et al., 2015b), and surveys (Zhu et al., 2012b; Lee et al., 2012; Sezen, 2008; Arimura et al., 2011) etc. In this regard, Jabbour and Jabbour (2016) provided a synergistic and integrative paradigm for linking green human resource management (GHRM) and GSCM. The primary goal of their research was to give insights into how GHRM can help GSCM in terms of reducing obstacles. Muduli et al. (2013b) attempted to identify and prioritise the dynamic behavioural elements influencing GSCM adoption in the mining industry. Luthra et al. (2016) conducted an empirical study of 123 Indian automotive manufacturers to assess the influence of critical success factors (CSFs) on GSCM adoption to attain long-term sustainability. Similarly, Luthra et al. (2015a) examined and modelled the 26 identified CSFs to deploy the GSCM sustainably. Hoejmose et al. (2012) investigated the GSCM implementation in B2B markets and found that establishing trust with supply chain partners and receiving support from top management are the two critical drivers of GSCM practice engagement in B2B markets.

From economic modernisation standpoint, Zhu et al. (2011) surveyed 376 Chinese manufacturers to evaluate the extent of GSCM existence in the Chinese manufacturing organisations. Teixeira et al. (2016) targeted different ISO 14001 certified firms in Brazil to explore the association between green supply chain and green training. Chan et al. (2012) surveyed the 194 foreign-invested enterprises operating in China to experimentally evaluate a model that elucidates the linkage between GSCM practices, environmental orientation, and corporate performance. To empirically investigate the connection between internal green practices, external green integration, firm competitiveness and green performance,

Yang et al. (2013) collected data from 163 Taiwanese container shipping firms. Chin et al. (2015) conducted a thorough literature assessment to develop a viable conceptual model to explain the relationship between environmental cooperation, GSCM, and sustainability performance. Khan et al. (2018) examined the connection between green logistics operations and economic development, energy usage, and environmental sustainability using panel data from 43 countries.

5. Discussion

Due to growing carbon emissions and global warming worldwide, the notion of green supply chain management has grown at an exponential rate. According to the above mentioned comprehensive literature review, most of the papers regarding GSCM cover a single aspect. Some papers explore the relationship between GSCM and other factors, while some cover the drivers and barriers to implementing GSCM practices. However, the rudimentary agenda of all the articles related to GSCM is to improve the organisations' economic, environmental, and operational performances. Web of Science database, one of the most reliable sources, was used to extract 375 papers, which includes the concept of GSCM. Our metadata analysis shows that the concept of GSCM has gained traction in recent years in numerous research domains and several scholars from all around the globe try to provide quantitative and qualitative models to enhance the supply chain efficiency of the organisations. Among all the years, 2018 was the peak year in which the majority of the research scholars acknowledged the concept of GSCM in their research articles. Similarly, the Environmental science, Green sustainable science and technology and Management subject areas cover most of the articles regarding GSCM which shows that the concept of GSCM is most prevalent among environmental specialists and industrial managers. The major reason behind this is that all these research domains provide necessary procedures to deal effectively with the rising pollutants during product manufacturing in any organisation. Govindan K from the University of Southern Denmark took first place among the prolific authors. Likewise, China, the United States, and India are the most significant contributors to the GSCM literature, demonstrating their concern about rising environmental pollution. It is interesting to note that most of the GSCM research mainly revolves around the emerging economies which produce a significant amount of carbon emissions in the environment due to their increase in the usage of fossil fuels during the manufacturing of products. However, among all the 375 research articles little focus has been given to the underdeveloped countries where the resources are scarce and the rules and regulations are different regarding environmental preservation. The Journal of Cleaner Production contributes about 12% to the GSCM literature, which is one of the most popular journals in the area of environmental science. This ultimately shows that the majority of the research scholars like to publish their work in this journal. In the case of the most commonly used keywords, Green supply chain management, Performance, Impact and Sustainability are the most widely used keywords adopted by many research articles from 2011 to 2021.

Fifty highly cited research papers from the Web of Science database were considered for content analysis. The selected papers were classified into four major research categories. Initially, in the first category, several researchers attempted to determine the influence of implementing GSCM practices on the firm's overall performance. In this regard, they gathered data from various manufacturing companies to validate their proposed findings. The structural equation modelling technique was commonly utilised to analyse the collected data in articles concerning GSCM practices and performances. The most common practices found in the literature include internal environmental management, Cooperation with suppliers and customers, Recycling and reuse, Reverse logistics, Eco-design, and Green purchasing. These six practices were found common in all the articles incorporating data from various industries. However, many other practices exist in the literature but these practices vary from industry to industry. Most of the articles regarding GSCM practices and performances mainly focused on the manufacturing sectors while little emphasis has been given to the service sectors. Similarly, the usage of mathematical techniques to handle particular problems connected to the GSCM is growing exponentially due to the difficulties in dealing with qualitative and quantitative elements. To effectively deal with data uncertainty, some authors incorporated the concept of fuzzy set theory into their proposed model. Among all these mathematical techniques, the multi-criteria decision-making (MCDM) methods have gained more attention due to their advantage in dealing with the conflicting criteria to reach the final goal. It is interesting to note that case study validation through simulation and modelling hasn't been given much significance by the research scholars in the existing literature. According to the third category, drivers or pressures play a significant role in implementing GSCM practices. At the same time, barriers impede the GSCM adoption. It is observed that only a few authors published articles related to this category. One probable explanation is that this research domain has developed enough in the preceding years that researchers no longer wish to discover this research area anymore. The fourth category, which accounts for a significant fraction of the highly cited research articles, discovers the theoretical aspect of GSCM. In this category, survey papers are highly adopted by different research scholars. These survey type articles try to analyse the relationship between several factors so that the concept of GSCM can be efficiently adopted by the industrial managers to enhance their overall industrial performance.

To summarise, figure 8 attempts to provide the proposed framework for GSCM adoption. According to Figure 8, drivers are the primary contributors who assist organisations in understanding the advantages of implementing green practices in their supply chain. As there is a positive relationship between drivers and GSCM practices adoption, it is represented by a blue arrow. Likewise, adopting GSCM practices also contributes positively to the firm's overall performance, so a blue

arrow is used again to represent it. However, on the other hand, barriers hinder GSCM practices' adoption, so a red arrow represents it.

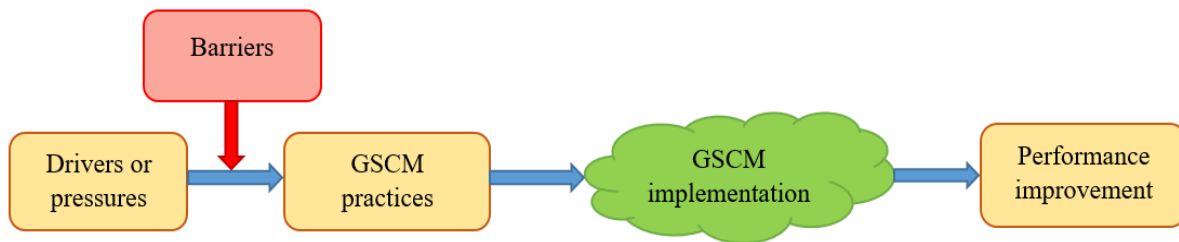


Figure 8. Proposed framework for GSCM implementation

6. Conclusion, limitations and future research directions

Due to increased environmental deterioration and unsustainable use of natural resources, governing agencies are exerting pressure on organisations to enhance their environmental performance. Furthermore, in response to market rivals and consumer awareness of environmental contamination, organisations are attempting to make their supply chains more eco-friendly. As the concept of GSCM is gaining traction in recent years, so this study proposed an updated comprehensive literature review on GSCM from 2011 to December 2021. In this context, the ISI Web of Science database was utilised as a reliable source for gathering papers concerning GSCM. The keywords “Green supply chain management” OR “GSCM” were searched on WoS to minimise redundant articles. The resulting 375 articles were mainly analysed for the metadata and content analyses. The metadata analysis mainly analysed the number of publications per year; most contributing authors, countries/regions and institutions; and most dominant journals, keywords, and subject areas. Later, the top fifty highly cited publications were selected from 375 identified articles for in-depth content analysis. The selected papers were classified into four main categories to define the four research domains related to GSCM literature. The four categories include (1) GSCM practices and performances; (2) Mathematical techniques; (3) Drivers and barriers of GSCM; (4) General articles related to GSCM. The final framework for GSCM implementation is proposed in detail based on these four categories. The main findings of this paper are mentioned below:

- China, the United States, and India account for around 60% of all GSCM-related articles. This demonstrates their concern about environmental contamination, as these countries consume a greater proportion of fossil fuels which adds a significant proportion of hazardous gases to the environment.
- All the articles regarding GSCM from the University of Southern Denmark are written by the sole author Govindan K.
- Theoretical papers, including literature reviews, bibliometric/metadata analysis, survey articles and theory-building articles, account for around 45% of the GSCM literature.
- Usage of mathematical techniques especially MCDM methods is more popular among research scholars to effectively deal with real-life problems. However, to validate the case study the usage of simulation and modelling has gained less attention.
- Most GSCM-related research is concentrated on the manufacturing sectors, whereas research scholars have paid little attention to the service sectors.

6.1. Limitations and future research directions

Although this research offers a comprehensive literature review on GSCM from 2011 to 2021, it still has some limitations. For example, this study only considered the Web of Science database for data collection. Since the Web of Science database doesn't include all the journals, so there might be a chance that many potential research articles have been omitted during the articles search. As a result, future research may search papers from numerous databases to evaluate the literature more in-depth. Second, since the notion of GSCM acquired prominence among research experts after 2000, this study only considers publications published between 2011 and 2021, resulting in the exclusion of prior studies. Third, the scope of this research is confined to metadata and content analyses of the GSCM literature. Future studies can further provide bibliographic coupling analysis and cooperation network analysis of authors, institutions, and countries/regions using various tools to provide more in-depth information to the readers.

The concept of GSCM is gaining popularity in the manufacturing sectors because of carbon emissions produced during product manufacturing. According to our literature review, most publications solely evaluated the manufacturing sectors for GSCM implementation, with the automobile sector receiving special attention. However, research scholars have paid less attention to the service industry. The service sectors are under less pressure from stakeholders and governing agencies than the manufacturing sectors. However, if the service sectors implement the idea of GSCM, it will provide consumers with a favourable image, which would immediately lead to customer loyalty. Future research studies may look at how the

deployment of the GSCM can enhance the performance of service sectors (i.e., banks, supermarkets, tourism etc.). Many authors studied the effect of GSCM practices adoption on the firm's economic, environmental and operational performances. However, consideration of social factors is still inadequate as stakeholders of any organisation may be more interested in environmental and social factors. As a result, future research can look at the impact of a firm's GSCM adoption on social performance. Future research may look at how GSCM deployment can increase the well-being of workers and local communities. Furthermore, numerous studies used survey questionnaires or interviews to obtain data. However, data gathered via surveys or interviews do not provide an accurate picture of any organisation. So, future studies can provide more interesting facts regarding GSCM implementation by using the actual data. Likewise, most articles provide insights into GSCM implementation in emerging economies like China, India, etc. However, GSCM practices implementation in underdeveloped countries has not been given much attention. So, future studies can consider the GSCM implementation in underdeveloped countries as the GSCM implementation in underdeveloped countries might be challenging due to different governmental rules and regulations, limited capital, scarcity of resources, and inadequate infrastructures.

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