Green Supply Chain Integration: A Bibliometric Analysis

Shallone Munongo[1,*], David Pooe[2]

[1]Department of Business Management, University of Johannesburg, Johannesburg, South Africa, Orcid: 0000-0003-3114-1810

[2]Department of Business Management, University of Johannesburg, Johannesburg, South Africa, Orcid: 0000-0003-3232-7203

Keywords

Green supply chain

Integration

Bibliometric

Bibliometrix

Abstract

Production inputs and other resources utilised in organisational operations have significant environmental effects. Green supply chain integration (GSCI) has attracted enormous interest from both academics and practitioners lately, mainly because of its essential role in promoting sustainability. Studies on GSCI are largely of the view that there are significant gains to be realised from it. This study analysed the current research progress and frontier dynamics on GSCI. It utilised the Web of Science citation database to search and filter relevant documents. A total of 969 articles were obtained from 1999-2023. Thereafter, a bibliometric analysis method using Bibliometrix was employed to study the literature characteristics and research hotspots. The study found that GSCI is a contemporary study area; published literature GSCI is exponentially increasing, peaking in 2022; the Journal of Cleaner Production is the most relevant source; Harbin Institute of Technology, University of Derby, and others have a strong influence on GSCI research, the USA is the most cited country, and, China is the most active country in terms of collaborations with other countries, having the highest article collaborations with the United Kingdom.

*Corresponding Author

[1*]munongoshallone@gmail.com

[2]dpooe@uj.ac.za

1. Introduction

Organisations across the globe are currently grappling with a variety of issues related to environmental changes including global warming, energy use, and the depletion of natural resources (Wangsa et al., 2022; Zhang et al., 2022; Khan et al., 2022e). On the other hand, the pursuit of economic performance, which favours financial growth at the cost of the environment, has become a barrier for organisational survival and growth (Bildirici & Gökmenolu, 2017; Khan et al., 2022d). Also, offering eco-friendly goods and services has since evolved into a crucial strategy for organisations to gain a competitive edge amid the tightening of government environmental regulations and the increasing awareness of environmental protection among consumers (Khan et al., 2021b; 2022c). Furthermore, the intensified global competition and technological complexity, has overtime shifted market competition from individual firms to supply chains (Yeh et al., 2020). It is now difficult for organisations to react to the turbulent external environment by relying solely on organisational resources, as this often leads to a series of difficulties and risks (Huang & Li, 2017). Consequently, seeking a sustainable development path to balance the contradiction between economic growth and ecological environment development has become a top organisational priority.

There is therefore an increased need to break through organisational boundaries and actively seek cooperation with all supply chain partners to access complementary resources and foster green supply chain integration (Birasnav & Bienstock, 2019; Khan et al., 2022d). In fact, Laari et al. (2016) opine that production inputs and other resources utilised in an organisation's operations have significant environmental effects which cannot be borne within the boundaries of a single firm; rather, it is crucial that all supply chain stakeholders be environmentally conscious. Accordingly, scholars submit an urgent call for green supply chain integration (GSCI) (Mondal & Giri, 2022; Khan et al., 2021a). GSCI is the extent to which companies and supply chain partners can improve resource utilisation and achieve environmental goals through environmental cooperation and collaborative management of intra- and inter-organisational processes (Du et al., 2018).

1.1 Background

Studies have submitted empirical evidence for the effects of GSCI, with many of the view that there is a "upbeat side" to it. For instance, Kong et al. (2021) conclude that GSCI can support organisational internal and external communication and cooperation, which in turn enhances a firms' financial performance. Furthermore, Straka, Oláh, and Kassakorn (2021) and Al-Sheyadi et al. (2019) highlight that GSCI has a favourable and substantial impact on both organisational technological performance and financial outcomes. Furthermore, incorporating green supply chain activities into organisational operations is increasingly important since it boosts firms' competitiveness. Also, because of GSCI, small and medium enterprises (SMEs) now have the chance to conduct business globally while increasing their awareness of,

and responsiveness to environmental challenges. In addition, Ji et al. (2020) and Zhang et al. (2022) establish that GSCI assists organisations to acquire cutting-edge green technologies from their suppliers, which in turn aids in becoming more environmentally conscious and improve their environmental performance. Moreover, as an essential strategy for SMEs, GSCI not only helps to enhance trust among supply chain members and promotes the interaction and flow of information and knowledge resources; it also helps to integrate multiple and scattered advantageous resources in the supply chain, thus compensating for the lack of corporate resources (Yang et al., 2020). Additional studies indicate that GSCI improves supply chain agility, which in turn enables organisations to quickly and effectively respond to turbulent market changes and perform better in terms of green innovation by allocating or coordinating organisational resource to avoid the adverse effects of supply chain disruptions (Dubey et al., 2018; Zhang et al., 2022; Khan et al., 2022a; Khan & Ponce, 2022). Interestingly, however, scholars also point out the adverse side to GSCI. For instance, Shi et al. (2022) submit that green customer integration, a component of GSCI is typically thought of as a firm-customer-specific investment, which oftentimes results in high switching costs, boost partners' opportunistic behaviour, and pose substantial organisational risks.

1.2 Problem Statement

Research on the GSCI theme has attracted the attention of academics and practitioners recently (Zhang et al., 2022; Khan et al., 2022a; 2022d; Ji et al., 2020). However, despite the benefits associated with GSCI, there still remains a lack of understanding among various stakeholders in supply chain. Also, while a growing number of studies have investigated activities related to GSCI, it appears that they stem predominantly from developed countries. This indicates a disconcerting gap in the body of knowledge, and consequently warrants a holistic view of current knowledge development on GSCI has the potential to improve supply chain sustainability in developing economies which oftentimes are worst hit by supply chain disruptions.

1.3 Research Objectives

The study analyses the current research progress and frontier dynamics on green supply chain integration. More specifically, it builds on both prior literature review and bibliometric papers on GSCI and seeks to answer the following research questions:

1. What is the current level of research on GSCI?
2. What are the most relevant sources of research on GSCI?
3. Who are the most relevant authors on GSCI?
4. Which are the most relevant documents, institutions and countries on GSCI?
5. What are the potential research avenues on GSCI?

The rest of the is structured as follows: Section 2 presents the literature review while the research methodology is outlined in Section 3. Section 4 discusses the results and findings. The implications, conclusions, limitations and future research are presented in Sections 5 and 6 respectively.

2. Literature Review

2.1 Green supply chain integration

Integration of supply chain management involves the seamless exchange of information and communication between the stakeholders throughout the supply chain. As public awareness of the environment increases, emerges GSCI; the extent to which manufacturing organisations and their supply chain partners can improve resource utilisation and attain environmental targets through environmental cooperation and the collaborative management of intra- and inter-organisational processes (Zhang et al., 2022; Du et al., 2018). Similar to supply chain integration, GSCI can be divided into two; green internal integration and green external integration (Straka, Oláh, and Kassakorn, 2021; Lo et al., 2018).

2.2 Green internal integration

In supply chain management, internal integration "involves the coordination and integration logistics within the organisation that culminates with the provision of the end products to the customers" (Straka, Oláh, and Kassakorn, 2021:4). From another perspective, Flynn et al. (2010) view it as integrated activities such as joint planning, information sharing and cross-functional teams in which all functions work together. Therefore, green internal integration translates to organisations removing cross-functional barriers and allowing various departments to collaborate environmentally in strategy, decision-making, and operations to respond promptly to potential environmental issues, which enables respective departments to understand and effectively utilise organisational resources and capabilities (Shah & Soomro, 2021). Studies indicate that green internal integration aids organisations to plan effectively and reduce frictions and challenges in communication and cooperation, which ultimately assists in the flow of explicit and implicit knowledge among members within an organisation and how their swift response to dynamic market shifts (Khanuja & Jain, 2021; Zhang et al., 2022). Also, Shah and Soomro (2021) suggest that the collective environmental awareness fostered by green internal integration increases the organisational commitment and emotional attachment among employees. The study further notes that such a sense of identity in turn, enhances communication efficiency among cross-functional members, bringing improved and quicker decision-making and problem-solving by sharing information about corporate operations in real-time (Liu et al., 2018; Ramos et al., 2021).

Other scholars find that the integration of environmental issues in the internal organisational processes positively a significant positive effect on performance. For example, Song et al. (2017) report that green internal integration encourages sustainable product innovation among SMEs, improves their competitive advantage, offers them an opportunity follow in real-time the demand trends in the market and maintain closely-connected and profitable logistics networks among the supply chain partners. In support, Du et al. (2018) and Straka et al. (2021) establish that internal information sharing and logistics networks result in a significant positive impact on overall business performance since it empowers decision-makers, increases their awareness of the available resources that could be leveraged to evade wastages and protect the environment.

2.3 Green external integration

Green external integration comprises two components; green supplier and green customer integration (Guo et al., 2022). According to Straka, Oláh, and Kassakorn (2021:3), supplier integration "involves partnering an organisation with suppliers in the sharing of information and knowledge aimed at improving business performance". In an effort to increase their competitiveness, cut costs, and boost productivity, suppliers often participate in activities conventionally undertaken by retailers. Green supplier integration therefore requires that organisations and suppliers understand each other's environmental obligations and participate in pollutant emission reduction at the source, by jointly setting environmental goals and sharing environmental strategies (Ji et al., 2020). On the other hand, customer integration refers to the "close collaboration and information sharing activities with key customers that provide the firm with strategic insights into market expectations and opportunities, ultimately enabling a more efficient and effective response to customer needs" (Schoenherr & Swink, 2012:100). Consequently, green customer integration enhances the firms' understanding of the green needs of their target markets, enabling them to attain the similar environmental goals, for both supply and demand, through joint planning (Zhang et al., 2020).

A study by Guo et al. (2022) indicates that green external integration creates an aura of mutual trust between organisations, which then allows them to share risks and benefits with supply chain partners, thus building a long-term and stable cooperation network between them. This stable partnership effectively enhances mutual trust and dependence, reduces the risk of resource spill-over and speculation, and alleviates the tendency of opportunistic behaviour by supply chain members. This in turn facilitates the interaction and flow of information and knowledge within the supply chain (Zhao et al., 2021; Parenete et al., 2022), and further improves supply chain agility (Donbesuur et al., 2021). Moreover, compared to general knowledge sources, the external knowledge acquired through green external integration has higher synchronisation and validity, which will help improve the efficiency of organisational use of external knowledge (Wei et al.,

2020). Wong et al. (2020), Ji et al. (2020), and Kong et al. (2021) establish that green supplier and customer integration allow organisations, suppliers and customers to have a deeper understanding of each other's operating models, mutual needs, improve the communication efficiency, and facilitate high-quality information-sharing in all aspects of production planning, inventory levels, and demand forecasting, which assist companies in developing robust supply chain disruption response strategies.

Also, Ramos et al. (2021) and Mao et al. (2017) find that through green external integration, organisations are able to timeously acquire important market information on competitor development, environmental demands and policies, all which aid organisations to effectively understand the overall market trends and take prompt response measures. Interestingly, the concept of green external integration also impacts on innovation among SMEs. Setyadi (2019) observes that supplier involvement helps in the integration of novel SME product development, which involves business frameworks that help them to achieve their innovation goals. The study further notes that oftentimes, SMEs that apply the green supplier integration model obtain assistance from suppliers towards the attainment of their innovation goals, and in turn, product innovation leads to improved business performance.

3. Research Methodology

As the objective is to assess the current research progress and frontier dynamics on green supply chain integration, the study opted for a bibliometric approach, which is the "statistical analyses of books, articles, or other publications" (University of Illinois at Chicago, 2023). The approach was selected for its reliability to rigorously explore, analyse and make sense of large volumes of unstructured data, its flexibility for use across various disciplines, succinctness in deciphering and mapping the cumulative scientific knowledge and evolutionary nuances of well-established fields, identifying knowledge gaps, positioning intended contributions to a particular field, uncover emerging trends in article and journal performance, collaboration patterns, and research constituents, and to explore the intellectual structure of a specific domain in the extant literature (Donthu et al., 2021a; 2022; Verma & Gustafsson, 2020).

Bibliometrix, an R-tool for comprehensive science mapping analysis developed by Aria and Cuccurullo (2017) was used to produce the bibliographic output map in assessing green supply chain integration. The bibliometric software was also utilised owing to its flexibility across disciplines and capability in handling large datasets with ease. Our bibliometric analysis followed the lead of other closely related studies (Fosso-Wamba, 2020; Vila-Lopez & Küster-Boluda, 2021; Nagariya, Kumar & Kumar, 2021; Fang, Fang, Hu & Wan, 2022).

3.1 Data Sources

The bibliometric study employed data from the Web of Science (WoS) database. The Web of Science is a prominent global database with a robust research engine that can track data across "disciplines and time from over 1.7 billion cited references from over 159 million records" (Web of Science 2020:1). The bibliometric analysis approach used can be summarised in three sections. The initial stage was to establish the search query. The study identified search terms that explored the GSCI domain thoroughly and precisely. To avoid incorrect results, search strings were applied to the entire article record, including titles, abstracts, keywords, and cited references. On the 27th of June 2023, a search within the WoS database using the following keywords: “green” and “supply chain integration”.

The search yielded 969 relevant publications from 1999 to 2023, which were chosen for further analysis. Second, the identified publications were retrieved from WoS and uploaded into Bibliometrix, a bibliometric tool. Bibliometrix is an R-tool that does in-depth science mapping analysis (Aria and Cuccurullo 2017). The study used the "shiny" interface for Bibliometrix called "Biblioshiny" which performs data mining and visualization, cross relationship mapping, cluster maps describing collaborative relationships between countries, research areas, affiliates, trends of research areas, journals, author keywords, and authors in GSCI research more intuitively. Third was data visualisation, which showed the results in tables, graphs, and map formats.

4. Results and Findings

The sections below present and discuss the key findings from the bibliometric analysis.

4.1 Main documents in WoS

Table 1 displays the main information about the dataset extracted from WoS containing papers dealing with GSCI. The table shows expanse information; for instance, the 969 publications spanned from 1999 to 2023 with an annual growth rate of 21.77%, from 318 sources and 2650 authors across the globe. Also, 854 (88.13%) of the identified publications are articles (798 articles, 1 book chapter article and 55 early access articles).

Table 1: Main information about documents published in WoS

Description	Results
MAIN INFORMATION ABOUT DATA	
Timespan	1999-2023
Sources (Journals, Books, etc.)	318
Documents	969
Annual Growth Rate %	21.77
Document Average Age	4.22
Average citations per doc	44.61
References	47459
DOCUMENT CONTENTS	
Keywords Plus (ID)	1704
Author's Keywords (DE)	2669
AUTHORS	
Authors	2650
Authors of single-authored docs	68
AUTHORS COLLABORATION	
Single-authored docs	71
Co-Authors per Doc	3.47
International co-authorships %	38.7
DOCUMENT TYPES	
Article	798
Article; book chapter	1
Article; early access	55
Article; proceedings paper	15
Correction	4
Editorial material	1
Meeting abstract	1
Reprint	1
Review	90
Review; early access	3

Source: Bibliometrix output

4.2 Annual scientific production

The annual scientific output of GSCI publications is shown in Figure 1. From 1999 to 2013, there was a definite upward trend in the number of published research articles. The first paper in the WoS database was published in 1999, and after that, just one paper was released in 2000, and with no research output for the period 2001-2002. The first increase in GSCI papers began in 2010 (13 publications), and the upward trend continued with a peak of 156 articles in 2022 and a decrease to 113 publications in 2023. However, because this is a mid-year census, the 2023 total is subject to change.

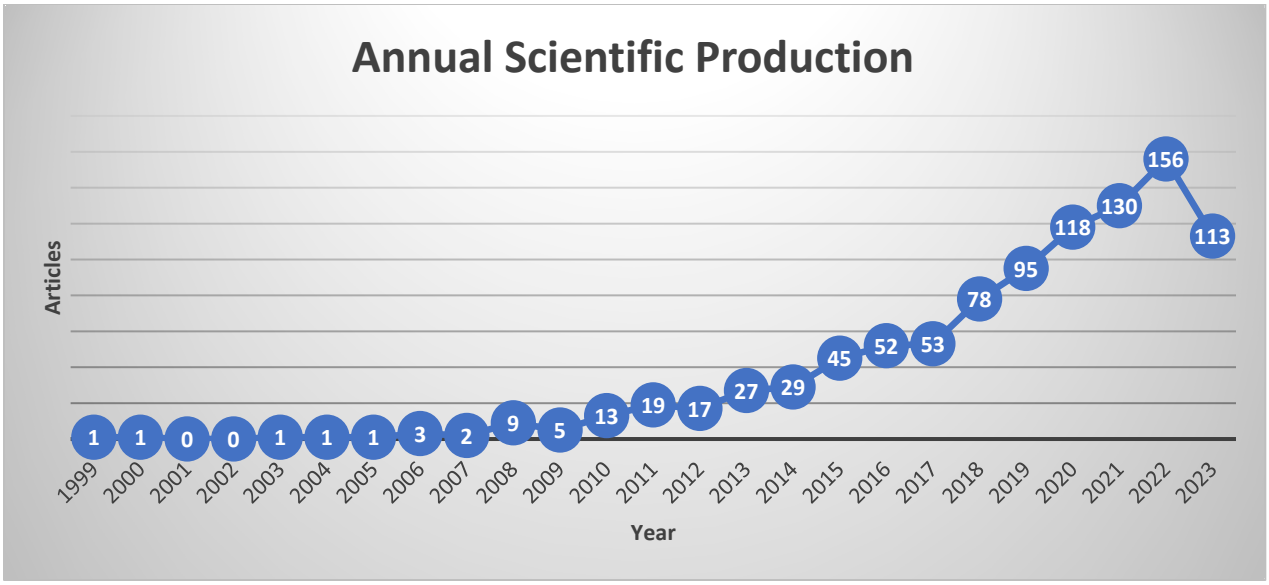

Figure 1: Annual scientific production
Source: Authors' own construction from Bibliometric data

4.3 Most relevant sources

Figure 2 depicts the distribution of the top ten most relevant sources of GSCI in the WoS database. The Journal of Cleaner Production leads with 107 publications, as expected given its primary focus on environmental and sustainability issues. Sustainability comes in second with 83 documents, followed by the International Journal of Production Economics (39), Supply Chain Management - An International Journal (22), Business Strategy and the Environment (21), Process Integration and Optimization for Sustainability (19), while Management of Environmental Quality ranks ninth with 15 publications.

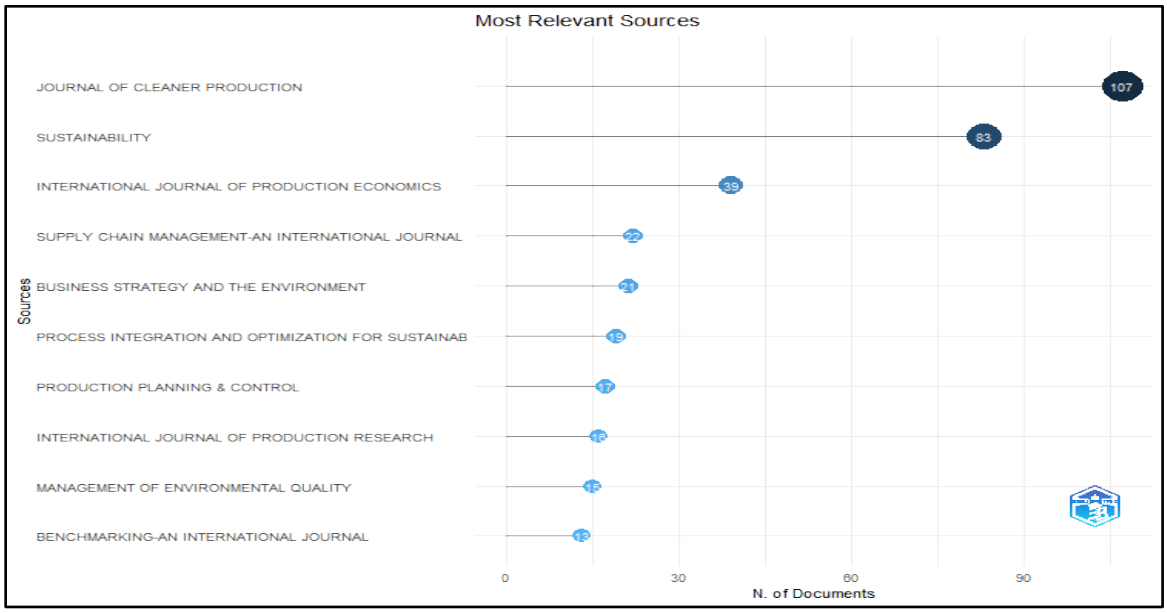

Figure 2: Annual scientific production
Source: Bibliometrix output

4.4 Source growth dynamics

The source growth on GSCI published in the WoS database is shown in Table 2. The Journal of Cleaner Production, Sustainability, the International Journal of Production Economics, Supply Chain Management - An International Perspective, and Business Strategy and the Environment were identified as the 5 journals with the most significant increase. As of June 27, 2023, these journals had published 272 (32%) of the total 854 articles (article, book chapter, and early access). The Journal of Cleaner Production had 107 publications (39%), followed by Sustainability, the International Journal of Production Economics with 83 articles (31%), the International Journal of Production had 39 documents (14%), Supply Chain Management – An International Perspective and Business Strategy and the Environment with 22 and 21 articles (8%) respectively.

Table 2: Journal source growth dynamics

Year	Journal of Cleaner Production	Sustainability	International Journal of Production Economics	Supply Chain Management- International Journal	Business Strategy and the Environment	Annual Cumulative Total
1999	0	0	0	0	0	
2000	0	0	0	0	0	
2001	0	0	0	0	0	
2002	0	0	0	0	0	
2003	1	0	0	0	0	
2004	1	0	0	0	0	
2005	1	0	0	0	0	
2006	1	0	0	0	0	
2007	1	0	0	0	0	
2008	3	0	1	1	0	
2009	3	0	1	2	0	
2010	4	0	2	2	0	
2011	4	0	3	2	2	
2012	5	0	3	4	3	
2013	9	0	6	6	3	
2014	14	0	10	7	3	
2015	17	0	13	9	4	
2016	27	1	15	10	5	
2017	35	4	19	10	6	
2018	48	13	23	11	7	
2019	67	28	25	13	7	
2020	84	47	30	16	9	
2021	94	58	34	17	12	
2022	105	73	37	20	16	
2023	107	83	39	22	21	272
%	39.3	30.5	14.3	8.1	7.7	100

Source: Bibliometrix output

4.5 Relevant authors

The top 20 authors based on the number of articles published in the WoS database are listed in Table 3. The list indicates that the top 3 authors published 11 or more articles each, while from the 7th to the 20th position, the respective author output was less than 10 articles. The table of the relevant authors shows that Feng is 1st with 25 published articles, followed by Garza-Reyes with 17 articles, while Lam and Sarkis are jointly in the 3rd position with 11 articles. The 5th, 7th and 9th positions had two authors each, with 10, 9 and 7 publications respectively. Furthermore, nine authors were jointly in 11th position with 6 articles each, while Belhadi was 20th with 5 articles.

Table 3: Top 20 relevant authors

Rank	Authors	Articles
1	Feng, T. W.	25
2	Garza-Reyes, J. A.	17
3	Lam, H. L.	11
3	Sarkis, J.	11
5	Cherrafi, A.	10
5	Green, K. W.	10
7	Govindan, K.	9
7	Kumar, A.	9
9	Huo, B. F.	7
9	Inman, R. A.	7
11	Afum, E.	6
11	Agyabeng-Mensah, Y.	6
11	Elfezazi, S.	6
11	Foo, D. C. Y.	6
11	Hartley, J. L.	6
11	Hong, P.	6
11	Kumar, V.	6
11	Lim, C. H.	6
11	Zailani, S.	6
20	Belhadi, A.	5

Source: Own compilation.

4.6 Most globally cited documents

Table 4 illustrates the distribution of the top 10 most globally cited articles in the WoS database. It shows that in the lead was a study by Seuring (2008) with 3109 citations, followed by Saberi (2019) with 1111 citations, while Vachon (2008) was in third position with 981 citations.

Table 4: Most globally cited documents

Rank	Author	Title	Source	Number of Citations
1	Seuring (2008)	From a literature review to a conceptual framework for sustainable supply chain management.	Journal of Cleaner Production	3109
2	Saberi (2019)	Blockchain technology and its relationships to sustainable supply chain management.	International Journal of Production Research	1111
3	Vachon (2008)	Environmental management and manufacturing performance: The role of collaboration in the supply chain.	International Journal of Production Economics	981
4	Vachon (2006)	Extending green practices across the supply chain: The impact of upstream and downstream integration.	International Journal of Operations and Production Management	825
5	Sarkis (2003)	A strategic decision framework for green supply chain management.	Journal of Cleaner Production	774
6	Klewitz (2014)	Sustainability-oriented innovation of SMEs: a systematic review.	Journal of Cleaner Production	650
7	Genovese (2017)	Sustainable supply chain management and the transition towards a circular economy: Evidence and some applications.	OMEGA-International Journal of Management Sciences	620
8	Chiou (2011)	The influence of greening the suppliers and green innovation on environmental performance and competitive advantage in Taiwan.	Transportation Research, Part E: Logistics and Transportation Review	602
9	Yang (2011)	Impact of lean manufacturing and environmental management on business performance: An empirical study of manufacturing firms.	International Journal of Production Economics	566
10	Dekker (2012)	Operations Research for green logistics – An overview of aspects, issues, contributions and challenges.	European Journal of Operational Research	513

Source: Own compilation

4.7 Relevant affiliations

The top ten institutions in the field of GSCI are displayed in Table 5. Harbin Institute of Technology leads with 25 articles, followed by the University of Derby (17 articles), while the University System of Ohio and White Rose University Consortium are jointly in third position with 15 articles each. It can be noticed that from the list of the ten most relevant affiliations on GSCI, as it appears in the WoS database, only three institutions are from Asian developing countries (Indian Institute of Technology System, Islamic Azad University and Universiti Teknologi Malaysia).

Table 5: Most relevant affiliations

Rank	Affiliation	Articles
1	Harbin Institute of Technology (China)	25
2	University of Derby (UK)	17
3	University System of Ohio (USA)	15
3	White Rose University Consortium (UK)	15
5	N8 Research Partnership (UK)	14
6	Indian Institute of Technology System (IIT System) (India)	13
7	Bowling Green State University (USA)	12
8	Islamic Azad University (Iran)	11
8	N8 Research Partnership (UK)	11
8	Universiti Teknologi Malaysia (Malaysia)	11

Source: Bibliometrix output

4.8 Most cited country and scientific production

For the top 10 most cited countries, Table 6 shows that the United States of America (USA) has the highest total citations count (7785), followed by China with 7140 total citations, and Germany in third place with 5227. The remaining countries on the list have a total citation count of less than 5000, ranging between 4639 and 1010.

Table 6: Most cited country

Rank	Country	Total Citations
1	USA	7785
2	China	7140
3	Germany	5227
4	United Kingdom	4639
5	Canada	2206
6	India	2002
7	Denmark	1663
8	Brazil	1255
9	Netherlands	1063
10	Spain	1010

Source: Bibliometrix output.

In addition, a bibliometric coupling was performed to determine the top 10 of country scientific production on GSCI published in the WoS database. It can be seen from Table 7 that most productive country was China with 589 documents, followed by the USA and India with 239 and 191 documents respectively. The United Kingdom (UK) was ranked fourth with 165 documents, while Malaysia came fifth with 104 documents. Each of the bottom five countries on the list had less than 100 relevant publications: Australia (99), Japan (92), Canada (76), Turkey (74), and The Netherlands (67)

Table 7: Country scientific production

Rank	Country	Frequency
1	China	589
2	USA	239
3	India	191
4	UK	165
5	Malaysia	104
6	Brazil	92
7	Iran	86
8	Germany	71
9	Italy	57
10	Pakistan	56

Source: Bibliometrix output.

4.9 Most frequent words and Wordcloud

The most frequent words and wordcloud related GSCI from the WoS database search are displayed in Table 8 and Figure 3. “Integration” emerged with the highest number of occurrences (321) among the most frequent keywords used by authors in their publications. This clearly indicates the significance of integration in the framework of GSCI. The second most frequent word is “impact”, with 275 occurrences, followed by “performance” with 256 occurrences, “green” with 209 occurrences, and ‘management” with 183 occurrences. Hence, the top five most frequent words reveal the emerging research niches within the GSCI domain. Surprisingly, “supply chain” is ranked 15th, with 77 occurrences from the reviewed publications.

Table 8: Most frequent words

Rank	Words	Occurrences
1	Integration	321
2	Impact	275
3	Performance	256
4	Green	209
5	Management	183
6	Model	155
7	Framework	130

8	Supply chain management	129
9	Sustainability	123
10	Design	98
11	Implementation	96
12	Innovation	92
13	Environmental-management	89
14	Firm performance	86
15	Supply chain	77
16	Strategy	67
17	Competitive advantage	63
18	Resource-based view	62
19	Industry	60
20	Strategies	60

Source: Bibliometrix output

Figure 3: Wordcloud related to HSC
Source: Bibliometrix output

4.10 Co-citation network

Consistent with Batistič and van der Laken (2019), co-citation network analysis which is considered a valuable measure, was undertaken to show the state of scholarly production on GSCI as well as the evolution of theories therein. Co-citation of two articles occurs when both are cited in a third (Batistič &

van der Laken, 2019; Aria & Cuccurullo, 2017). The co-citation analysis led to two clusters and is depicted in the network diagram in Figure 4 and in Table 9. Zhu (2004) emerged as the most influential author, with a between centrality reading of 30.92352761.

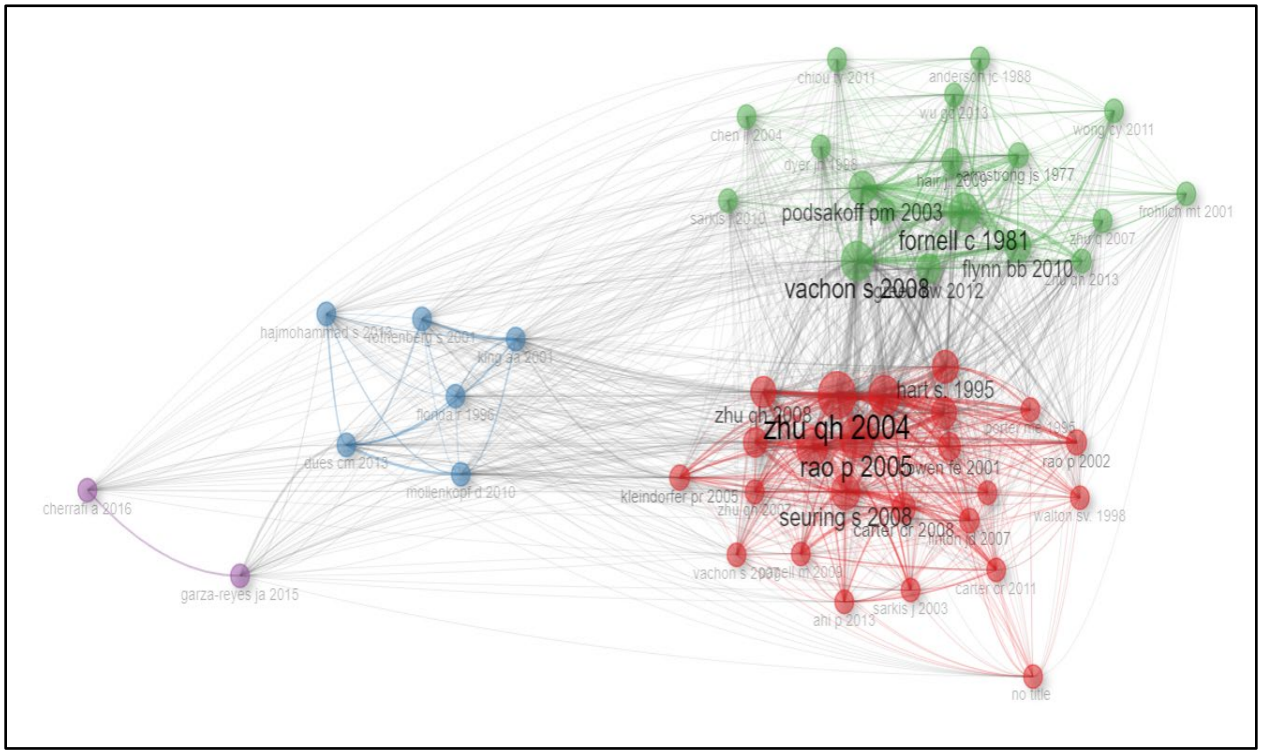

Figure 4: Co-citation network
Source: Bibliometrix output

Table 9: Co-citation network parameters

Node	Cluster	Between Centrality
Zhu, Q. H., 2004	1	30.92352761
Srivastava, S. K., 2007	1	10.43477366
Seuring, S., 2008	1	8.258617389
Rao, P., 2005	1	19.1528716
Vachon, S., 2006	1	22.7183815
Hart, S., 1995	1	16.06001815
Carter, C. R., 2008	1	5.243354325
Zhu, Q. H., 2008	1	9.368666924
Sarkis, J., 2011	1	7.570522101
No Title	1	0.193687061
Zhu, Q. Q., 2005	1	10.48489069
Kleindorfer, P. R., 2005	1	5.691070861
Bowen, F. E., 2001	1	6.903743416
Linton, J. D., 2007	1	2.721608592
Ahi, P., 2013	1	1.56118182

Rao, P., 2002	1	6.302081323
Zhu, Q., H. 2007	1	4.623781057
Porter, M. E., 1995	1	4.979568816
Sarkis, J., 2003	1	0.766921152
Hervani, A. A., 2005	1	1.079365923
Carter, C. R., 2011	1	1.693901935
Pagell, M., 2009	1	3.216509173
Vachon, S., 2007	1	1.978313561
Walton, S. V., 1998	1	1.96613126
Mollenkopf, D., 2010	2	19.79098916
Dues, C. M., 2013	2	9.440946676
King, A. A., 2001	2	17.71189261
Florida, R.,1996	2	13.07180052

Source: Bibliometrix output

4.11 Country collaborations

Figure 5 and Table 10 show the collaborated research map among the GSCI authors across countries. The collaboration map identified China as the most active country as it had the most collaborations with other research counterparts in various countries. China had the highest article collaborations with the UK (31), USA (28), Pakistan (20), Australia (11), and Malaysia (10). Furthermore, it was observed that while there were collaborations between developed and African countries on GSCI, these however were still very few; for instance, Finland-South Africa (3), Norway-South Africa (2), France-South Africa (1), Germany-South Africa (1), Ghana-Hungary (1). The same was observed for collaborative studies between developing countries, for instance, South Africa-Ghana (1), India-South Africa (4), and Iraq-Iran (1).

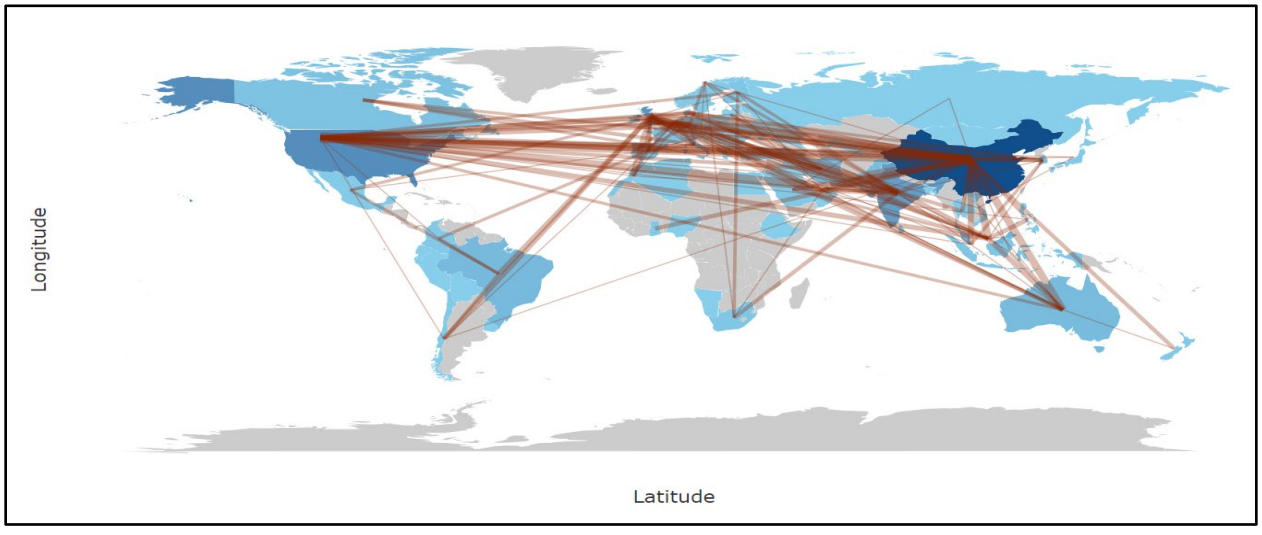

Figure 5: Research collaboration worldmap
Source: Bibliometrix output

Table 10: Country collaborations

From	Collaborative Country	Frequency
China	UK	31
	USA	28
	Pakistan	20
	Australia	11
	Malaysia	10
Australia	South Africa	1
Finland	South Africa	3
France	South Africa	1
Germany	South Africa	1
Hungary	Tunisia	1
Italy	South Africa	1
Iran	Iraq	1
South Africa	Ghana	1
	Hungary	1
	Japan	1
	Namibia	1
	Norway	2

Source: Bibliometrix output

5. Managerial Implications

The study offers important insights for policymakers, decision-makers, managers, scholars and practitioners involved in GSCI issues. A bibliometric analysis of literature identified the evolution of GSCI dynamics overtime. Regarding the contributions for practice, our investigation revealed that of the ten most relevant affiliations on supply chain integration, only three institutions are from developing countries (Indian Institute of Technology System, Islamic Azad University and Universiti Teknologi Malaysia). Moreover, none of these affiliations are from Africa and Latin America, indicating the immense need for more research from developing economies is fundamental for all relevant stakeholders to have an in-depth understanding of the particularities of GSCI in these regions.

While GSCI is a contemporary issue, our findings reveal that the highest article collaborations were only observed between developed economies like China and the UK, USA, and Australia. This result emphasizes the need for increased bilateral collaboration on GSCI, first between developed and developing nations, and also among the latter.

6. Conclusions, Limitations and Future Research

The main objective of this paper was to analyse the current research progress and frontier dynamics on green supply chain integration. To attain this, a bibliometric analysis of GSCI-related data extracted from the Web of Science (WoS) database was conducted. The main insights presented included the following: (1) the main information on the publications reviewed; (2) the global annual scientific production of research work; (3) the most relevant sources; (4) the growth dynamics; (5) most productive authors, globally cited documents; (6) the most relevant institutions, moist cited countries, their scientific production; (7) most frequent words, co-citation network; and country collaborations on green supply chain integration.

For instance, the study found that from the 969 most GSCI-related documents extracted from WoS, 854 (88.13%) were articles (798 articles, 1 book chapter article and 55 early access articles). Therefore, future research may consider expanding the nature and portfolio of documents on GSCI by including case studies. Furthermore, when compared to other fields, and based on the data collected from the WoS, GSCI is a fairly new domain, as the first paper published on the topic only dates back to 1999, as shown by the WoS database. However, the number of relevant documents published since then, peaking to 156 in 2022 in the WoS database is clear proof that the field is attracting researcher attention.

This study makes three specific contributions to theory and practice. Firstly, it adds to GSCI literature by evaluating the research undertaken to date. This is important because it identifies current gaps by taking a global perspective which helps to detect overlooked countries/regions. Secondly, it focused specifically on green or environmental aspects of supply chain integration, therefore providing a holistic view of a contemporary research niche. Thirdly, it supports supply chain researchers, practitioners and other relevant stakeholders with an enhanced understanding of GSCI which in the long run improves organisational green performance.

As the main limitation of this study, a particular string of key search words was used; “green” and “supply chain integration”. Consequently, the study cannot ensure that all published papers were covered. Therefore, forthcoming research could explore GSCI with the mediated effects, for instance, the fourth industrial revolution (4IR) technology. In the same line, the current study’s selection of the WoS as a database might have limited the search. Future studies could expand the scope of this study by collecting data from other renowned databases such as Scopus, Science Direct and Source Premier among others. Also, we employed a conventional bibliometric approach as the main method to analyse the literature, and forthcoming research can combine different types of literature review with bibliometric analysis.

Acknowledgments

No grants were received for this study.

REFERENCES

Al-Sheyadi A., Muyldermans, L., & Kauppi, K. (2019). The complementarity of green supply chain management practices and the impact on environmental performance. *Journal of Environmental Management*, 242: 186-198. https://doi.org/10.1016/j.jenvman.2019.04.078.

Aria, M., & Cuccurullo, C. (2017). Bibliometrix: An R-tool for comprehensive science mapping analysis. *Journal of Informetrics*, 11(4), 959-975, Elsevier.

Bildirici, M. E., & Gökmenoğlu, S. M. (2017). Environmental pollution, hydropower energy consumption and economic growth: Evidence from G7 countries. *Renewable and Sustainable Energy Reviews*, 75, 68–85. https://doi.org/10.1016/j.rser.2016.10.052.

Birasnav, M., & Bienstock, J. (2019). Supply chain integration, advanced manufacturing technology, and strategic leadership: An empirical study. *Computers and Industrial Engineering*, 130, 142–157. https://doi.org/10.1016/j.cie.2019.01.021.

Donbesuur, F., Zahoor, N., & Adomako, S. (2021). Postformation alliance capabilities and environmental innovation: The roles of environmental in-learning and relation-specific investments. *Business Strategy and the Environment,* 30 (7), 3330–3343. https://doi.org/10. 1002/bse.2805.

Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., & Gupta, P. (2021c). Forty years of the International Journal of Information Management: A bibliometric analysis. *International Journal of Information Management,* 57, 102307. ISSN 0268-4012. https://doi.org/10.1016/j.ijinfomgt.2020.102307

Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., & Lim, W. M. (2021a). How to conduct a bibliometric analysis: An overview and guidelines. *Journal of Business Research*, 133, 285-296. https://doi.org/10.1016/j.jbusres.2021.04.070.

Donthu, N., Kumar, S., Paul, J., Pattnaik, D., & Strong, C. (2022). A retrospective of the Journal of Strategic Marketing from 1993 to 2019 using bibliometric analysis. Journal of Strategic Marketing, 30(3), 239–259.

Du, L., Zhang, Z., & Feng, T. (2018). Linking green customer and supplier integration with green innovation performance: The role of internal integration. *Business Strategy and the Environment*, 27(8): 1583-1595.

Dubey, R., Altay, N., Gunasekaran, A., Blome, C., Papadopoulos, T., & Childe, S. J. (2018). Supply chain agility, adaptability and alignment Empirical evidence from the Indian auto components industry. International. Journal Operational Production Management 38 (1), 129–148.

https://doi:10.1108/ijopm-04-2016-0173.

Ebrahim, S., Niemann, W., & Kotzé, T., 2022, 'Sustainable supply chain integration: An exploration of South African fast-moving consumer goods manufacturers', South African Journal of Economic and Management Sciences 25(1), a4192. https://doi.org/10.4102/ sajems.v25i1.4192

Fosso Wamba, S. 2020. Humanitarian supply chain: a bibliometric analysis and future research directions. *Annals of Operations Research*, 1-27. https://doi.org/10.1007/s10479-020-03594-9.

Guo, X., Xia, W., Feng, T., & Sheng, H. (2022). Sustainable supply chain finance adoption and firm performance: Is green supply chain integration a missing link? Sustainable Development 1, 1135–1154. https://doi:10.1002/sd.2307.

Huang, J., & Li, Y. (2017). Green innovation and performance: The view of organizational capability and social reciprocity. *Journal of Business Ethics*, 145 (2), 309–324. https://doi.org/10.1007/s10551-015-2903-y.

Ji, L., Yuan, C., Feng, T., & Wang, C. (2020). Achieving the environmental profits of green supplier integration: The roles of supply chain resilience and knowledge combination. *Sustainable Development*, 28 (4), 978–989. https://doi.org/10.1002/sd.2050.

Khan, S. A. R., Godil, D. I., Jabbour, C. J. C., Shujaat, S., Razzaq, A., & Yu, Z. (2021a). Green data analytics, blockchain technology for sustainable development, and sustainable supply chain practices: evidence from small and medium enterprises. *Annals of Operations Research*, 1–25. https://doi:10.1007/s10479-021-04275-x.

Khan, S. A. R., Razzaq, A., Yu, Z., Shah, A., Sharif, A., & Janjua, L. (2022a). Disruption in food supply chain and undernourishment challenges: An empirical study in the context of Asian countries. *Socioeconomic Planning Sciences*, 82, 101033. https://doi.org/10. 1016/j.seps.2021.101033.

Khan, S. A. R., Yu, Z., & Sharif, A. (2021b). No silver bullet for de-carbonization: Preparing for tomorrow, today. *Resource Policy*, 71, 101942. https://doi:10. 1016/j.resourpol.2020.101942

Khan, S. A. R., Yu, Z., Umar, M., & Tanveer, M. (2022d). Green capabilities and green purchasing practices: A strategy striving towards sustainable operations. *Business Strategy and the Environment***,** 31 (4), 1719–1729. https://doi.org/10.1002/bse.2979.

Khan, S. A. R., Yu, Z., Umar, M., Jabbour, A., & Mor, R. S. (2022c). Tackling post-pandemic challenges with digital technologies: an empirical study. *Journal of Enterprise Information Management*, 35 (1), 36–57. https://doi.org/10.1108/JEIM-01-2021-0040.

Khan, S. A. R., Yu, Z., Umar, M., Zia-ul-haq, H. M., Tanveer, M., & Janjua, L. R. (2022e). Renewable energy and advanced logistical infrastructure: Carbon-free economic development. Sustainable Development, 30 (4), 693–702. https://doi.org/10.1002/sd.2266

Khanuja, A., & Jain, R. K. (2021). The mediating effect of supply chain flexibility on the relationship between supply chain integration and supply chain performance. Journal of Enterprise Information Management. https://doi:10.1108/jeim-11-2020-0449.

Kong, T., Feng, T., & Huo, B. (2021). Green supply chain integration and financial performance: A social contagion and information sharing perspective. Business Strategy and the Environment, 30 (5), 2255–2270. https://doi.org/10.1002/bse.2745.

Laari, S., Töyli, J., Solakivi, T. & Ojala, L. (2016). Firm performance and customer-driven green supply chain management. *Journal of Cleaner Production,* 112, 1960–1970. https://doi.org/10.1016/j.jclepro.2015.06.150

Laari, S., Töyli, J., Solakivi, T. & Ojala, L., 2016, 'Firm performance and customer-driven green supply chain management', Journal of Cleaner Production 112, 1960–1970. https://doi.org/10.1016/j.jclepro.2015.06.150

Lo, S., Zhang, S., Wang, Z., & Zhao, X. (2018). The impact of relationship quality and supplier development on green supply chain integration: A mediation and moderation analysis. Journal of Cleaner Production, 202, 524–535. https://doi:10.1016/j.jclepro.2018. 08.175.

Mao, Z., Zhang, S., & Li, X. (2017). Low carbon supply chain firm integration and firm performance in China. *Journal of Cleaner Production*, 153 (1), 354–361. https://doi:10.1016/j. jclepro.2016.07.081.

Mishra, M. K., Choudhury, D., & Rao, K.S.V.G. (2019). Impact of SMEs green supply chain practice adoption on SMEs firm and environmental performance. *Theoretical Economics Letters*, 9(6): 1901-1919.

Mondal, C., & Giri, B. C. (2022). Investigating strategies of a green closed-loop supply chain for substitutable products under government subsidy. *Journal of Industrial and Production Engineering*, 39 (4), 253–276. https://doi:10.1080/21681015.2021.1974962.

Nagariya, R., Kumar, D., & Kumar, I. (2021). Service supply chain: from bibliometric analysis to content analysis, current research trends and future research directions. *Benchmarking: An International Journal*, 28(1) 333–369.

Parente, R., Murray, J. Y., Zhao, Y., Kotabe, M., & Dias, R. (2022). Relational resources, tacit knowledge integration capability, and business performance. *Journal of Knowledge Management*, 26 (4), 805–823. https://doi:10.1108/JKM-07-2020-0501

Ramos, E., Patrucco, A. S., & Chavez, M. (2021). Dynamic capabilities in the "new normal": a study of organizational flexibility, integration and agility in the Peruvian coffee supply chain. *Supply Chain Management*. https://doi.org/10.1108/SCM-12-2020- 0620

Schoenherr, T. & Swink, M. (2012). Revisiting the arcs of integration: Cross-validations and extensions. *Journal of Operations Management*, 30(1–2), 99–115. https://doi. org/10.1016/j.jom.2011.09.001

Setyadi, A. (2019). Does green supply chain integration contribute towards sustainable performance? *Uncertain Supply Chain Management*, 7(2): 121-132.

Shah, N., & Soomro, B. A. (2021). Internal green integration and environmental performance: The predictive power of proactive environmental strategy, greening the supplier, and environmental collaboration with the supplier. *Business Strategy and the Environment*, 30 (2), 1333–1344. https://doi.org/10.1002/bse.2687.

Shah, N., & Soomro, B. A. (2021). Internal green integration and environmental performance: The predictive power of proactive environmental strategy, greening the supplier, and environmental collaboration with the supplier. Bus. Strategy Environ. 30 (2), 1333–1344. https://doi:10.1002/bse.2687

Shi, H., Feng, T., & Li, Z. (2022). Too much is not always good: the inverted U-shaped link between green customer integration and opportunistic behaviour. *Asia Pacific Journal of Marketing and Logistics*, 34 (5), 987–1009. https://doi.org/10.1108/apjml-01-2021-0062.

Song, Y., Cai, J., & Feng, T. (2017). The influence of green supply chain integration on firm performance: A contingency and configuration perspective. *Sustainability*, 9(5): 763.

Straka, M., Oláh, J., &. Kassakorn, N. (2021). Impact of Green Supply Chain Integration on SMEs Technological and Economic Performance. Global Journal of Entrepreneurship and Management, 2(1):12-30. https://doi.org/10.57585/GJEM.021.006

University of Illinois at Chicago. (2023). Bibliometrics - Bibliometric Analysis and Visualization - Subject and Course Guides at University of Illinois at Chicago (uic.edu). Retrieved from https://researchguides.uic.edu/bibliometrics/. [Accessed: 11 July 2023].

Verma, S., & Gustafsson, A. (2020). Investigating the emerging COVID-19 research trends in the field of business and management: A bibliometric analysis approach. Journal of Business Research, 118:253-261. https://doi.org/10.1016/j.jbusres.2020.06.057.

Vila-Lopez, N., & Küster-Boluda, I. (2021). A bibliometric analysis on packaging research: towards sustainable and healthy packages. *British Food Journal*, 123(2), 684–701.

Wangsa, I. D., Vanany1Ca, I., & Siswanto1, N. (2022). An optimization model for fresh-food electronic commerce supply chain with carbon emissions and food waste. Journal of Industrial and Production Engineering., 1–21. https://doi.org/10.1080/21681015.2022.2099473.

Wei, L., Zhu, R., & Yuan, C. (2020). Embracing green innovation via green supply chain learning: The moderating role of green technology turbulence. Sustainable Development, 28 (1), 155–168. https://doi.org/10.1002/sd.1979.

Wong, C. Y., Wong, C. W. Y., & Boon-itt, S. (2020). Effects of green supply chain integration and green innovation on environmental and cost performance. *International Journal of Production Research*, 58 (15), 4589–4609. https://doi.org/10.1080/00207543.2020.1756510.

Yang, Q., Geng, R., & Feng, T. (2020). Does the configuration of macro- and micro-institutional environments affect the effectiveness of green supply chain integration? Business Strategy and the Environment,29 (4), 1695–1713. https://doi.org/10.1002/bse.2462.

Yeh, T., Pai, F., & Wu, L. (2020). Relationship stability and supply chain performance for smes: From internal, supplier, and customer integration perspectives. *Mathematics*, 8 (11), 1902–1918. https://doi.org/10.3390/math8111902.

Zhang, B., Zhao, S., Fan, X., Wang, S., & Shao, D. (2022). Green supply chain integration, supply chain agility and green innovation performance: Evidence from Chinese manufacturing enterprises. Frontiers in Environmental Science, 10:1045414. https://doi.org/10.3389/fenvs.2022.1045414