RESEARCH ARTICLE

Green supply chain management/green finance: a bibliometric analysis of the last twenty years by using the Scopus database

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Abstract

Mostly, the product manufacturer and activities related to transportation have a greater influence on the supply chain and the environment. Hence, the green investment in water, biodiversity protection, waste treatment, resources, and climate change alleviation help in enhancing industrial production. Thus, for the enhancement of green growth, the industries must adopt green financing by making investments in ecology, climate change, and carbon reduction. Despite having the greatest growth in green supply chain management, still, the implementations of greening the product and processes have not been seen properly in many industries. A bibliometric analysis was conducted through VOS viewer version 1.6.7. of last twenty years (2001–2021). A total of 2385 articles were retrieved from the Scopus database. The results revealed that China, India, Iran, and Taiwan have a vast collection of articles and have very strong international collaborations. The most cited authors were Sarkis, J., Zhu, Q., and Khan, S.A.R. The results also suggest that green supply chain management research was related to the field of engineering, environmental science, energy sciences, social sciences, and business management. Some new areas are discovered like green innovation, green information technology, green productivity, corporate environmental responsibility, green investments, green credit, and green credit policy. As evidenced from our bibliographic database search, it is observed that integrated work on green supply chain management and green finance is limited, and this makes this research work to be novel. This study is beneficial for credit managers and policymakers.

Keywords Green supply chain management · Green finance · Green credit · Sustainability · Environmental performance

Introduction

Global warming is considered an essential challenge for any activity that is related to finance or economics. All the damages to the supply chain or firms' assets that are caused by climate change have become the main reasons for the transition and physical risks; the only way to treat these transition risks is to follow low carbon family (Stern 2013; Burke et al. 2015; Elie et al. 2021a). Literature shows that the fossil fuels higher ratio leads to a hazardous scenario. In this situation, this is best to cut down global warming by 2 °C by keeping the economy at low carbon. The low carbon reduction further brings up a new challenge that includes a reduction in carbon emissions by adopting sustainable renewable energies and greater energy preservation (Elie et al. 2021a).

Globally sustainability and climate change have gained vast attention; the leaders from all over the world discussed the Paris Agreement 2015 under the UNFCCC (United Nations Framework Convention on Climate Change) and realized the urgent need to mitigate the issue of greenhouse gas emissions. The member countries of the United Nations have agreed to work together; one of the biggest challenges the member country realized is to finance the actions that should be taken to mitigate climate change and sustainability. It has been observed that a significant amount is required for maintaining 2 °C temperature which is estimated at a $53 trillion investment in energy-related products by 2035 (Zhang et al. 2019). In 2010, 194 countries have established the GCF (Green Climate Fund) intending to financially support those countries that involve themselves in mitigating the greenhouse gas emissions, after that the term green finance

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appeared in most places in international firms (Zhang et al. 2019).

However, green finance and climate finance are mixed and both terms are taken as the same, the term green finance has still been defined ambiguously. Sometimes authors and scholars considered it very challenging to describe the concept clearly. The concept of green finance is related to the investments that give environmental benefits to society (Zhang et al. 2019). However, UNFCCC (United Nations Framework Convention on Climate Change) has described the term green finance as "all the financing from locals, public, private and financial intermediaries should be in support with mitigation of greenhouse gas emissions, and adaptation of all actions that address the problem of climate change." Sometimes the term green finance-related to coping with climate change and sometimes it is related to sustainability (Zhang et al. 2019).

The investments in environmentally friendly products and processes urge the manufacturer to adopt green finance practices. This increases the need to involve the manufacturer in green supply chain management. Despite having the enormous potential of a green supply chain, many firms and manufacturers still face so many difficulties to achieve their goals. Many small and medium enterprises are unable to promote green supply chain management. Now, industries are linking their supplier environmental performance to green supply chain management. Green supply chain management plays a crucial role, the environment has an impact at all stages of the product and supply chain, where green supply chain management can be taken as a new approach to accomplish an environmentally friendly atmosphere (Yang et al. 2021).

After the 1990s revolution in the supply chain, the companies have changed their framework for environmental performance; for the best results, most companies have included the sustainability goals in their vision, further they realized that it is also necessary to integrate the environmental management practices into all departments of the organizations (Maditati et al. 2018). Environmentally friendly is not related to driving the costs only but it is also related to creating value for businesses and advancing the financial performance of the organizations (Zhu and Sarkis 2004; Maditati et al. 2018). From this viewpoint, organizations are now moving toward the implications of green supply chain management (GSCM) in their strategic decisions which are validated by (Sarkis 2003).

On the other hand, green finance is the reason to stop those businesses that do not adhere to the rules of a friendly environment (Scarpellini et al. 2018; Yu et al. 2021a). Thus, it brings enormous attention to academicians (Bolderdijk et al. 2013; Yu et al. 2021a). Scientific pieces of evidence depict that green finance is surrounded by renewable energy (Guertler 2012), technological eco-innovations (Ghisetti

et al. 2017), hygienic production (Scarpellini et al. 2018), green transportation (Greene 2011), green constructions (Chan et al. 2018), use of land, prevention of pollution and control (Sun et al. 2019), waste and water management (Pan et al. 2015), sustainability and supply management (Fletcher et al. 2019), and adaptation of climate change (Winkler and Dubash 2016; Yu et al. 2021a). However, regardless of these many advances, still previous and existing studies are dispersed and fragmented in their research approach and prospect (Zhang et al. 2019; Yu et al. 2021a). Hence, this bibliometric study addresses the research calls made by academic actors to bring clarity to the green finance phenomenon in the context of green supply chain management, arguing that this topic, which is gaining attention, requires to be analyzed, organized, and synthetized. Previous studies show that the phenomenon lacks a clear understanding which is important to analyze as the concept has the potential to address the climate crisis and the well-being of humanity through the financing of public and private green investments (Chien et al. 2021; Wang et al. 2021; Zhou et al. 2021; Madaleno et al. 2022).

Thus, this gives the motivation of the study to explore the phenomenon, evolution of the concept, proper current understanding, and future research directions towards green finance in the vast sagacity. This study focuses mainly on green supply chain management and green finance concerning environmental performances. Previous studies used subjective approaches which could create prejudice against green supply chain management, that's why current authors feel to present this research with objective approaches as well. The principal research questions that the current study addresses are as follows;

RQ1: What are the main journals that contributed to green supply chain management?
RQ2: What is the trend in Publications on green supply chain management?
RQ3: Which countries and institutions are the top contributors?
RQ4: Which subject areas have been associated more with green supply chain management?
RQ5: Who are the most influential authors of green supply chain management?
RQ6: Is the green finance theme used more often with green supply chain management?
RQ7: Which key terms are used more frequently in green supply chain management?
RQ8: What is the best conceptual framework to understand the core theme of green finance/ green supply chain management?

Thus, the main objective of the paper is to analyze the extant literature on green supply chain management and

propose and develop an understanding of green finance/ green supply chain management along with its future direction. In this context, this study uses bibliometric analysis which is an effective method for an in-depth analysis of current research trends and understanding of the emerging new research extents. By analyzing bibliometric analysis, it becomes easy for the scholars to determine the existing research trends and development of a concept for future use by identifying the characteristics of the specific topic, authors, categories, publications, keywords, citation analysis, and references (Chen 2015; Elie et al. 2021b; Yu et al. 2021b).

The recent paper flinches with the succinct present literature review, to draw a picture of specific scholars' research. By analyzing the current trends, this research will lead us to the understanding of the concept, development of the conceptual issues, major important terms that are associated with green finance, emerging concepts that link with green finance, new dimensions, and new concepts that need to be given consideration, and further, it will also help us to generate future directions with full guidance. Therefore, the objectives of the paper were (i) to analyze patterns of journal distribution; (ii) to show the productive author's contribution to their academic associations and leading countries; (iii) to figure out common concepts and understandings; (iv) to identify the dominance of countries; (v) to identify the core areas that have been associated with green supply chain management; (vi) to figure out the theme of green finance with green supply chain management; (vii) to develop the conceptual framework to understand the concept of green finance/green supply chain management; (viii) and to provide prospective association and future research directions. This paper will be valuable to scholars, policymakers, investors, and individuals to understand the trends in green finance and make constructive contributions to future research.

The current paper is structured as Section 2 defines the methodology of the research and source of data, and Section 3 describes the key results or findings (relevant top 10 journal publication/distribution, top 15 authors, authors' country of origin, keyword analysis, citation analysis, research trends), and conceptual framework of the study whereas Section 4 discusses the conclusion, describes the Policy recommendations, implications, and future directions of the study.

Methods

Bibliometric studies are the mechanistic studies that help in understanding the research areas globally in a specific field. It is based on the existing literature that is on databases. This differentiates the bibliometric paper from a review paper which intends to discuss the challenges, current progress, and future directions of a topic.

Data source and search strategy

The data extraction was conducted between November 2nd and 7th 2021 by using the Scopus database. Previous research has shown that the Scopus database is the largest abstract and citation database for academic reputed research papers and is more appropriate for bibliometric analysis. Likewise, the Scopus database has been chosen for this research as it centers on research studies from cross-disciplinary fields, such as Life Sciences, Health Sciences, Physical Sciences, and Social Sciences. Hence, it provides a broader coverage of relevant papers (Bag et al. 2018; Gao et al. 2021). This study distinguishes itself from existing studies as it links green finance with green supply chain management by highlighting the critical role of green finance in achieving GSCM performance.

The principal concept that was in the search was related to "green," with "finance," credit, trade-credit, and supply chain. The publications that were involved were from the year 2001 till 2021. The search string that was used for the first search was TITLE-ABS-KEY (*"green credit"* OR *"green finance"* OR *"green trade-credit"* OR *"green supply chain"* OR *"green supply chain finance"*); this results in a total of 3545 articles. The second search was TITLE-ABS (*"green credit"* OR *"green finance"* OR *"green trade-credit"* OR *"green supply chain"* OR *"green supply chain finance"*). This results in 2606 articles. The current authors found that these search results have 52 articles that were not in English, and then the current authors applied English limits and found 2554 articles were relevant. After that in the fourth search, the current authors limit the search to publication years from 2001 to 2021 and found 2385 useful articles. The current study has excluded all review papers and included journal articles, book chapters, and conference papers.

The search result of the primary theme was analyzed based on the author, source, year, document type, country, subject area, and affiliation. The indicators of our bibliometric study used for grading were total citations, total publication, CiteScore, and h-index. We have used the theme to explore more about green finance uses. The major terms were (i) green credit; (ii) green supply chain; (iii) green supply chain finance; and (iv) green trade-credit. In addition to this, we have selected those articles that specifically related to sustainability, that's why we used (sustainable*). For this, we have restricted our themes and sub-themes to the environment, energy science, economics, earth, sociology, engineering, and businesses. The overall process for all the inclusion and exclusion criteria is summarized in Fig. 1.
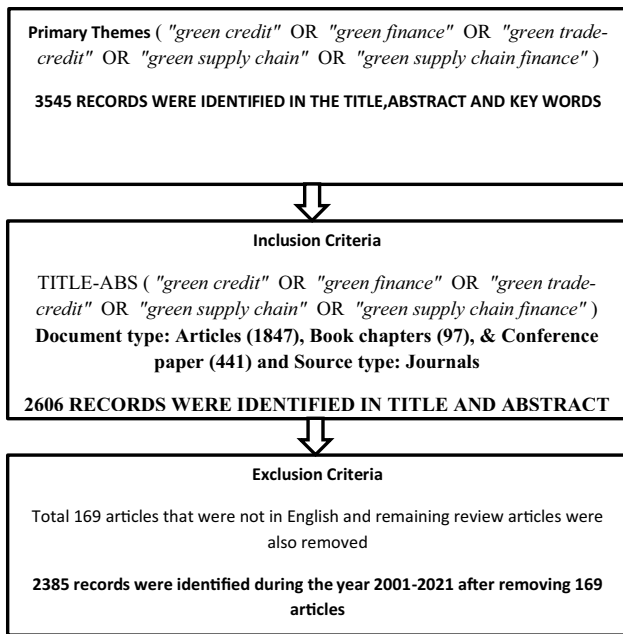
Primary Themes (*"green credit"* OR *"green finance"* OR *"green trade-credit"* OR *"green supply chain"* OR *"green supply chain finance"*)

3545 RECORDS WERE IDENTIFIED IN THE TITLE,ABSTRACT AND KEY WORDS

Inclusion Criteria

TITLE-ABS (*"green credit"* OR *"green finance"* OR *"green trade-credit"* OR *"green supply chain"* OR *"green supply chain finance"*)
Document type: Articles (1847), Book chapters (97), & Conference paper (441) and Source type: Journals

2606 RECORDS WERE IDENTIFIED IN TITLE AND ABSTRACT

Exclusion Criteria

Total 169 articles that were not in English and remaining review articles were also removed

2385 records were identified during the year 2001-2021 after removing 169 articles

Fig. 1 Flowchart of gathering data of publications for inclusion and exclusion criteria

Bibliometric maps

The pieces of information regarding citation, author keywords, and bibliography of 2385 articles were analyzed through VOSviewer version 1.6.7. Access to Scopus was granted by the University Technology Malaysia. VOSviewer is a tool that is specially made for creating bibliographic maps. The bibliographic maps include items; the current study has taken items (related to author keywords or countries) for its best interest. If there is a link or connection form between any items, it is represented by a numerical value, if the value is positive; it means the association between those items is positive and strong. If the two authors work together and form a research paper, belonging

to a different territory, then the co-authorship analysis is useful for indicating the publication status of the affiliated two countries. Similarly, co-occurrence analysis is useful for the link strength of author keywords that appears together in a publication.

Key results and findings

Publication output and growth of research interest

A total of 2385 articles had been published during the last 20 years (Fig. 2). The oldest year that the current analysis had taken was 2001 and the most recent was 2021. In 2001, there were only three publications, in 2002, there were only five publications, then 2003, it was eight publications, in 2005, it was 25, 2006 had 39 publications, further, it grows to 53 publications in 2007, then the tremendous shift has been seen from 2010. The cumulative publications that had been recorded under Scopus in 2021 were 2385. The peak period was from 2017 to 2021 had observed in the current analysis. As it has been seen that it was increasing to 300 publications per year, hence, the study can be anticipated it will grow in future by the same number. However, most of the articles were not accessed freely, users have to pay to get the relevant information. This is proven by the total publication categorized in the following subject area: Business Management & Accounting (1210 articles), Engineering (995 articles), Environmental Sciences (728 articles), Decision Sciences (560 articles), Energy (427 articles), Social sciences (417 articles), Economics, Econometrics & Finance (291 articles), Earth and Planetary Sciences (78 articles), Materials and Sciences (66 articles), Agricultural and Biological Sciences (49 articles), Psychology (15 articles), and Pharmacology, Taxonomy and Pharmaceutics (seven articles). According to the analysis, the most significant part of published articles was associated with the Business,

Fig. 2 The annual and cumulative numbers of research articles on Green Finance Indexed in Scopus from 2001 until 2021
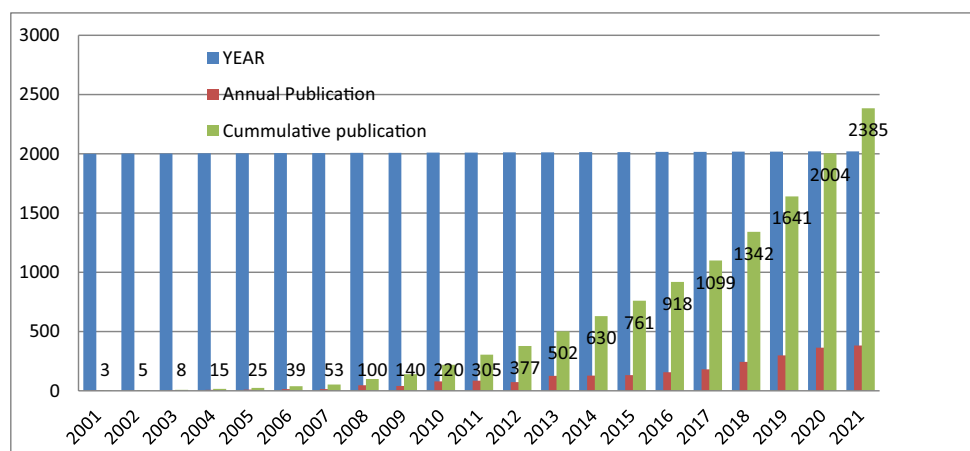
Management, Accounting, Engineering, and Environmental sciences subject areas (Fig. 3).

Results also indicated that the articles used in the current study were published in five different languages including English: English (2385; 99%), Croatian (2; 0.00083%), French (1; 0.00041%), Russian (1; 0.00041%), and Spanish (1; 0.00041%).

Preferred journals

The results revealed that the topmost 10 productive journals were owned by the seven different publishers group (Table 1). The topmost journal is associated with Elsevier named Journal of Cleaner Production. Out of ten, four journals of Elsevier were contributed towards "green supply chain," "green finance," or "green supply chain finance." Other journals related to Emerald Publishing group, one journal associated with Taylor & Francis, one journal associated with Multidisciplinary Digital Publishing Institute (MDPI), one journal belonged to Springer Nature, rest were associated with Excelling Tech Publishers and IOP Publishing Ltd.

The most prolific journal was the Journal of Cleaner Production with the highest number of publications (170 publications), it has the highest 2021 CiteScore of 14.1. The Journal of Cleaner Production has the highest number of citations (14,787) and falls under the quartile 1 category with the 97th percentile. Out of ten journals, eight journals fall under the quartile 1 category (Q1), except for the International Journal of Supply Chain Management which has fallen under Q3. Rest IOP Conference Series on Earth and Environmental Science fall under Q4. The journal of Sustainability belongs to MDPI has (155) publications with a CiteScore of 3.9, and has also a good number of total citations (1540). Three journals had a CiteScore of 10 and

above. However, an International Journal of Supply Chain Management has existed with CiteScore 1.0. and Iop Conference Series on Earth and Environmental Science have a CiteScore of 0.6 which is less than one but still, it was number seven in the list out of ten because of the greater number of publications (32 publications).

Further, the International Journal of Production Economies of Elsevier has the second-highest number of total citations (5989) with the second-highest h-Index of 36. The International Journal of Production research belonging to Taylor & Francis has the third-highest number of total citations (3567) and also has the third-highest h-Index 24 but still, both journals have fallen in the Q1 category under Scopus. The most cited title belonged to the Journal of Cleaner Production (A strategic decision framework for green supply chain management), it has been cited 895 times as compared to other titles. The second most cited title was (Performance measurement for green supply chain management), which belonged to Benchmarking Journal Emerald group of publishers, it has been cited 889 times as compared to the other cited titles. The third most cited title was (Confirmation of a measurement model for green supply chain management practices implementation), which belonged to the (International Journal Of Production Economics) and has been cited 761 times.

The journal's quality was also assessed through AJG (Academic Journal Guide) 2021. The AJG assigns ranking grades based on the quality of the journal to all the management and business journals. Their ranking ranges from 1, 2, 3, to 4 grades. Grade 4 refers to the highest quality whereas grade 1 refers to the lowest quality of the journal. Most academicians and scholars of finance and management consider AJG ranking for the evaluation of the journals (Sahi et al. 2022). The results indicated in Table 1 that out of the top 10 journals, 5 journals fall

Fig. 3 The total number of research articles by subject areas related to "green supply chain or green finance" Indexed in Scopus from 2001 until 2021
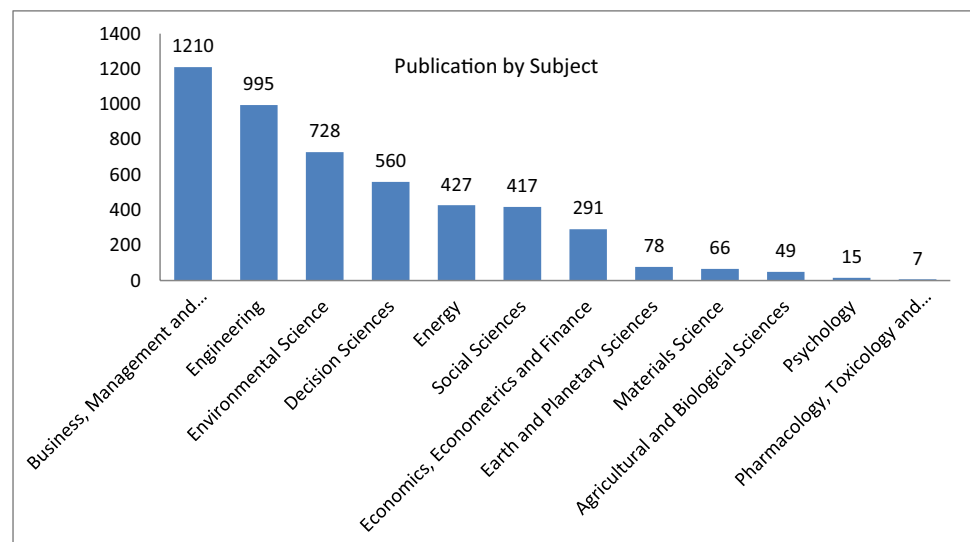
Table 1 The topmost productive journals on green finance or green supply chain research with the most cited articles

No	Journal	T(P)	T(C)	Cite score 2021	Quartile	Title of most cited article	Times cited	Publisher	SNIP	SJR	H-index	AJG
1	Journal Of Cleaner Production	170	14,787	14.1	Q1	A strategic decision framework for green supply chain management	895	Elsevier	1.937	2.475	63	2
2	Sustainability Switzerland	155	1540	3.9	Q1	Blockchain practices, potentials, and perspectives in greening supply chains	93	Multidisciplinary Digital Publishing Institute (MDPI)	1.242	0.612	21	-
3	International Journal Of Supply Chain Management	69	640	1.0	Q3	The correlates of developing green supply chain management practices: Firms level analysis in Malaysia	332	Excelling Tech Publishers	0.585	0.190	11	-
4	International Journal Of Production Economics	49	5989	13.4	Q1	Confirmation of a measurement model for green supply chain management practices implementation	761	Elsevier	2.792	2.406	36	3
5	Environmental Science And Pollution Research	39	321	6.3	Q1	Impact of green supply chain management practices on firms' performance: an empirical study from the perspective of Pakistan	141	Springer Nature	1.114	0.845	8	-
6	International Journal Of Production Research	36	3567	13.7	Q1	The moderating effects of institutional pressures on emergent green supply chain practices and performance	657	Taylor & Francis	2.396	1.909	24	3
7	IOP Conference Series Earth And Environmental Science	32	2	0.6	Q4	Evolutionary Game Model Study of Construction Green Supply Chain Management under the Government Intervention	6	IOP Publishing Ltd	0.436	0.179	2	-
8	Benchmarking	31	1580	6.9	Q1	Performance measurement for green supply chain management	889	Emerald	1.087	0.640	17	1
9	Transportation Research Part E Logistics And Transportation Review	31	2969	10.9	Q1	The influence of greening the suppliers and green innovation on environmental performance and competitive advantage in Taiwan	488	Elsevier	2.485	2.042	21	3
10	Computers And Industrial Engineering	30	1551	9.0	Q1	A holistic approach for selecting a third-party reverse logistics provider in the presence of vagueness	212	Elsevier	2.030	1.315	18	-

T(P) total publications, T(C) total citations, SNIP source-normalized impact per paper, SJR (Scimago Journal Rank)

under the AJG ranking list 2021, The highest-ranking journal Q1 Journal of Cleaner Production only falls under the ranking grade 2 in AJG list 2021, whereas top-notch journals International Journal of Production Economics, The International Journal of Production Research, and Transportation Research Part E Logistics And Transportation Review which are the part of Q1 falls under ranking grade 3 under AJG list 2021, whereas Benchmarking journal falls under ranking 1 which is the lowest grade quality in AJG list 2021. This suggests that half of the study's total publications (317 publications) on green supply chain management have been published in ranked journals, whereas half of the studies (325 publications) on green supply chain management have been published in non-ranked journals according to AJG 2021.

Moreover, a CiteScore can affect authors' decision in selecting the journals; however, authors should consider the quality of work along with the specific details of whether the journal depicts correct work to the right audience and its progress in the specific field. Elsevier-Scopus uses CiteScore and Clarivate Analytics uses the Impact factor. Both are the metrics used to measure the impact of the journal based on the citations (Md Khudzari et al. 2018).

SNIP (Source-Normalized Impact Per Paper) is used to compare different journals in their subject fields. SNIP ratio is based on the citation potential, citation potential is the number of citations that a journal would expect to receive in a specific subject field. From Table 1, it has been clear that the topmost journal was (the International Journal Of Production Economics) in the economics subject field according to its SNIP (2.792), Second topmost journal according to SNIP was (Transportation Research Part E Logistics And Transportation Review) its SNIP (2.485) also related to the economics. The third most productive journal according to the SNIP (2.396) was the (International Journal Of Production Research), Thus, it is depicted that the number of citations of the journal that are related to green supply chain finance is mostly related to the economics subject field.

SJR (Scimago Journal Rank) is used to measure journal prestige, it is used to compare journals in a different discipline. Scimago uses the Scopus database to give a certain rank to the journal in the different subject areas through quartiles. According to the SJR from (Table 1), it has been clear that the (Journal of Cleaner Production) has the greater SJR ratio (2.475). The second journal according to the SJR ratio (2.406) was (the International Journal Of Production Economics). The third journal according to SJR ratio (2.042) was (Transportation Research Part E Logistics And Transportation Review). Thus, it is depicted that the above-stated three journals have a higher SJR ratio in their disciplines.

Leading countries, top institutions, and international collaboration

Figure 4 shows the top ten most productive countries that contributed to the growth of green supply chain management across the world. India contributed about 78.40%, Iran contributed about 68.63%, and Taiwan and China contributed about 66%. It can be established that these four countries are the main contributor globally. China was the foremost country that had started the publications related to green supply chain or green finance with 802 publications in a total of 132 journals. India was ranked the second most prolific country with 301 publications. Among the ten countries India, China, Taiwan, and Iran had more than 2/3 of single country publications (SCP). This established that these four countries have very strong intra-country collaborations. On the other hand, Australia and the UK were the countries that have the least SCP with 25%. The most benefit of international collaboration is not limited to networking, knowledge, and expertise sharing but also it's a useful strategy for enhancing a ranking globally (Md Khudzari et al. 2018).

Moreover, the China University of Mining and Technology has a total of 18 publications and is ranked in the first position among the top ten institutions that produced great work on green supply chain management. Indian Institute of Technology Roorkee has a total of 14 publications, and despite having (383 ranking positions) in the QS university ranking 2021, this Indian Institute of Technology Roorkee ranked in the second position among the top ten countries/academic institutions. The University of Sydney listed at (the top 40th ranking position) in the QS university ranking 2021 has produced a total of 4 publications. Despite having the least single country publication, the authors from the University of Sydney have produced ample work related to green supply chain management. The University of Sains Malaysia has contributed 56.59% and ranked in 6th position among the top ten institutions according to the analysis, it produced a total of 17 publications. The University of Sains Malaysia is in (142 ranking position) in the QS university ranking 2021. It proves that GSCM (green supply chain management) has received attention from top universities across the globe.

The distribution of countries is shown in Fig. 5. The countries which are closer to each other can be found having a thicker line between each other. Co-authorship results revealed that China was the topmost affiliated country that has linked to 46 countries with 375 times co-authorship. The second most affiliated country was the UK which has linked to 43 countries with 220 co-authorships. The third most affiliated country was the USA which has linked to 38 countries with 230 co-authorships. Rest India also has some good links with other countries (33 links and 111 co-authorships), Malaysia (31
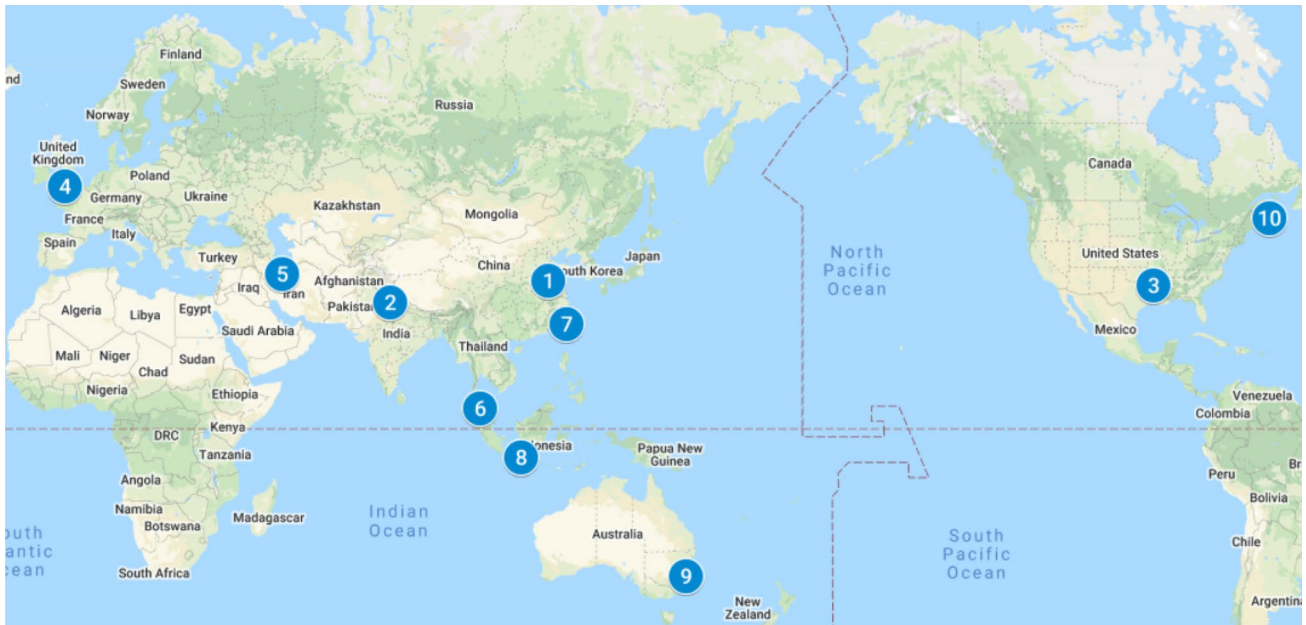
Rank	Country	TPc	SCP %	The most Productive Institutions	TPi
1.	China	802	533/802=66.45%	China University of Mining and Technology	18
2.	India	301	236/301=78.40%	Indian Institute of Technology Roorkee	14
3.	USA	236	73/236=30.93%	Southern Arkansas University	07
4.	UK	192	48/192=25%	University of the West of England	05
5.	Iran	169	116/169=68.63%	Islamic Azad University	21
6.	Malaysia	154	87/154=56.49	Universiti Sains Malaysia	17
7.	Taiwan	151	101/151=66.88	National Taipei University of Technology	11
8.	Indonesia	91	59/91=64.83	Universitas Diponegoro	12
9.	Australia	75	19/75=25.33	The University of Sydney	04
10.	Canada	72	32/72=44.44	Université de Moncton	08

Fig. 4 The top ten most productive countries and academic institutions in green supply chain finance or green finance. TPc, total publication of a given country; TPi, total publication of given academic institutions; SCP, single-country publication

links and 111 co-authorships), Taiwan (17 links and 66 co-authorships), Indonesia (17 links and 44 co-author-ships), and Pakistan has also a good affiliation with (29 countries and 85 co-authorships). It is also established by the results that all top affiliated countries have published the work related to green supply chain management in the year 2017.

Further, results revealed that (Fig. 5a, b) a total of 11 clusters were found in country co-authorship, and a total of 1209 co-authorship among 397 countries were established;

the explanations of each cluster have been discussed as follows:

Cluster 1 (red)

It includes 11 countries named Bahrain, Cyprus, Egypt, Greece, Indonesia, Kuwait, Malaysia, Pakistan, Palestine, Saudi Arabia, and Turkey. In cluster 1, the topmost publica-tions related to the green supply chain belonged to Malay-sia which has linked with 31 countries, including 111 times co-authorship with a total of 3512 citations. This means
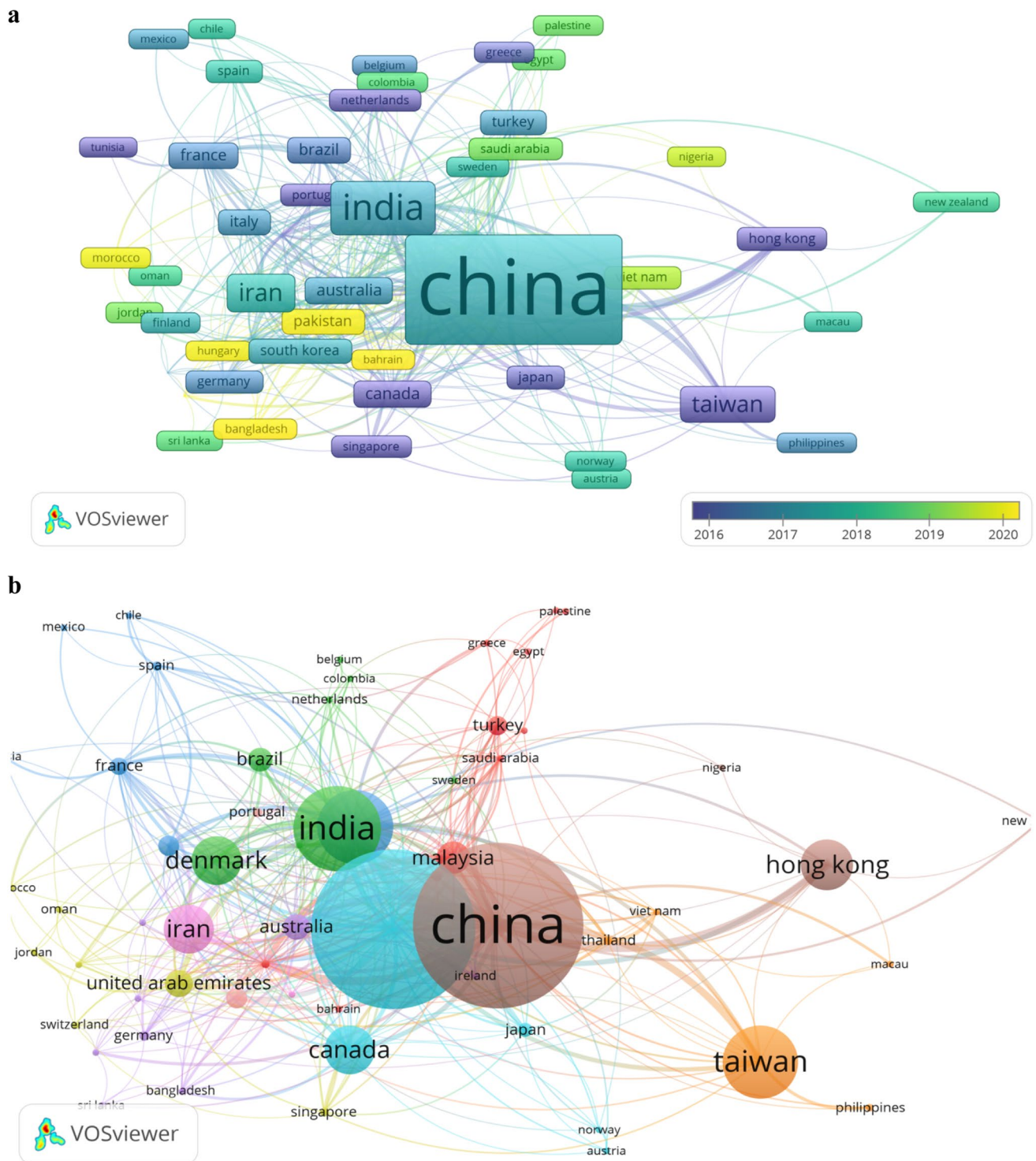
a

b

Fig. 5 **a** A screenshot of the bibliometric map created based on co-authorship with overlay visualization mode. The following URL can be used to open Fig. 5 in VOSviewer: https://bit.ly/3rnGHUZ. **b** A screenshot of the bibliometric map created based on co-authorship with network visualization mode. The following URL can be used to open Fig. 5b in VOSviewer: https://bit.ly/3Jy5BHB

Malaysia has a strong association with 31 countries. In cluster 1, the least publications are from Cyprus with the association of 5 countries with 5 times co-authorship and 21 total citations; this suggests that the scholars from Cyprus need to take more attention to the networking with different country scholars that have publications related to green supply chain management as this is the most emerging field and need close attention of scholars (Fig. 5).

Cluster 2 (green)

Cluster 2 includes 8 countries such as Belgium, Brazil, Columbia, Denmark, India, Netherlands, Poland, and Sweden. It has been found that India has the highest number of 306 publications, and the highest number of total citations 10,193 with 33 countries that include 111 times co-authorship. Whereas Belgium has the minimum number of publications of 04, with 186 total citations, they have the least affiliated country that has 4 affiliations with only 5 times co-authorship, in this cluster; Sweden also has the minimum number of publications 07, 22 total citations with 7 countries, and only has 10 co-authorship. This suggests that scholars in Belgium and Sweden need to take more interest in maintaining and creating moral and strong relations and associations among scholars belonging to different territories that have the most publications in green supply chain management (refer to Fig. 5).

Cluster 3 (light blue)

It includes 7 countries namely, Chile, France, Italy, Mexico, Spain, Tunisia, and the UK. According to the co-authorship networking, the UKhas the strongest relations with 43 countries which include 230 co-authorship, along with the highest 8790 citations. Further, Tunisia, and Chile have the least networking with other scholars belonging from different countries with a total of 5 publications and a total of 143 and 214 citations respectively. They should have created relationships with united kingdom scholars.

Cluster 4 (yellow)

It includes 7 countries, namely, Finland, Jordan, Morocco, Oman, Singapore, Switzerland, and United Arab Emirates. In this cluster, United Arab Emirates has the strongest associations with 22 countries, with 64 co-authorship, and 2899 citations, (Fig. 5) depicts that the United Arab Emirates has created good relations with Jordan, Oman Singapore, Switzerland, and Morocco authors. Despite having a good number of Publications on the green supply chain management United Arab Emirates has the lowest rank in degree centrality (Fig. 4). Degree centrality is a proxy for the association, it is not always a measure of publications (Fonseca et al. 2016). In this cluster, Switzerland and Oman have the least associations with international authors with 7 publications and 440 and 533 citations respectively. They have a minimum number of publications; this suggests that they both need to improve their associations with other International Scholars.

Cluster 5 (purple)

This cluster includes 7 countries mainly, Australia, Bangladesh, Germany, Ghana, Hungry, South Africa, and Srilanka. Australia shows the highest level of association with 75 countries with 90 co-authorship at the International level. Despite having the greatest associations Australia ranks at 9th Rank (Fig. 4) among the topmost countries and academic institutions that are published in green supply chain management with having 2767 citations. In this cluster, Hungry and Srilanka have the least international collaborations with 7 and 10 publications, networking with 10 and 5 countries, and 11 and 6 co-authorship respectively.

Cluster 6 (sea green)

It includes 5 countries, Austria, Canada, Japan, Norway, and the USA. The results revealed that the USA has the greatest number of publications 235, with 38 countries, 230 co-authorship with 20,568 citations, whereas Austria and Norway have the least international collaborations 6 and 8 respectively; this depicts that the USA has more charm towards international collaborations; nearby countries should have collaborated with the US scholars as they are keener towards the green supply chain management field.

Cluster 7 (orange)

Cluster 7 has 5 countries, Macau, Philippines, Taiwan, Thailand, and Vietnam. Taiwan has the highest international collaborations with 150 publications from 17 countries, and 66 co-authorship with 8661 citations. Whereas, Philipines and Macau have the least international collaborations 9 and 10 respectively. They need to involve themselves with nearby international scholars such as Taiwan in this specified field.

Cluster 8 (brown)

It includes 4 countries, China, Hong Kong, New Zealand, and Nigeria. The analysis depicts that China has the most International collaborations (Fig. 5) with 46 countries worldwide, 375 co-authorship with the highest citations 21,380, and it is the topmost productive country that contributed to the field of green supply chain management widely (Fig. 4). However, New Zealand and Nigeria have the least international collaboration 9 and 4 respectively. Thus, the current author believes that scholars of New Zealand and Nigeria must collaborate with their neighboring countries China.

Cluster 9 (light pink)

It includes 2 countries, Iran and Lithuania, where Iran has the most documents 169 with 21 countries and 80

international collaborations (Fig. 5). Iran scholars need to create strong relations with their neighboring countries Pakistan and the United Arab Emirates and with European countries too.

Cluster 10 (dark pink) and Cluster 11 (grey)

Cluster 10 includes 2 countries named Portugal and South Korea, where South Korea has 50 publications with 18 countries and 44 co-authorship; this depicts that South Korean scholars need to improve their international associations with Taiwan and with other East Asian countries. In cluster 11, only 1 country includes that is Ireland, Ireland is the newest entrant in this field, and the scholars of Ireland need to create international collaborations with the UK as UK scholars are keener in an international association.

Leading authors

Table 2 shows the 15 most prolific authors in green supply chain management; these authors were associated with nine different countries as follows: India (5 authors), China (3 authors), the USA (1 author), France (1 author), Denmark (1 author), Malaysia (1 author), Iran (I author), Taiwan (1 author), and the UK (1author). The year of first publication ranges from 2003 to 2017, where 10 authors had the role of 1st author, 4 authors had the role of

co-author, and 1 author had the role of the last author. The topmost author Sarkis. J. from the USA had a record of 43 total publications since 2003, with document H-index 30, and had 11,069 total citations affiliated with Worcester Polytechnic Institute, Worcester, USA. The second author Zhu, Q. belonged from China, with a total of 27 publications since 2004, 8856 total citations, and is affiliated with the top university of China, Shanghai Jiao Tong University, Shanghai, with document H-index 23. Govindan, K. the third author belonged from Syddansk Universitet Denmark with 22 publications since 2011, 3854 total citations, and had an H-index of 20. Mathiyazhagan, K, Luthra, S., Mangla, S.K., Barve, A., and Kant, R. all belonged to prestigious universities in India.

This suggests that mostly the green supply chain management has grasped the interest of Indian authors and scholars. Tseng, M.L. ranked at 7th position belonged from Asia University, Taichung Taiwan with 13 publications since 2010, 953 total citations, and with H-index 11. Hafezalkotob, A. ranked at 13th position affiliated with Islamic Azad University, South Tehran Branch, Tehran, Iran, had 11 publications since 2017, with 313 total citations, and document H-index 06. The authors for the most cited articles listed in the table in Table 1 do not necessarily seem in Table 2 except Sarkis, J., Zhu, Q., and Khan, S.A.R. The affiliation of authors had established that green supply chain management research was related to the field of engineering,

Table 2 The list of the 15 most prolific authors in green supply chian or green finance research areas

Rank	Author	Scopus author ID	Year of 1st publication	T(P)	Document H-index	T(C)	Current affiliation	Country
1	Sarkis, J	•57,194,726,123	2003	43	29	11,069	Worcester Polytechnic Institute, Worcester	USA
2	Zhu, Q	•7,403,313,115	2004	27	23	8856	Shanghai Jiao Tong University, Shanghai,	China
3	Govindan, K	•54,986,334,000	2011	22	20	3854	Syddansk Universitet	Denmark
4	Jabbour, C.J.C	•54,977,014,200	2013	17	14	1306	EM Normandie, Le Havre, France	France
5	Mathiyazhagan, K	•55,599,573,800	2013	14	9	1036	Thiagarajar School of Management,	India
6	Luthra, S	•43,361,407,000	2011	13	12	1269	State Institute of Engineering & Technology	India
7	Tseng, M.L	•44,261,803,600	2010	13	11	953	Asia University, Taichung	Taiwan
8	Bai, C	•24,485,581,400	2010	12	10	695	School of Management and Economics of UESTC, Chengdu	China
9	Khan, S.A.R	•57,188,874,922	2016	12	07	350	Tsinghua University, Beijing	China
10	Mangla, S.K	•55,735,821,600	2014	12	09	634	O. P. Jindal Global University, Sonipat	India
11	Barve, A	•23,501,049,000	2013	11	08	632	Maulana Azad National Institute of Technology, Bhopal	India
12	Fernando, Y	•26,664,524,300	2015	11	06	128	Universiti Malaysia Pahang, Kuantan	Malaysia
13	Hafezalkotob, A	•54,880,543,400	2017	11	07	313	Islamic Azad University, South Tehran Branch, Tehran	Iran
14	Kant, R	•36,147,550,000	2014	11	06	168	S. V. National Institute of Technology, Surat	India
15	Koh, S.C.L	•24,824,748,600	2010	11	09	655	The University of Sheffield, Sheffield	UK

environmental science, energy sciences, social sciences, and business management.

Co-citation analysis

The connections formed between two referencing articles when both authors refer to the same article are called bibliographic coupling. Strong coupling is formed when two documents have a large number of citations. Further, bibliographic coupling indicates the similarity in the subject matter. If the two authors are associated bibliographically, then the commonly cited research reflects in their reference list. Various techniques can be used to review the academic structure of a particular field, such as co-citation and citation analysis, still, these methods lack in identifying the evolving themes, thus bibliographic coupling is best to overcome these lacking by analyzing the current topics within a field (Sahi et al. 2022). When the two articles published the same reference more than once this depicts the similarity in their methodology, theory, or empirical papers. The link strength between the two articles has been analyzed by VOSviewer, to quantify the associations between the pair references (Table 3).

Table 3 The list of the main keywords with their peak year

SNO	Item	Links	Total link strength	Occurrences	Year
1	Green Finance	66	132	115	2020
2	Environmental Performance	91	240	102	2017
3	Reverse Logistics	66	127	57	2015
4	Firm Performances	22	40	26	2019
5	Climate Change	23	26	12	2018
6	Climate Finance	15	16	6	2019
7	Climate Policy	1	1	6	2019
8	Green Credit	29	34	39	2019
9	Green Credit Policy	24	32	22	2019
10	Trade Credit	8	10	60	2019
11	Sustainable Finance	7	10	60	2019
12	Sustainable Supply Chain	40	56	24	2017
13	Green Investment	15	21	13	2020
14	Green Logistics	23	33	16	2017
15	Green Innovation	45	76	34	2019
16	Green Productivity	4	4	3	2016
17	GSCM Practices	40	53	22	2018
18	Green Purchasing	36	67	22	2017
19	Green Procurement	30	42	15	2015
20	Green Manufacturing	42	73	26	2017
21	Green technology	10	10	4	2020
22	Green Credit Guidelines	0	0	3	2010
23	Green Circular Economy	2	2	2	2020
24	Industry 4.0	15	19	9	2020
25	CSR	32	41	21	2018
26	Corporate Sustainability	6	6	5	2016
27	Sustainable Investment	2	2	2	2020
28	Cleaner Production	7	7	2	2015
29	Green Product Development	3	4	3	2020
30	Corporate Environmental Responsibility	4	4	2	2020
31	Prospect Theory	4	5	3	2019
32	Cold Chain logistics	3	3	2	2021
33	Carbon emissions	3	4	2	2020
34	RBV	7	7	5	2015
35	NRBV	6	7	2	2013
36	Institutional Theory	28	40	18	2016

This study has used bibliographic coupling for citation analysis; different units of analysis can be used such as publications, journals, and authors. The current study has taken documents as a unit of analysis and fractional counting was set as the method in VOSviewer. The larger circles indicate the importance of a publication (Fig. 8). Five hundred numerical value was set to a minimum number of citations of documents, where 18 documents meet the minimum threshold. This threshold has been selected to have a deepen analysis and not to complicate the investigation. A total of four clusters were identified. The three main clusters and one minor cluster were created, and suggest the collection of themes. The first cluster was red color and contain 6 articles, all the articles were related to the main theme of the study green supply chain management, (Table 4). The second cluster was green in color and contains 6 articles, with the main theme of green supply chain management and sustainable supply chain management practices, (Table 5). The third cluster was blue and contains 5 articles, the majority of the articles were related to drivers, barriers, and implementation of green supply chain management, (Table 6). The last cluster was yellow,

and contains only 1 article, that was related to performance measurement in green supply chain management, (Table 7).

Author keywords

A total of 4867 author keywords were recorded. One thousand sixty-two keywords were matched with the minimum threshold of 2 occurrences in VOSviewer, out of 1062, 477 keywords were connected (Fig. 6a, b).

Terminology and concept

The results showed that "Green Supply Chain Management" was the most recurrent keyword with 536 occurrences and 271 links with other keywords. It has been widely used with theoretical keywords such as green finance, green credit, sustainable performances, carbon emissions, renewable energy, climate finance, trade credit, sustainable finance, green logistics, and many more (Fig. 6a). Further, it has been observed that "green finance (66 links and 115 occurrences)," "green credit (29 links and 390 occurrences)," "sustainable finance (07 links and 60 occurrences)," and "sustainable supply chain (40 links and 240 occurrences)," "green logistics (23

Table 4 Summary of studies in cluster 1

NO	Authors	Titles	Citations	TLS
1	Zhu and Sarkis (2004)	Relationships between operational practices and performance among early adopters of green supply chain management practices in Chinese manufacturing enterprises	1655	119
2	Zhu et al. (2005)	Green supply chain management in China: pressures, practices, and performance	940	123
3	Zhu and Sarkis (2006)	An inter-sectoral comparison of green supply chain management in China: Drivers and practices	626	98
4	Zhu et al. (2007)	Green supply chain management: pressures, practices, and performance within the Chinese automobile industry	744	60
5	Zhu and Sarkis (2007)	The moderating effects of institutional pressures on emergent green supply chain practices and performance	690	65
6	Zhu et al. (2008)	Confirmation of a measurement model for green supply chain management practices implementation	850	53

Table 5 Summary of studies in cluster 2

NO	Authors	Titles	Citations	TLS
1	Sarkis (2003)	A strategic decision framework for green supply chain management	958	8
2	Chiou et al. (2011)	The influence of greening the suppliers and green innovation on environmental performance and competitive advantage in Taiwan	540	51
3	Darnall et al. (2008)	Environmental management systems and green supply chain management: complements for sustainability?	511	40
4	Green et al. (2012)	Green supply chain management practices: impact on performance	733	51
5	Vachon and Klassen (2006)	Extending green practices across the supply chain: The impact of upstream and downstream integration	950	61
6	Wu et al. (2011)	Balancing priorities: Decision-making in sustainable supply chain management	513	35

Table 6 Summary of studies in cluster 3

NO	Authors	Title	Citations	TOOLS
1	Walker and Preuss (2008)	Drivers and barriers to environmental supply chain management practices: Lessons from the public and private sectors	837	88
2	Diabat and Govindan (2011)	An analysis of the drivers affecting the implementation of green supply chain management	642	76
3	Büyüközkan and Çifçi (2012)	A novel hybrid MCDM approach based on fuzzy DEMATEL, fuzzy ANP, and fuzzy TOPSIS to evaluate green suppliers	643	39
4	Ahi and Searcy (2013)	A comparative literature analysis of definitions for green and sustainable supply chain management	750	20
5	Zhu et al. (2013)	Institutional-based antecedents and performance outcomes of internal and external green supply chain management practices	548	84

Table 7 Summary of studies in cluster 4

No	Author	Title	Citations	TLS
1	Hervani et al. (2005)	Performance measurement for green supply chain management	925	45

links and 160 occurrences)," "green supply chain management practices (40 links and 22 occurrences)," "green supply chain (217 links and 443 occurrences)," "trade-credit (8 links and 60 occurrences)," "environmental management (62 links and 49 occurrences)," and "green purchasing (36 links and 22 occurrences)" were used simultaneously with the green supply chain management.

The concept of green supply chain management has been found in the early 1990s, but it gain its popularity after 2000 when the environmental management movement came into force (Seuring and Müller 2008; Fahimnia et al. 2015; Tseng et al. 2019). Green supply chain management (GSCM) is an evolutionary concept that is linked with environmental management principles (Handfield et al. 1997). The concept of GSCM is inter-organizational practices of a sustainable supply chain and it includes reverse logistics (Sarkis et al. 2011). The concept is broad and hard to describe by a single definition (Ahi and Searcy 2013). Further, it has been observed that several more attributes and mechanisms were used in naming green supply chain management. Examples of green supply chain management associated with substrate or mechanisms were green supplier selection (41 occurrences), green supply chain management practices (26 occurrences), green supply chain integration (16 occurrences), green supply chain coordination (6 occurrences), green supply chain network (5 occurrences), green supply chain performance (5 occurrences), green supply chain design (5 occurrences), green supply chain initiatives (5 occurrences), green supply chain enablers (2 occurrences), and green supply chain collaborations (2 occurrences) (Fig. 6a, b).

Moreover, it is also interesting to see how a particular term has been established. For example, the term green supply chain integration, defined by Wu (2013), "the firm collaborates with its supply chain partners to manage both intra-organizational and inter-organizational environmental practices"; further, it must be divided into internal and external integration. Internal integration based on barriers increases firms' environmental skills and fosters employees' gain of knowledge about environmental initiatives (Wu et al. 2012), whereas external integration includes collaboration between customer and supplier to mutually handle firms' environmental issues (Vachon and Klassen 2008). Later, the term green supply chain integration has gained the vast attention of different research scholars in many publications, such as (Geng et al. 2017; Zhu et al. 2018; de Oliveira et al. 2018).

Similarly, many other terms were used to refer to green supply chain management such as operational performance (29 occurrences), green manufacturing (26 occurrences), green finance (115 occurrences), green credit (39 occurrences), green credit policy (22 occurrences), environmental risk management (2 occurrences), green investments (13 occurrences), green logistics (16 occurrences), green training (6 occurrences), green competitive advantage (4 occurrences), green distribution (5 occurrences), and green procurement (15 occurrences) (Fig. 6a, b).

Topics of interest

The main keyword that appeared more frequently was 'green finance' with 66 links and 115 occurrences. The second topmost keyword was 'Environmental Performance' with 91 inks and 102 occurrences (Table 3). Both keywords have the strongest link with each other. Green finance is the strongest investment activity that creates environmental advantages to upkeep sustainable growth, this is one of the groundbreaking

a

b

Fig. 6 a A screenshot of the bibliometric map created based on co-occurrence with overlay visualization mode. The minimum occurrence was set to 2. The following URL can be used to open Fig. 6 in VOSviewer: link: https://bit.ly/3t3nw4i. **b** A screenshot of the bib-

liometric map created based on co-occurrence with network visualization mode. The minimum occurrence was set to 2. The following URL can be used to open Fig. 6 in VOSviewer: link: https://bit.ly/3t3nw4i

theories that interconnect the environment with financial businesses (Lv et al. 2021).

Green finance is referred to as a financial tool that helps to attain the goal of sustainable, economic, social, and environmental development (Scholtens 2006). This green

finance term is the same as environmental finance, sustainable finance, low-carbon finance, and all the financial activities and tools that involve in reducing greenhouse gas emissions. The term green finance is constantly evolving because the whole world is now giving importance to the

environment (Lv et al. 2021). This term has gained vast attention at the micro and macro level. Its growth influences all the nationwide economies and financial intermediaries. The implementation of green finance can help in reducing carbon strength (Ren et al. 2020). It is one of the hot topics for many scholars of the year 2020 and onwards (Fig. 7a, b). For the realization of green finance, it is important to set a green credit policy. The 'green credit policy' has 24 links with 22 occurrences (Table 3). The green credit policy is one of the best penalties for those polluting companies that create pollution in China (Lv et al. 2021). According to Wang et al. (2019), green credit is one of the implementations of green finance; this also helps in expanding the green credit scale in enterprises. Thus, this results in increasing the technological advances which ultimately help in reducing the carbon emissions that will lead to improving the environmental quality (Li et al., 2018). 'Carbon emission' has 3 links with 2 occurrences (Table 3). Results revealed that the reduction of carbon emissions is also one of the hottest topics of the year 2020 and onwards (Fig. 7a).

Now, firms are investing in sustainable development projects and taking initiatives just to encourage green investments. This helps companies to take part in sustainable

a

b

operations called sustainable finance (An et al. 2021). 'Sustainable finance' was also one of the keywords that were used frequently in a substrate to green supply chain management, with 7 links and 60 occurrences (Table 3).

Moreover, green credit financing is way different from bank financing because it does not require any mechanism, it only requires linear profit to reduce carbon emissions. Green credit financing considers one of the indicators of environmental performance which was used as a substrate keyword that has 91 links with 102 occurrences. The firms need to invest in a decarbonized portfolio where all firms need to finance in a way to limit their environmental footprints. One of the examples is BNP Paribas (the French banking group) providing financing to the Danone (a food product company in France), which aligned all their investment with the Paris agreement (to reduce their carbon emissions). If a company fails to meet the emissions requirement of the Paris agreement then BNP Paribas will stop lending money to them. Besides this, BNP Paribas has made strict green financing policies for firms who were engaged in generating electricity; if their carbon power exceeds 491 gCo2/kilowatt in 2017, they must lower it by 325 gCo2/ kilowatt by 2025 to maintain International Energy Agency (IEA) sustainable growth setup (An et al. 2021).

However, traditionally, in the context of the supply chain, the trade credit financing term was used to solve all capital constraints of firms (Chen 2015; An et al. 2021). Results revealed that the term 'trade credit' was also used as a substrate of green supply chain management with 8 links and 60 occurrences (Table 3). The term has gained tremendous attention in the year 2019 and onwards (Fig. 7a, b). Trade-credit financing is referred to as a deferred payment mode where supplier and manufacturer have an agreement, wherein in a particular supply chain a supplier is an investor and the manufacturer act as a buyer (Chen 2015). Trade credit allows for a delay in payments (Wang et al. 2018a). It is considered the second most alternative option after bank financing and is widely used in the USA. Trade credit has a positive impact on sustainable and financial development (An et al. 2021).

Further, 'green Investment' was also one of the substitute keywords of the green supply chain, which has 15 links and 13 occurrences; the concept has been new and at its peak since 2020 (Fig. 7a,7b). All over the world, banks and firms have been using green investment as green credit financing to mitigate all financial risk and distress. If a firm prefers green credit financing then the firm has to bear all the financial risk but at the same time firm can enjoy lesser interest rates as compared to trade credit financing. On the other hand, if a firm prefers trade-credit financing, then the supplier will act as a financier and will bear all the financial and default payment risks of the downstream manufacturer. Thus, it is important to see which financing approach is much better for
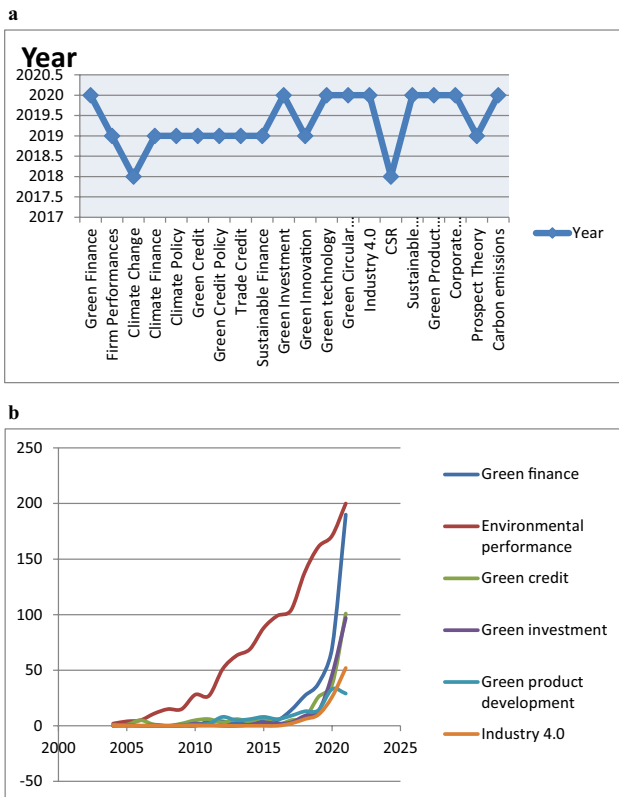
Fig. 7 a The graphical representation of the keywords along with its peak year. **b** The graphical representation of the topics of interest keywords along with their peak year

green Investment. It has been observed that significant contributions have been made toward carbon emissions in the operation management field (Reefke and Sundaram 2017; Guo et al. 2017; An et al. 2021). However, few studies have been done on carbon emissions within green credit financing and trade credit financing (An et al. 2021). Thus, the current study suggests that there is a need to investigate the differences between trade credit and green credit financing under the carbon emissions concept.

Additionally, one of the keywords 'green technology' was also found in keywords analysis with 10 links and 4 occurrences; the term has gained attention since 2020 and onwards (Fig. 7a). If a firm wants to meet the requirement of low carbon emissions then the firm needs to involve itself in green technology. In this way, a firm can meet its green production requirement. 'Green productivity' was also one of the keywords that were used with 4 links and 3 occurrences since 2016 (Fig. 7a). Investing in green technology is very costly for the manufacturer. Thus, for encouraging the manufacturer, there is a necessity to explore more green technology. This result suggests that there is a need to investigate green technology more in future research.

One of the keywords was found 'green circular economy' with 2 links and 2 occurrences since 2020 (Fig. 7a). The term circular economy is linked with sustainable concepts and may overlap with green supply chain management (Liu et al. 2018). Both terms have an objective to enhance environmental performance and economic standards. Green supply chain management helps in improving environmental performance (Sarkis 2012). However, the circular economy can be taken as a policy that helps in improving economic growth by mitigating ecological challenges (Geng et al. 2009; Liu et al. 2018). Studies on green supply chain management and circular economy have been investigated (Zhu and Sarkis 2004; Brandenburg et al. 2014; Dubey et al. 2016; Ghisellini et al. 2016); nevertheless, theoretical associations are still needed (Liu et al. 2018). Thus, the current study depicts that the field is still required the attention of academicians and scholars.

Another keyword that substrate the green supply chain management was 'industry 4.0'. Industry 4.0 had 15 links and 9 occurrences, the concept had reached its peak in the year 2020. Industry 4.0, the new industrial uprising has come up with new creative customer values. Through modern technologies, now the firm can meet customer product requirements. Digitalization allows the customers to select better products; thus, this can increase in firm's value even more. Industry 4.0 has created an intelligent industrial revolution known as 'smart,' that involves the life cycle of products, business information technology, and value chain. This should integrate with the supply chain, product planning, product designing, product process, and manufacturing (Roblek et al. 2016). Thus, the current study suggests that

there is a need to explore more industry 4.0 and green supply chain management with green technologies (Fig. 7a, b).

## Conceptual development and framework

Earlier, the initiatives of sustainability were taken to resolve environmental issues; however, as time passes, now the scholars are adopting the concept of the triple bottom line (environmental, economic, and social) methods towards sustainability. This method consists of a larger number of interrelating factors, that's why the complications can be predicted (Maditati et al. 2018). After the keyword analysis, the results revealed that out of 39 clusters, 5 clusters were the main ones with the highest occurrences, such as cluster 1 (red color with 115 occurrences), cluster 2 (green color with 443 occurrences), cluster 15 (sky green color with 68 occurrences), cluster 17 (light brown color with 150 occurrences), and lastly cluster 26 consists (grey color with 536 occurrences), it can be seen from Fig. 6a and b. The results also clearly depict that construct used to be related to green supply chain management, such as the green supply chain management drivers, green supply chain management practices, and green supply chain management enablers that leads to maintaining the organizational performance which ultimately improves the environmental performance these constructs are still not getting the vast attention of scholars (Maditati et al. 2018). The study of Maditati et al. (2018) lacks the fact of COVID-19. Thus, the current study observed that due to COVID-19 circumstances, the trust factor has been raised due to which companies need to involve themselves in green finance and adopt it as a green supply chain management practice to achieve the sustainability goal. Thus, the current study has modified the conceptual framework of (Maditati et al. 2018). The logical development has been discussed in the subsequent para.

The knowledge synthesis has been used to propose a conceptual framework, which is done through the use of quantitative data first, followed by the qualitative analysis (Seuring and Gold 2012). Firstly, out of 2385 articles, the important papers were selected based on the citations, (the minimum citations must be 500) that were taken for qualitative (content analysis). A total of 18 papers meet the criteria (Fig. 8). The papers were scrutinized based on three factors, (1) drivers of green supply chain management, (2) green supply chain management practices, (3) the influence of COVID-19 on green supply chain management practices, and lastly (4) sustainable firm performance and environmental performance.

Green supply chain management drivers

There are many drivers of green supply chain management proposed by different scholars (Wu et al. 2012). One of the

**Fig. 8** A screenshot of the bibliographic coupling with network visualization mode
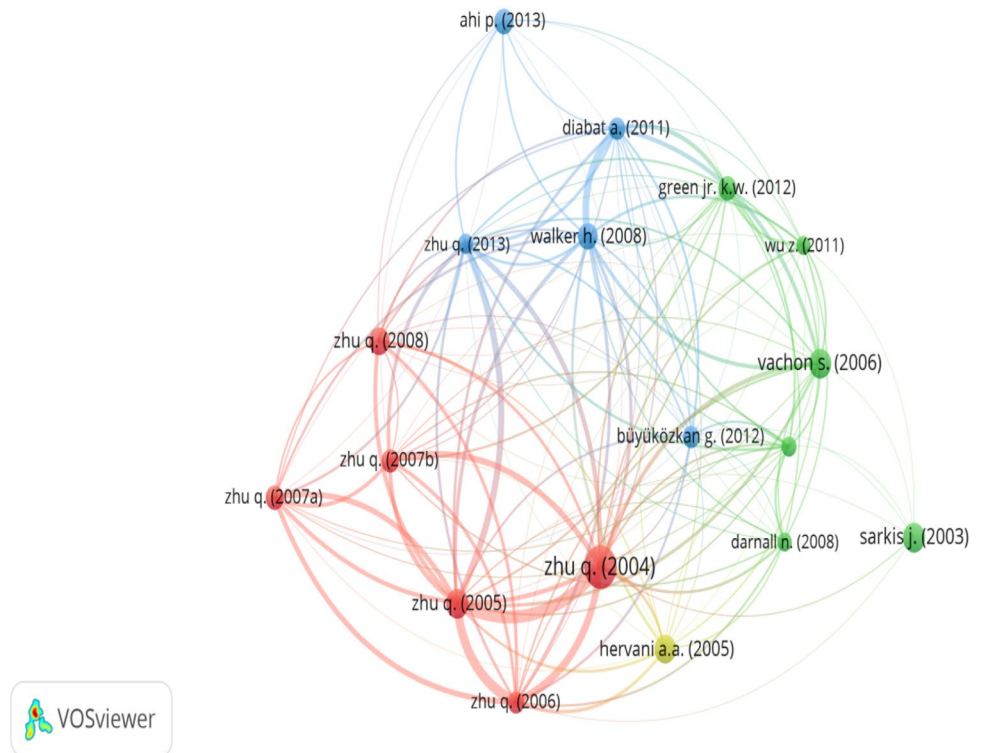
studies was conducted in Taiwan on the drivers of green supply chain management; the study concluded that green supply chain management drivers must include suppliers' environmental collaboration, fulfillment of customer needs, and expedition to improve organizational performances (Wu et al. 2011; Ososanmi and Ojo 2022). However, Diabat and Govindan (2011) were taken government regulations as the critical driver of green supply chain management, whereas in Germany, it was found that suppliers' collaboration and environmental performance are considered the green purchasing determinants (Large and Gimenez Thomsen 2011). Additionally, Wang et al. (2018b) grouped the drivers of green supply chain management into internal or external green activities that lead to the environmental enactment. On the other hand, in Dubai, the drivers of green supply chain management were also identified between internal and external practices (Ben Brik et al. 2013). Thus, based on the different scholar's identification and pieces of evidence, this confirms that the drivers of green supply chain management revolve around internal and external (Zeng et al. 2011; Longoni et al. 2018). After a thorough review of articles, the internal and external drivers of green supply chain management are segregated into three dimensions, (a) responsibility, (b) suppliers' requirements, and (c) demand requirements. Where dimension (a) responsibility consists of government regulations; it refers to the rules and regulations imposed by governments by using green practices (Rehman Khan and Yu 2021), and environmental awareness; refers to the

awareness of firms regarding the reduction of carbon emissions, dimension (b) consists of strategies against competitors'; it refers to the strategies that foster the organization success and enhances its processes, and establishing the company's green image; it refers to the need of an organization to own a brand image that cannot be overlooked and dimension (c) includes external pressures of stakeholders; it refers to the stakeholder's requirements and internal motivators; it refers to the firm's inter-organizational demand (Maditati et al. 2018) (Fig. 9a).

Green supply chain management practices

The scholars and practitioners introduced the concept of green supply chain management to resolve the issues of environmental performance; it is coined in the 1990s but gained popularity in 2000; after 2010, the current authors observed a tremendous shift from the year 2010 onwards (Fig. 2). Green supply chain management now becomes a need for many organizations to improve the relations between green product suppliers and customers and this is only possible if an organization tries to reduce the activities that are harmful to the environment and the society (Khan et al. 2022). Hervani et al. (2005) explain the term green supply chain management related to green procurement, green manufacturing, green distribution, and lastly, revere logistics. When the organizations take decisions based on green supply chain management, they must consider all stages of a product from

Fig. 9 **a** Grouping of green supply chain management drivers. **b** Conceptual framework of the study
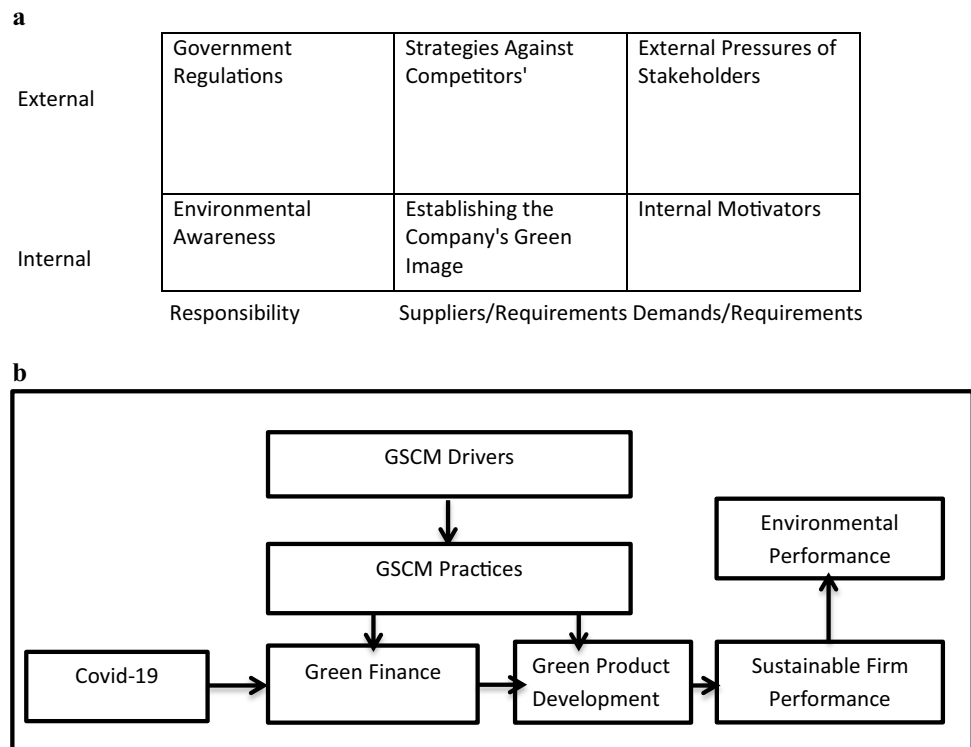
material to logistics, and the end-users (Khan et al. 2022). Similarly, Srivastava (2007) explains green supply chain management as the group of thinking related to the environment and supply chain management, which includes product design, fetching materials, the process of manufacturing, and distribution of products to the final users.

In the event of industrial development, small and medium enterprises are now realizing that it is necessary to maintain sustainable development goals such as sustainable employment, economic growth, sustainable innovation, and sustainable industrialization. According to the World Bank, small and medium enterprises contributed 90% to the global business, 40% to the national income, and 50% to the global employment; hence, the development of the new emerging technologies can be an asset to fulfill the sustainable development goals in the small and medium enterprise technological revolution. Firms around the world are now applying emerging technologies to shrink environmental issues (Awan 2021; Khan et al. 2021).

Pakistan and China are actively involved to protect their economic and environmental performances. The CPEC (China Pakistan Economic Corridor) indulged in many projects such as collaborative industrial zones, and infrastructure development, that lead the firms to involve in new emerging technologies (Cheng et al. 2021; An et al. 2021; Khan et al. 2021). Industry 4.0 is gaining importance due to the newly adopted transformations in the industrial zones. Industry 4.0 helps in sustainability practices such as green

remanufacturing, recycling, reuse, and green procurement (Mani et al. 2020; Cheng et al. 2021; Khan et al. 2021). The transformational change in the Industry 4.0 promotes green practices such as data analytics, blockchain technologies, and artificial intelligence (Dalenogare et al. 2018; Khan et al. 2021).

The organization's efficiency and productivity can be resolute by the logistic performances of the firm. The firm's logistics display the overall country's supply chain quality and performance (Rashidi and Cullinane 2019; Khan et al. 2019; Suki et al. 2021). For any country's economic development, the manufacturing industry plays a pivotal role; this creates pressure on academicians and managers to discover such practices that give fosters firms economic development. The implementation of green supply chain management practices varies from country to country. This purely depends on the country's culture and internal pressures; the countries are in the developing stage, and their manufacturing industry is still implementing the green supply chain management practices, that's why their initiatives regarding environmental performance will differ (Khan et al. 2021). According to Khan et al. (2021), more research must be done on developing countries to examine the relationship between green supply chain management practices and organizational performances. A positive association was found between green supply chain management practices (like recycling, supplier selection, and green packaging,) with financial and environmental performances (Abu Seman et al. 2019; Khan

et al. 2021). For enhancing a firm's performance firms must adopt green practices (such as green processes, green design, and green technology). Many empirical studies showed that firms having concerned about their environment helps in improving their firm performance and fostering sustainable developments (Svensson et al. 2016; Fahim and Mahadi 2022). A negative association was also found between green supply chain management practices and economic performance; therefore, there is a need to further investigate the green supply chain management practices to encourage firms to achieve firm sustainability (Khan et al. 2021). Sustainable firm performance helps businesses in creating the values and obtaining the shareholder objectives, by executing opportunities and managing the threats that originate from social, economic, and environmental development (Fahim and Mahadi 2022).

Moreover, after the industrial revolution, due to the inventions of new technologies, and the reduction in natural resources and energy, many negative impacts have been grown on the environment (Ture and Ganesh 2018; Whitburn et al. 2020; Cai and Guo 2021). Subsequently, many environmental issues have arisen, which make sure to remain focused on societal and human development without hurting the ecosystem (Whitburn et al. 2020; Raza et al. 2021). Some issues related to the environment pose a small threat while other issues significantly affect the whole environment, such as changes in weather, heat waves, depletion of the ozone layer, deforestation, and exploitation of natural resources. This greatly affected biodiversity. The gradual effect on the environment has given the reason for the whole world to pay attention to the relationship between humans and the environment, which in turn arisen the focus of environmental protection. Now, the trend has changed human wants to live with nature and focus on environmental sustainability (Yong et al. 2019; Cabral and Dhar 2020). Policymakers and professionals are nowadays taking interest in environmental sustainability; however, organizations understand the gravity of environmental issues and try to indulge themselves in "green practices" which then become the main objective of every organization. Practitioners are focusing on green practices, and green finance is one of the green practices Cai and Guo (2021) that are part of the main green supply chain management. There is a vast growth has been seen in green finance over the last few years (Fig. 7a, b).

Furthermore, it has been found that the atmosphere may get affected by pollution. The profits of industries are at risk due to this problem. Despite being treated the pollution, Porter and Linde (1995) stated that the creation of pollution is the inefficiency of industries. Hence, the green investment in water, biodiversity protection, waste treatment, resources, and climate change alleviation helps in enhancing industrial production. Many case studies show green investments help in the reduction of carbon emissions and protect the

environment (Liu et al. 2018; Chițimiea et al. 2021). The researchers of Columbia University have examined the link between green investments and renewable energy and established that they were using different levels of sustainable development goals (Zhang et al. 2022). Investments in green equity, carbon market tools, and green bonds help in promoting "green" and will lead to enhancing the sustainable development goals. Thus, for the enhancement of green growth, the industries must adopt green financing by making investments in ecology, climate change, and carbon reduction (Zhang et al. 2022). Green finance and environmental invention signify the main drivers of sustainable development which is linked with sustainable firm performances. The green finance performance declines when firms increased their financial constraints. Here, the green credit policy helps in mitigating those constraints and protecting the quality of the environment through determining investments and corporate financing. Green credit is the most crucial financial element that leads to sustainable firm performance, economic growth, environmental protection, and sustainable development (Song et al. 2021). Thus, green credit is a basic tool for the enhancement of green finance. Moreover, the current state of COVID-19 creates a situation where manufacturers also facing the biggest issues in green finance. Currently, the COVID-19 crisis has destroyed the world economy brutally; it gives an immense impact on the supply chain. It has been discussed in detail in the succeeding paragraph.

Due to the pandemic, all the economies of the world were stunned, and affected the manufacturing and service sectors viciously. This pandemic increases various issues related to socio-economic crises and public health(Yu et al. 2021b). The global economy was negatively affected by the coronavirus eruption. The networks of the supply chain were already suffering from geographical dispersion and had now become interdependent and complex. One of the surveys in the USA at the institute of supply chain management investigated and found that 75% of companies reported disruption in their supply chain. Due to this disruption, there was massive unavailability of product materials, leading to shortages in final products. This causes the situation of import and export of the materials and products to worsen with the lack of freight options. This created a "manufacturing desert" in the whole world, and the export from China declined significantly as China dominates the global supply chain (Ibn-Mohammed et al. 2021). Many organizations faced enormous issues, companies suffered multiple challenges such as a decline in demand, disturbances in the supply chain, cancellation in exports, raw material shortfall, and transportation network disbands (Yu et al. 2021b). The tremendous decline in industrial operations, supply, and demand for energy and transportation activities has given the long-term move in industrial and consumer behavior. Such

a move could reorient monetary and fiscal policies towards the SDGs (sustainable development goals). Thus, the government will is one of the successful features in enabling green finance in the country in this situation, which helps in financial policies, economic policies, manufacturing of products, and services that further transform the economy, system, and institutions to attain sustainable development. The importance of green finance has been seen in the last few years but COVID-19 has created a situation where green finance now become more prominent as a main theme; it comes up with the new economic strategies to recover the enormous losses that has been incurred due to this COVID-19 pandemic.

Moreover, in December 2019, the COVID-19 has brought severe challenges to the bond market and global stock market as well (Wagner 2020). Due to the COVID-19, the green bonds are tattered through the capital market and the environment. As green bonds are very famous in the financial market in China, it exceeds RMB 1.1 trillion from 2016 to 2019; it makes China the second-largest green bond market in the world. Thus, the larger amount spent on environmental protection and reducing pollution, which depicts the major importance of the green bond for the development of China's ecological building. Thus, how the green product market reacts to this pandemic is equally important to study (Wagner 2020; Li et al. 2021).

Additionally, for supporting sustainable firm performances and reducing financial grief, many banks all over the world have introduced the concept of green credit financing. It is a financial service that helps firm in investing in sustainable development projects which inspire firms to invest more in green investments. Green credit financing is beneficial for reducing carbon emissions; the main objective of green credit is to maintain the sustainable operation of a firm by adopting abundant loan standards. However, the manufacturing industry plays the biggest role in economic growth and creates wealth and employment (Ong et al. 2019). Globally manufacturing firms added the value of 14.17 trillion US dollars, further; however, presently manufacturing sector is one of the greatest sectors in the world which is negatively disturbing the whole environment (Piyathanavong et al. 2019).

More serious environmental issues have been faced and have gained much attention from public sectors and governments (Joo and Suh 2017; Chu et al. 2017). For the reduction of carbon emissions, different policies have been regulated by the governments for creating awareness of sustainability and to reduce the environmental effects of operational activities of firms. The UK for example already launched a (CRC) Carbon Reduction Commitment, a mandatory system that reduced carbon emissions by 1.2 million tons a year in 2020 (Bai et al. 2019). China has also implemented many systems to cut carbon emissions, in China, the Ministry of

Environmental Protection has issued a serious warning of closure to the companies that did not reduce carbon after a specific period (Banciu and Mirchandani 2013). Most companies in China are now upgrading themselves and trying to invest more and more in green tools, which ultimately aggravates their capital limitations (Cao and Yu 2018). At the same time, firms in many developing countries are struggling to access credit from banks that have greater default risk and low credit ratings (Chen et al. 2021). Therefore, such insufficient financial reserves may depress firms to successfully face all environmental and sustainable issues (Walker and Preuss 2008).

Thus, green products can work as a powerful tool to foster the sustainable performance of a business and to make environmental friendly strategies that help in the allocation of credit resources; thus, it is imperative that green financing should be established as a profitable firm proposition that gives potential to large firms (Zubair Mumtaz and Alexander Smith 2019; Majeed et al. 2020). Therefore, through the above discussion, the current study has been able to develop a conceptual framework of the study, (Fig. 9b).

Distribution of green supply chain management publications based on major applications

Based on the analysis of the number of articles and keywords, positive correlations were found between the central theme and the sub-themes. The search phrase ("green finance") had 324 articles in Scopus and had 115 occurrences in VOSviewer. This was the most famous application of green supply chain management. The second most famous application was ('Environmental performance') with 102 occurrences in VOSviewer along with 17,568 articles in Scopus. Further, ('trade-credit') was also found one of the major applications as this existed with 60 occurrences and had 1743 articles in Scopus. ("Sustainable finance") was also one of the popular terms concerning green supply chain management with 60 occurrences and had 253 total articles in Scopus. One of the terms ("Climate Finance") had 447 publications in Scopus; however, it had only 06 occurrences means, it appears 6 times with other keywords. ("Reverse Logistics") was also the famous keyword that was used widely in green supply chain management, it had a vast collection of articles (3347) in Scopus and had 57 links with other keywords. Thus, this suggests that now scholars are realizing that green supply chain management is not the only goal to achieve sustainable renewable energies. Before 2020, there was much reliance on green supply chain management but now the term has many substitutes, it has been observed that now green finance or climate finance had taken over the previous terms related to green supply chain management.

Furthermore, research interest in particular areas can also be examined by the link strength of keywords. For example,

'green credit' has 39 links (connected to 39 other keywords), namely, climate change, energy efficiency, environmental regulations, carbon emissions, economic growth, sustainable finance, green economy, green innovation, green bonds, circular economy, environmental quality, green investments, sustainable development goals, and energy policy. It is recommended that research interest in green finance- sustainable development (9 link strength) was much stronger as compared to renewable energy (7 link strength) and green bonds (6 link strength). It is also found that the publications related to green finance, green credit, climate finance, environmental performances, sustainable finance, reverse logistics, and renewable energies mostly came from China.

Limitations of the study

We restrict the search by using "green finance" or "green supply chain management" "green credit" or "green supply chain finance" in articles and abstracts; this search outcome might not shelter all the articles related to green supply chain management that were available in Scopus. Because some scholars do not use green supply chain management, instead they used different keywords (such as sustainable supply chain, and GSCM practices). Further, this study was based on the Scopus database; scholars may use different databases also such as the Web of Science (WoS), or they may use both databases to compare results. The current study deals with only sustainability and renewable energies; future scholars may use the concept to see its impact on economic development and financial development.

Conclusion

This study addresses the idiosyncrasies in the literature by presenting a comprehensive bibliometric analysis that will help researchers to broaden their knowledge about green finance and green supply chain management phenomenon. The current study has given a comprehensive overview of green supply chain management research trends based on 2385 articles that were retrieved from the Scopus database. Rapid growth has been seen in publications for the last 10 years, and it is predicted that it will further rise as the world now become more concerned for its environment. We have revealed countries and academic institutions and found that China, India, Iran, and Taiwan have a vast collection of articles in the field of green supply chain management and have very strong international collaborations. These countries can be a groundbreaking opportunity for the UK and Australia to widen their research associations. We have discussed many areas that are recently been well explored such as environmental performances, reverse logistics, and trade credit; however, a few new areas are discovered like

green innovation, green finance, CSR, green information technology, green productivity, corporate environmental responsibility, carbon emissions, cold chain logistics, green credit guidelines, green investments, green credit, and green credit policy that still needs scholars attention and can be the hot topics for future scholars.

Significance and implications of findings

This study fills a literature gap by presenting a comprehensive bibliometric analysis that will help researchers to broaden their knowledge about the link between green finance and green supply chain management research. This study will help researchers by providing a comprehensive overview of the origin, evolution, and status of green finance research concerning green supply chain management. As this study provides a synthesized summary of the existing definitions, perspectives, and research trends within this field and discusses its distribution between subject areas, journals, countries, institutions, and authors, it shows that the field is constantly developing and allows researchers to find the potential future research opportunities.

Managers can benefit from the findings of this study as they now have comprehensive information about the significant actors in the field who are constantly developing the field. This would help them identify references to gain additional insights into the phenomenon. This may help them determine various current research trends such as green finance practices adopted by the sustainable firm's founders and how these practices guarantee the improved environmental performance of organizations. Further, they can enhance the understanding of how the process of green finance in GSCM is implemented in different economic sectors and the potential of the phenomenon for social and economic development and climate resilience. In addition, this study would help policymakers by identifying the leading countries involved in green finance, understanding their systems, and taking guidance for their research and development programs.

Policy recommendations

We suggest various recommendations for policymakers. First, policymakers should develop clear standardized policies on green finance for various sectors across the globe as organizations have continued to relegate the environmental standards. For that, policymakers should set meaningful targets for environmental performance, and construct a useful index to monitor the level of green performance. Based on performance results obtained from those indicators, the experts should enforce the penalties for large organizations violating green performance standards and restructure the green policies and funding accordingly. This will sort out

any irregularities in the enforcement of local and international laws. Second, literature shows that green finance level is low in developing countries as compared to developed countries. The findings indicate that green finance can promote green economic growth; thus, government should allocate further funding to the needed local sectors and industries with high pollution index to promote technology innovation and green economic success. However, green funding should be governed strictly based on the expected outcome. To make this more effective, efforts should be made to strengthen the communication and trust between regulatory authorities and organizations. Third, regulatory authorities should provide incentive schemes to promote the private sector's green finance. This can be done by providing tax credits and refunding a part of the tax increase to increase the rate of return of these green projects.

Potential avenues for future research

Based on the analysis of the study, we suggest potential directions for future research. First, the current study deals with only sustainability and climate finance, future scholars may use the concept to see its impact on economic development and financial development (Chien et al. 2021). For example, they may determine how to use green finance to better improve the green financial system, reduce investment risks, and stimulate a green economy and sustainable development. In addition, determining cointegration among variables of green finance, green innovation, and green economic growth would be of significance. Second, the findings show that studies on green supply chain management and circular economy have been investigated (Zhu and Sarkis 2004; Brandenburg et al. 2014; Dubey et al. 2016; Ghisellini et al. 2016; Khan et al. 2021). Nevertheless, more theoretical associations are needed to provide better explanations and enhance the understanding of the phenomenon (Liu et al. 2018). For example, focusing on how to implement green finance projects to obtain circular economy objectives in the international framework would be useful for global sustainable development. Third, the result suggests that there is a need to investigate green technology concerning green finance as the literature lacks enough evidence about the phenomenon. For example, researchers can determine the associations between green finance and new technological concepts such as blockchain and artificial intelligence. This will be helpful to evaluate green innovation techniques and major roadblocks in the organizations for improving environmental performance (Madaleno et al. 2022). Fourth, as the past literature suggest that it is important to see which financing approach is much better for green investment. Yet, few studies have been done on carbon emissions within green credit financing and trade credit financing (An et al. 2021). Thus, the current study suggests that there is a need

to investigate the differences between trade credit and green credit financing under the carbon emissions concept.

Declarations

Ethics approval and consent to participate Not applicable.

Consent for publication Not applicable.

Competing interests The authors declare no competing interests.

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