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A Quantitative and Qualitative Review of Green Supply Chain Research from 2010 to 2024



Ruijiao Shi¹, Xiaolin Li² & Yu Qiao^{1,*}

¹ Department of Logistics management, Guangzhou Huali College, Guangzhou 511300, China

² Department of Construction Engineering and Management, North China University of Water Resources and Electric Power, Zhengzhou 450046, China

Abstract: Scientifically mapping the evolutionary trajectory of green supply chain management (GSCM) research and tracking its cutting-edge developments is of critical significance for enterprises' sustainable growth. Although there are literature reviews on green supply chain management in existing studies, with the development of society and time, their content has certain lag. Based on this, the study examines the research on green supply chain management from the Web of Science (WOS) database spanning from January 2001 to August 2024 as its subject matter. By utilizing bibliometric software Citespace 6.3R1, the article conducts quantitative statistical analysis, co-citation analysis, keyword clustering analysis, and keyword burst analysis on textual data from the 7,743 valid articles ultimately obtained. The article begins by outlining the overarching framework of green supply chain management research through quantitative analysis of textual data. Furthermore, by combining manual induction of literature content, the evolution path, hotspots, and frontiers of green supply chain management research are ultimately revealed. The study found that green supply chain management has experienced four stages of development, and finally presents four trends, such as environmental performance, supplier management, green supply chain management and green innovation. Based on this, suggestions have been put forward to conduct in-depth research on enterprise performance, green supplier management, circular economy, and green innovation. This study helps scholars to grasp the research context of green supply chain management as a whole and promote the theoretical development of green supply chain management research.

Keywords: green supply chain management; supplier management; knowledge graph; bibliometric analysis; green innovation

1. Introduction

Traditional supply chain management integrates value chain nodes by leveraging complementary strengths, specialized division of labor, and collaborative cooperation. This approach enhances the overall competitiveness of the supply chain (Weng et al., 2013). However, it also overlooks environmental and resource sustainability. The single-minded pursuit of economic benefits has resulted in environmental degradation, resource shortages, and ecological imbalance. In response to

the drawbacks of traditional supply chains, at the 1996 "Environmental Responsible Manufacturing (ERM)" seminar, environmental and resource allocation issues were first integrated with supply chain management. This gave rise to the concept of green supply chain management (Handfield, 1996). A green supply chain involves businesses integrating environmental protection into the entire supply chain. They implement measures to reduce resource consumption and minimize waste emissions and pollution. The goal is to achieve sustainable development in economic, environmental, and social aspects (Zhang et al., 2017). It has been found that

Corresponding Author: Yu Qiao

Department of Logistics management, Guangzhou Huali College, China

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green supply chain management brings a range of benefits, including enhancing corporate performance (Zhu & Sarkis, 2004), boosting core competitiveness (Hoek, 2013), reducing environmental regulation costs (Seman et al., 2019), increasing customer loyalty (Baker & Sinkula, 2005), promoting sustainable development (Hart & Dowell, 2011), encouraging green innovation activities (Boström et al., 2015), and improving productivity and eco-efficiency (Vivek & Sucheta, 2022). It can even impose additional costs exceeding the product's environmental premium, negatively impacting financial performance (Wang & Zheng, 2014). Based on this, to explore the aforementioned research differences, scholars have begun to focus on studying the intrinsic mechanisms and constraints between green supply chain management practices and corporate performance, aiming to uncover the relationship between them (Xie & Zhu, 2022). As can be seen, existing research mainly focuses on specific sub - fields or particular issues related to green supply chains. Little effort has been made toward conducting a systematic and comprehensive review of the green supply chain discipline, or tracking the evolutionary trajectory of green supply chain research over the long term.

In the face of the rapid growth of research outputs on green supply chains, further comprehensive reviews of existing research are of great significance. Therefore, this study employs science knowledge graphs. It utilizes papers from the Web of Science (WOS) Core Collection. Using CiteSpace6.3R1 software, it conducts bibliometric research such as keyword clustering, hotspot word clustering, literature co - citation, and emerging word analysis. This approach explores the evolution and frontiers of green supply chain management. This study makes three main contributions: (1) it systematically combs the discipline system of green supply chains, analyzing their research from the perspectives of theoretical origins, core concepts, and developmental threads; (2) it uses bibliometric tools to objectively describe the theoretical framework of green supply chain management, offering scientific evidence for building its discipline system; (3) it tracks the developmental trajectory of green supply chain management over time. By employing scientific knowledge graphs, it visualizes the

research process, hotspots, and frontiers of green supply chain management, clearly showing its developmental structure, threads, and patterns.

2. Research Design

2.1. Methods

In this study, quantitative and qualitative analysis were adopted to review green supply management research. By means of CiteSpace6.3R1, research hot spots and frontiers can be preliminarily described using quantitative analysis, objectively. By quantitative analysis complementing the results of quantitative analysis, some important but neglected research topics can be identified (Li et al., 2023). In comparison with other bibliometrics software, CiteSpace6.3R1 has its own special advantage, that is, it can conduct keyword-burst analysis. Specifically, a keyword which has been of highly concern to the academic community in a certain period of time will be marked as citation burst (Sun et al., 2021). So, this function is usually utilized to find research frontiers. Consequently, this study mainly conducts document co-citation analysis and keyword-burst analysis, adopting CiteSpace6.3R1 to identify the research hotspots and research frontiers of green supply research.

2.2. Data Collection and Processing

The WoS database is one of the largest and most prestigious citation databases in the world, and contains many authoritative and influential international academic journals and publications (Li et al., 2021). What is more, it is often used as a data source to carry out bibliometric analysis in many research fields. Therefore, we took the WoS database as the main source to collect relevant literature on green supply chain management research. Important information from publications, such as publication year, source journals, etc., was gathered. In addition we set the time span from 2001 to 2024, the study examines the development of green supply chain management in the past 20 years, but due to the time limit of the study, the literature of this study is up to August 30, 2024.

3. Quantitative and Qualitative Analysis

3.1. Descriptive Analysis

3.1.1 Primary-Source Journals

This research identifies and evaluates selected primary-source journals for journal articles on green supply chain research. The results are presented in Table 1.

Table 1. The Top10 Source Journals in the Green Supply Chain Research Field from 2001 to 2024

Source Journal	Publication	Co	Countries	Field	IF	Category Quartile
Journal of Cleaner Production	884 (11.34%)	69	USA	EN	9.7	Q1
Sustainability	726 (9.31%)	64	Switzerland	EVS	3.3	Q3
International Journal of Production Economics	252 (3.23%)	101	Holland	EN	9.8	Q1
Computers & Industrial Engineering	149 (1.91%)	2545	England	EN	6.7	Q1
Environmental Science and Pollution Research	171 (2.19%)	1174	Germany	EVS	5.8	Q3
International Journal of Production Research	161 (2.07%)	101	England	EN	5	Q2
Business Strategy and the Environment	182 (2.33%)	713	USA	EVS	12.5	Q1
Resources Conservation and Recycling	102 (1.31%)	2919	Holland	EVS	11.2	Q1
Supply Chain Management-an International Journal	97 (1.24%)	2655	England	MGT	7.9	Q3
Transportation Research Part E-logistics and Transportation Review	86 (1.10%)	2744	England	EN	8.3	Q1

Note:Co= Frequency of Co-citations of Journals;Country= Host Countries;EN= Engineering; EVS= Environmental sciences;MGT=Management;IF=Impact Factor

The total 1127 journals published 7743 articles from 2001 to 2024, and Table 1 shows the top 10 publishers with the highest yield in the green supply chain research field, including journal percentages and co-citation frequencies as assessed by Citespace's journal cocitation function, and journals' host countries and research areas. Obviously, most of the top 10 journals are closely related to engineering. Journal of Cleaner Production had published 884 articles in the green supply chain research field,

ranking first. The journal with the second largest number of publications is Sustainability (publication=726) followed by International Journal of Production Economics (publication =252). According to Li et al. (2021), the degree of authority and influence of a journal can be evaluated by its citation frequency. Thus, from this perspective, the top three most influential journals were resources conservation and recycling (co-citation=2919), transportation research part

e-logistics and transportation review(co-citation=2744) and supply chain management-an international journal(co-citation=2655).Considering the publishing quantity,frequency of co.citations of journals and IF, this research takes Resources Conservation and Recycling and the Supply Chain Management-an International Journal as the most influential journals in the green supply chain research field.

3.1.2 Academic Performance of Different

Table 2. The Top10 Productive Countries/Regions in the Green Supply Chain Research Field from 2001 to 2024

Country/Region	Publication	Centrality	Country/Region	Publication	Centrality
China	2691(34.75%)	0.05	Taiwan	379 (4.90%)	0.03
India	945 (12.21%)	0.06	Italy	361 (4.66%)	0.04
USA	884 (11.42%)	0.14	Malaysia	341 (4.40%)	0.03
England	782 (10.10%)	0.16	Pakistan	329 (4.25%)	0.09
Iran	509 (6.58%)	0.00	Australia	318 (4.10%)	0.06

In summary, authors from 128 countries/regions published their articles in the green supply chain research field from 2001 to 2024. Table 2 presents the top 10 most effective countries/regions. It can be seen that China exceeds the number of papers published by all other countries/regions, with 2691 papers. It is obvious that the top three countries, including China, India, and The USA published 58.38% of all the publications, showing their huge contributions. Among other countries/regions, researchers from Italy, Malaysia, England, Pakistan, Iran and Australia, contributed greatly to this field, as well. In addition, the connection between different countries and

Stakeholders

The academic contribution of stakeholders was separated into different levels: macro level (countries/regions), intermediate level (institutions) and micro level (authors) (Li et al., 2023). Such classification can provide researchers with a comprehensive understanding of the scholarly performances of important stakeholders at all levels (Li et al., 2021).

regions of the academic activities of central countries/regions are identified, using betweenness centrality(>0.1). To be specific, England (centrality =0.16), USA (centrality = 0.14) occupy the key position in connecting different countries and regions showing their outstanding academic performances in the green supply chain research field (as can be seen in Table 2).

Table 3. The Top10 Most Productive Institutions in the Green Supply Chain Research Field from 2001 to 2024

Institution	Country	Publication	Percentage	AVE
Indian Institute of Technology System IIT System	Indian	160	2.07%	56.39
Islamic Azad University	Iran	141	1.82%	39.38
Hong Kong Polytechnic University	China	137	1.77%	104.71
University System of Ohio		136	1.76	51.33
Chinese Academy of Sciences	China	120	1.55%	56.38
National Institute of Technology Nit System	India	113	1.46%	47.2

University of Southern Denmark	Denmark	98	1.27%	147.72
Indian Institute of Management Iim System	Indian	95	1.23%	58.36
Tianjin University	China	94	1.21%	34.99
Dalian University of Technology	China	89	1.15%	170.15

Note: AVE = The Average Citation Frequency Of All Papers In the Corresponding Institutions.

From an intermediate-level (institution) perspective, Table 3 displays the top 10 institutions in terms of the number of publications. As can be seen, Indian Institute of Technology System IIT System topped the list with 160 papers, followed by the Islamic Azad University (publication=141). The remaining productive organizations came from China, Denmark and Indian. Additionally, AVE in Table 3 refers to the average citation frequency of an institutions correlative publications, as $AVE = NCF$

/n. Here, "NCF" represents the citation frequency of all publications of institutions, and "n" means the number of papers published by different institutions. Consequently, AVE could be used to describe the academic influence and visibility of institutions. It is noteworthy that the AVE of Dalian University of Technology ($AVE = 170.15$) and University of Southern Denmark ($AVE = 147.72$) are quite high, indicating that these institutions have great academic influence and popularity.

Table 4. The Top10 Productive Authors in the Green Supply Chain Research Field from 2001 to 2024

Author	Publi-	H-Index	AVE	Author	Publi-	h-Index	AVE
		x				x	
Sarkis, Joseph	97	104	120.31	Tseng, Ming-Lang	46	67	38
Govindan, Kannan	77	102	84.12	Mangla, Sachin K.	43	56	49.58
Zhu, Qinghua	49	63	138.82	Lopes De Sousa Jabbour, Ana Beatriz	40	45	69.29
Khan, SYED ABDUL REHMAN Chiappetta	48	66	55	Lai, Kee-hung	38	66	70.9
Jabbour, Charbel Jose	48	68	65.96	Luthra, Sunil	33	56	53.48

Note: Publi= Publication; AVE = average citations per publication.

Table 4 lists the top10 most productive authors in the field of green supply chain research. It can be seen that all the listed scholars have at least 33 articles in the green supply chain research field. To further evaluate their academic performances, we used both h-index and average citation per publication (AVE). In this respect, Sarkis, Joseph had the highest h-index, of 97. In addition, Sarkis, Joseph and Zhu, Qinghua had an AVE of 120.31 and 138.82, respectively showing their outstanding influence in

this field. All thing considered, this research takes Sarkis, Joseph, and Zhu, Qinghua as the core authors in the green supply chain research field.

3.2 Quantitative Analysis

3.2.1 Document Co-citation Analysis

To grasp the research path in this field as a whole, Citespace 6.3 R1 was examined with a 4-year time period and threshold values of (2, 2, 20), (3, 3, 20), and (3, 3, 20) were set to co cite 7743 literature records. The Time zone view was used to display the

structural relationships of co cited network nodes over time. Table 5 lists the key milestone literature in this field from 2001 to 2024, including their publication time, co citation frequency, and total citation frequency (as of August 30, 2024).

Table 5. List of Total Cited Documents in Green Supply Chain Management

Author	Document	Year	Co	TC
Hong ZF and Guo XL	Green product supply chain contracts considering environmental responsibilities	2019	222	473
Zhu WG and He, YJ	Green product design in supply chains under competition	2017	191	449
Abu Seman NA,et al.	The mediating effect of green innovation on the relationship between green supply chain management and environmental performance	2019	171	307
Singh SK,et al.	Green innovation and environmental performance: The role of green transformational leadership and green human resource management	2020	167	889
Çankaya SYand Sezen, B	Effects of green supply chain management practices on sustainability performance	2019	166	300
Sarkis J,et al.	An organizational theoretic review of green supply chain management literature	2011	161	1323
Zaid AA, et al.	The impact of green human resource management and green supply chain management practices on sustainable performance: An empirical study	2018	160	387
Geng RQ,et al.	The relationship between green supply chain management and performance: A meta-analysis of empirical evidences in Asian emerging economies	2017	154	349
Ahi P, and Searcy, C	A comparative literature analysis of definitions for green and sustainable supply chain management	2013	149	821
Fahimnia B,et al.	Green supply chain management: A review and bibliometric analysis	2015	141	1093

	Quantitative models for sustainable supply chain management: Developments and directions	2014	132	781
Brandenburg M, et al.				
	Green supply chain game model and analysis under revenue-sharing contract	2018	131	271
Song HH and Gao, XX				
	A game theoretic approach for green and non-green product pricing in chain-to-chain competitive sustainable and regular dual-channel supply chains	2018	124	234
Jamali MB and Rasti-Barzoki, M				
	Green innovation and organizational performance: The influence of big data and the moderating role of management commitment and HR practices	2019	124	626
El-Kassar AN and Singh, SK				
	Multi criteria decision making approaches for green supplier evaluation and selection: a literature review	2015	123	703
Govindan K,et al.				
	Green supply chain management: An investigation of pressures, practices, and performance within the Brazilian automotive supply chain	2017	114	259
Vanalle RM, et al.				
	Blockchain technology and its relationships to sustainable supply chain management	2019	111	1594
Saberi S,et al.				
	Pricing policies of a competitive dual-channel green supply chain	2016	110	412
Li B, et al.				

Note: Co = frequency of co-citations of journals;TC=frequency of Total Citations of journals

(1)Concept Germination Stage (2001-2005): Initial Exploration of Green Supply Chain Research

During this stage, scholars began to explore the concept of the green supply chain, with research primarily focusing on the conceptual definition and fundamental theories of green supply chain management.For instance, Bowen F E et al. (2001), with 560 total citations in this field, sampled 70 UK firms and initially explored the role of incorporating green management concepts into supply chain management. Their results indicate that green supply chain management can somewhat promote corporate development. Sarkis J (2003) explored green supply

chain management concepts, models, and practices, and proposed using ANP technology to determine the relative priority of different elements. This provides theoretical and methodological guidance for green supply chain management practices.Ahi P and Searcy C (2013) differentiated between green and sustainable supply chain management across various dimensions. They found that green supply chain management mainly focuses on the environmental dimension, while sustainable supply chain management typically encompasses economic, environmental, and social dimensions.

(2)preliminary development stage (2006-2012): Research on influencing factors and evaluation system of green supply chain

According to the knowledge map of the time - zone cited in the literature, the number of key nodes in this stage is gradually increasing, and scholars have launched research on green supply chains. The research focuses on “influencing factors” and “evaluation system”: 1) In terms of influencing factors, some scholars have analyzed them from the perspective of different pressure systems. An empirical analysis of 98 automobile enterprises shows that competition, regulation, and market pressure can further promote corporate supply chain development (Zhu et al., 2007). In addition, some scholars believe that company leaders, suppliers (Testa & Iraldo, 2010), environmental legislation (Diabat & Govindan, 2011), green product types (Zhu & He, 2017), the types of cooperation contracts (Hong & Guo, 2019), green innovation (Seman et al., 2019), green procurement (Yildiz Çankaya & Sezen, 2019) and internal environmental management (Zaid et al., 2018) promote or inhibit the development of green supply chain to varying degrees. 2) In terms of evaluation system, many scholars evaluate the application effect of green supply chain through the performance of enterprises. For example, Zhu, Qinghua evaluate the adjustment effect of internal and external green supply chain practice on enterprise performance through the results of environmental performance, economic performance and operational performance (Zhu et al., 2012).

(3)Diversification Stage (2013-2017): Applied Empirical Exploration of Green Supply Chains across Multiple Industries

During this period, green supply chain management research entered a diversification stage, expanding its scope across multiple industries with ample applied empirical studies. Scholars focused on industry - specific characteristics in green supply chain management and effective implementation strategies. Annual publications in this field grew from 119 in 2013 to 339 in 2017, almost tripling. This growth reflects the growing integration of green concepts into various industries. Luthra S et al. (Luthra et al., 2015) used India's mining industry as a case to explore the interplay between key factors during green supply chain implementation. This

helps practitioners, regulators, and scholars ensure sustainable green supply chain management at all levels. Scur G and Barbosa M E (Scur & Barbosa, 2017) studied the green supply chain management practices of several Brazilian appliance manufacturers. Their study found that these enterprises most commonly applied waste management in their green supply chain management practices. Motivating factors included national and international regulatory pressures and export - related environmental requirements.

(4)Technological Innovation Stage (2018-2024): Applied Exploration of Technological Innovation in Green Supply Chains

Amid sudden changes in international political and economic landscapes, innovation has become crucial for domestic breakthroughs (Qi & Mao, 2020). Consequently, driven by these environmental factors, technological innovation in green supply chains has become a research focus. The main keywords in this stage are “green innovation”, “green technology”, “digital twins”, “closed-loop supply chains”, “Industry 4.0”, “blockchain technology”, and “digital transformation”. Unlike other stages, scholars here mainly use big data as a technological innovation tool to study green supply chains. As Saberi S et al. (2019) posited, blockchain technology can revolutionize supply chain design, organization, operation, and management. Its ability to ensure information reliability, traceability, and authenticity facilitates smart contract relationships within the supply chain, thereby driving its re-evaluation and optimization.

3.2.2 Research Hotspot Analysis of Green Supply Chain Management

Keywords are words or terms extracted from literature that reflect its core content. Studying keywords helps analyze hotspot issues in a scientific field (Liu et al., 2019). Therefore, this study will comprehensively determine the research hotspots of green supply chain management by using keyword centrality and cluster analysis.

(1)Keyword Clustering Analysis

In CiteSpace 6.3R1, select the Keyword node with a time - span of 2001–2024, keep other settings at their defaults, and remove irrelevant or small sub - networks to generate a keyword clustering map (Li et al., 2022). The network-modularity-based Modularity

and the network-homogeneity-based Sihouette both range from 0 to 1. A larger Modularity value indicates better clustering, with values exceeding 0.3 suggesting significant network communities. A larger

Sihouette value denotes higher network homogeneity, and values above 0.5 indicate reasonable clustering (Li & Chen, 2017).

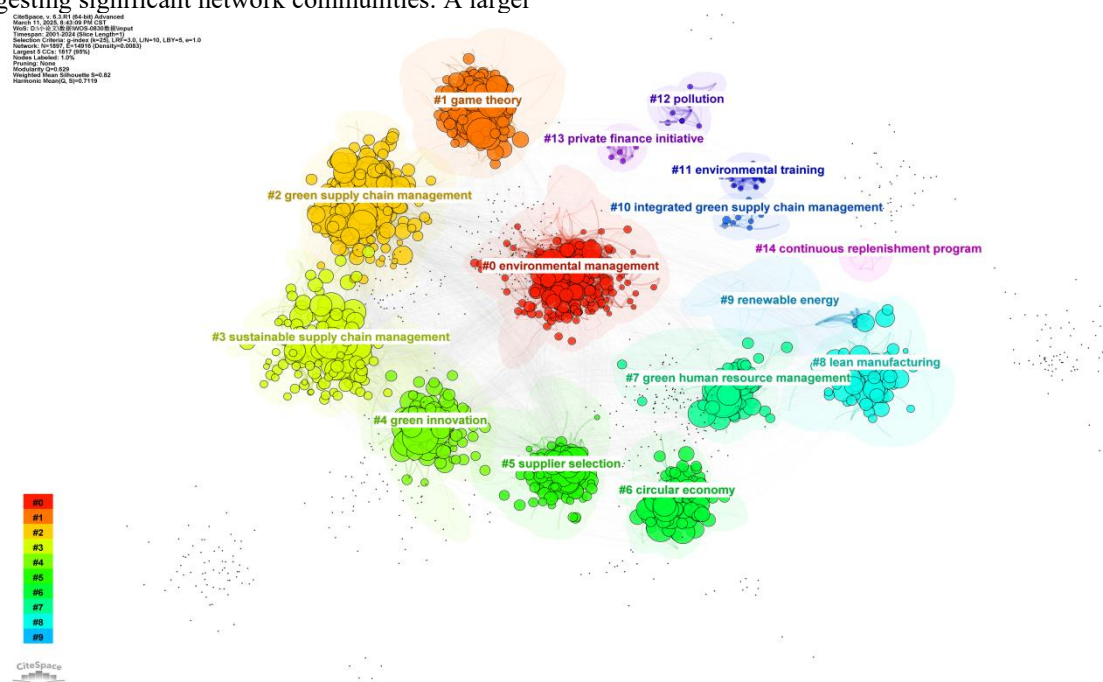


Figure 1.Keyword Clustering Map

In the keyword clustering map (Figure 1), Modularity and Sihouette values of 0.7119 and 0.82 indicate good network clustering. The map can be divided into several clusters, such as environmentail management, game theory, supplier selection, and circular economy. These clusters reveal research hotspots in green supply chain management. The detailed cluster information is listed in the table, showing that most clustering occurred between 2014 and 2018. Recent research hasn't yet formed distinct clusters.

Table 6. Table of Cluster Details

Cluster Label (LLR)	Size	Silhouette	Average Time	Key Words
#0 environmental management	351	0.997	2007	supply chain management;performance Framework;environmental management
#1 game theory	269	0.999	2017	channel coordination;green products;optimal decisions;supply chain members;stackelberg game GSCM practices;institutional
#2 green supply chain management	260	0.997	2015	pressures; economic performance;critical success factors;green manufacturing sustainable supply
#3 sustainable supply chain management	221	0.997	2013	chains;sustainability performance;performance measurement;environmental impact firm performance;green innovation;financial
#4 green innovation	169	0.998	2018	performance;product innovation;green product innovation;manufacturing firms
#5 supplier selection	169	0.999	2013	supplier selection;green supplier selection;environmental criteria; group decision making;performance evaluation
#6 circular economy	123	0.999	2018	industry 4;big data analytics; circular economy practices; business models;global supply chains
#7 green human resource management	86	0.999	2018	human resource management;mediating role;planned behavior;studys

				findings;environmental
				pollution;sustainable consumption
#8 lean manufacturing				life cycle;green practices;
				sustainable performance;
	80	0.999	2015	manufacturing companies;
				sustainable manufacturing;
				structural equation modelling
#9 renewable energy				Co ₂ emissions;environmental
	27	1	2010	protection;cleaner manufacturing;
				green hydrogen;green multiplier effect
#10 integrated green				industrial ecology;comparative
supply chain management	14	1	2001	logistics
#11 environmental				air transportation;analyzing logistics;
training	14	1	2002	alternative scenario
#12 pollution	12	1	2000	air pollution;business perspectives

(2) Manual Summary of Research Hotspots

Combined with keyword frequency, centrality, and cluster analysis, and drawing on classic literature and expert judgment, four major research hotspots in green supply chain management were identified.

Performance Management (#0 Environmental Management). Representative keywords include green supply chain management, automotive industry, environmental performance, and environmental sustainability. Green supply chain management, a new organizational philosophy evolved from supply chain management, refers to businesses enhancing their own and their partners' environmental and social performances while achieving economic benefits (Yi & Xue, 2016). The Taiwan scholar Ming-gui Qian (2007) divided the performance of green supply chain management into two dimensions: financial and environmental performance. Ren Ligai's (2021) research indicates that implementing green supply chain management can enhance a company's green competitiveness through various pathways, including green procurement, eco-design, internal environmental management, green consumption, and investment recycling. This also ensures greater support for improving the intensity and efficiency of green technological innovation investments and for boosting financial performance

levels. However, Esfahbodi A et al. (2017) argue that green supply chain management doesn't significantly impact corporate financial management performance. Instead, due to heavy initial capital investment, it can considerably negatively affect economic performance and competitive advantage (Walley, 1994).

Game Theory (#1 Game Theory). Representative keywords include channel coordination, green products, and optimal decisions. This hotspot mainly focuses on two aspects: ① Using game theory models to set product pricing strategies. For instance, Zhu Qinghua, using a game - theory model, proposed two pricing strategies. For manufacturers with a passive green supply chain management strategy, as consumers' environmental awareness grows, they should maintain product greenness and slightly increase prices. And with a higher government-set subsidy floor, they should keep the product greenness but moderately lower the price. ② Using game - theory models to investigate maximizing the interests of supply chain nodes. Cao Jian's (2011) research shows that coordination strategies based on collaborative decision - making benefit the green supply chain system/members and boost consumer welfare. Long Q et al. (2021) proposed using game-theory models to promote green supply chain development by enhancing green sensitivity among enterprises and consumers.

Circular Economy (#6 Circular Economy, #8 Lean Manufacturing, #9 Renewable Energy, #11 Environmental Training, #12 Pollution). Representative keywords: industry 4, big data analytics, circular economy practices, cleaner manufacturing, air pollution. The circular economy aims to minimize environmental pollution and waste generation by optimizing waste recycling, urban industrial symbiosis, and other lifecycle management measures for resource and energy circulation (Dong et al., 2021). Scholars mainly conduct cross-sectional studies to explore the relationship between the circular economy and green supply chain management, concluding that the circular economy promotes green supply chain management (Aming et al., 2024; Caniels et al., 2013). Green supply chain management is a key corporate strategy for implementing the circular economy principles of reduce, reuse, recycle, and recover (Wu et al., 2001). From a sustainable development perspective, green supply chain management is an inevitable trend for corporate survival and circular economy building (Wang & Yan, 2009).

Supplier Management (#5 Supplier Selection, #7 Green Human Resource Management). Representative keywords: supplier selection, green supplier selection, human resource management. As per the EU definition, green supply chain management integrates environmental principles into supplier and manufacturing mechanisms. This makes products more eco-friendly and competitive, ushering in a new era of environmentally friendly manufacturing. Some research has covered green supply chain management and corporate social responsibility individually. However, few studies have examined the integration of internal corporate management and external supplier management from the perspective of sustainable supply chain management (Xie et al., 2017). Supplier management is crucial to green supply chain management and has gained more attention in recent years. This model is extending along the supply chain, indicating that future cooperation among multi-level suppliers will be closer (Wang, 2011). Ecological supplier management, a new field emerging with green supply chain management, is also one of its core components (Tang, 2011).

Sustainable Supply Chain Management (#2 Green Supply Chain Management, #3 Sustainable Supply Chain Management, #10 Integrated Green Supply Chain Management). Representative keywords: GSCM practices, institutional pressures, sustainability performance. Green supply chain management runs through product lifecycle stages like design, raw-material procurement, and logistics, emphasizing environmental factors. Sustainable supply chain management goes further by stressing social responsibility in supply chain stages, such as economic benefits and employee-rights protection. For example, well-known companies like Coca-Cola, Walmart, and JD.com collaborate with suppliers, distributors, and users to create “low-carbon supply chains”, achieving environmental and economic wins and laying the foundation for sustainable supply chain development.

Green Innovation (#2 Green Supply Chain Management, #4 Green Innovation, #8 Lean Manufacturing). Representative keywords: firm performance, green innovation, financial performance. This research hotspot mainly focuses on two aspects: ① Exploring the impact of innovation tools on green innovation. For example, Mehmood K et al. (2023), based on an empirical study of 397 manufacturing enterprises, found that big data analytics significantly promotes green innovation. ② Empirical studies on how green innovation affects corporate performance and recommendations. For instance, Ren H et al. (2023) indicate that enhancing supply chain performance and forming information and communication technology capital are key drivers for green growth. They advise companies to increase investment in green manufacturing practices, smart distribution networks, and energy-efficient logistics infrastructure to reduce the environmental impact of economic growth.

(4) Analysis of Research Frontiers in Green Supply Chain Management

The keyword burst detection based Citespace6.3R1 technique can spot scientific research frontiers. Import literature data into Citespace6.3R1, select the Keyword node and set the property to BurstTerms (2015–2024), and 15 burst terms will be generated. Scholars have noted that research frontiers are transitory elements in scientific literature. As they are in a constant state of flux, it is challenging to

ascertain their long term value. Based on this, emergent burst terms after 2015 are displayed, as shown in Table 7.

Table 7. Top 15 Keywords with Strongest Bursts of Big Data Research

Bursts keyword	Bursts intensity	Starting year	Termination year	2015-2024
Environmental management	29.4	2015	2018	
Reverse logistics	21.13	2015	2018	
Product development	15.3	2015	2018	
Life cycle assessment	12.83	2015	2018	
Group decision making	9.2	2016	2017	
Analytic network process	9.85	2017	2018	
Cleaner production	10.09	2020	2022	
Sustainable performance	14.04	2022	2024	
Mediating role	11.49	2021	2024	
Industry 4.0	14.76	2022	2024	
Green human resource management	13.46	2020	2023	
Blockchain technology	11.19	2023	2024	
Cooperation	10.79	2022	2024	
Trade credit	9.09	2023	2024	
Risk	9.09	2023	2024	

It can be seen that keywords such as industry 4.0, sustainable performance and blockchain technology in Table 4 have surged in recent years, indicating that research on industry 4.0, sustainable performance and blockchain technology is likely to be the forefront of current research on green supply chain management.

4. Tentative Conclusions

4.1 Conclusions

This research takes the literature of green supply chain management as the research object in the web of science core collection database as the data basis. Firstly, the research power of green supply chain and the distribution of source journals are statistically analyzed, and the overall situation of green supply chain management research is revealed. Then, with the help of CiteSpace 6.3r1, it quantitatively and visually analyzes and displays the research evolution path, hot spots and frontier fields. The results show that the research evolution of green supply chain management has gone through four stages: the embryonic stage of concept

(2001-2005): the preliminary exploration of green supply chain research; Preliminary development stage (2006-2012): Research on influencing factors and evaluation system of green supply chain; Diversified development stage (2013-2017): Empirical Exploration on the application of multi industry green supply chain; Technology innovation stage (2018-2024): application and exploration of technology innovation in green supply chain. The four research hotspots are performance management, game theory, circular economy and supplier management; Research on industry4, green hydrogen, digital transformation, carbon neutrality and so on is likely to be the forefront of current green supply chain management research.

4.2 Recommendations

This study shows that the research of green supply chain management is an evolving process. In practice, green supply chain management presents three trends: environmental performance occupies an important position in enterprise performance; Supplier management has become the key of enterprise green supply chain management; Green supply chain management has become an important

means of circular economy development; Green innovation has become an important tool for the transformation of green supply chain management. Based on the research conclusion and practical development trend of this paper, the following topics are worth further discussion: (1) enterprise performance research. Because the impact of environmental performance, financial performance and operational performance on enterprise performance is quite different, it is still a valuable research topic to explore the impact of different performance on the overall performance of enterprises; (2) Research on green supplier management. Supplier management is an indispensable part of enterprise supply chain management. The success of an enterprise not only depends on the efficiency of its internal operation, but also largely depends on the quality and stability of its supplier network. Therefore, in order to maintain the sustainability of green supply chain, green supplier management is also a hot topic; (3) Circular economy. With the increasing tension of global resources and increasing environmental pressure, the excessive consumption of resources and the worsening environment have become major challenges facing human society. As a new economic model, circular economy has become an important path to achieve sustainable development with its characteristics of efficient utilization of resources and environmental friendliness. Green supply chain promotes the development of circular economy through source control, optimizing product design, greening packaging and transportation, promoting product recycling and reuse, and improving economic and social benefits. (4) Green innovation. Because green innovation can help enterprises optimize resource allocation, reduce pollution emissions, improve resource utilization efficiency, and achieve sustainable development of enterprises, it has gradually become a hot topic in academia. In addition, with the rising level of global science and technology, digital transformation will become a new trend of green innovation. The use of digital technologies such as big data, cloud computing and artificial intelligence can further promote the development of green innovation.

Conflict of Interest

The authors declare that they have no conflicts of interest to this work.

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