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Supply Chain Management, Sustainability, Performance and Technology: A Bibliometric Analysis

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ABSTRACT

The current study undertakes a quantitative bibliometric approach to examine a global research landscape on Supply Chain Management, Sustainability, Performance, and Technology. emerging research themes using keywords clustering are explored and underexplored themes are uncovered. Only 659 articles from the Clarivate Analytics Web of Science database are considered The search strategy included the terms (((TS=("Supply Chain Management")) AND TS=(Sustainability)) AND TS=(Performance)) AND TS=(Technology).keywords clustering revealed most prominent topics as " blockchain applications for supply chain management sustainability", " technology driven sustainability" . This study highlights literature gaps advocated mainly to industry 4.0 technologies long-term sustainability implications and trade-offs in sustainable supply chain practices of blockchain technology. Technological advancement alone does not adequately address sustainability challenges related to environmental, social, and economic sustainability objectives. The originality of the problem is attracting increasing attention from researchers and industry professionals, as evidenced by the large number of recent bibliometric studies on this topic. However, the topic of this article has not yet been addressed.

Keywords: Bibliometric Analysis, Supply Chain, Sustainability, Industry4.0, Performance, Technology.

INTRODUCTION

The s**upply chain** management involves coordinating a network of entities, activities, resources, and technologies that participate in goods and services flows from suppliers to final consumers (Beamon, 1998). Organizational performance is enhanced by supply chain processes through efficient logistics and material flows (Ikevuje et al., 2024). Furthermore, SCM includes the planning and control of information and inter-organizational operations (Cooper et al., 1997).

Supply chain management improves organization's performance and its overall competitiveness (Harifi, 2024). The Supply Chain Operations Reference (SCOR) is a widely accepted model for assessing SCM performance using metrics related to reliability, responsiveness, agility, assets, and costs (Tsang et al., 2024).

Industrial activities and the burning of polluting fuels since the 1970s have contributed to a remarkable 90% increase in carbon dioxide emissions, principal reason for climate change. Henceforth, there is an urgent need to implement sustainable business practices and to prevent additional climate change (Guan et al., 2022).

Modern SCM must take into account (the sustainability "triple bottom line") environmental, social, alongside economic objectives, through sustainable performance (Pinto, 2017). They must meet the developmental needs of organizations without compromising the ability of subsequent generations to meet their own developmental needs.

In the past two decades e-commerce knew a remarkable growth. The principal challenge was to enhance growth and achieving sustainable development goals. Such trade-off has made global competition among

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companies more complex. Hence, sustainable business model has provided a competitive advantage for organizations (Nosratabadi et al., 2019). In a dynamic commercial environment and Industry 4.0 framework, new challenges arose in front of SC **resilience, and corporate performance sustainability**. Industry 4.0 brings a new vision of industry regarding how manufacturing collaborates with integrated information technologies, such as cyber physical systems, cloud computing and Internet of Things, to achieve maximum performance with minimal resources. Industry 4.0 is expected to strengthen declining economic, environmental, and social values by using modern technologies and integrating processes (Stock & Seliger, 2016). Nevertheless, new Industry 4.0 sustainability issues which need to be urgently addressed (Kamble et al., 2018).

Several emerging technologies such as artificial intelligence, business analytics (big data), the Internet of Things, blockchain and cloud computing have been introduced. Business processes and corporate performance have been significantly impacted by the technological progress. Resource allocation and network connectivity either (Urbach et al., 2017). A special literature focused on sustainability driven by blockchain technology. Blockchain technology is identified as a prominent emerging technology. A study by McKinsey showed that using blockchain technology facilitates the exchange of transaction records among entities and eliminate intermediaries. More than 90 use cases of blockchain technology in business applications showed that the main blockchain impact was reducing costs of existing operations (Batra et al., 2019).

Previously cited emerging technologies alongside with machine learning, virtual reality, augmented reality, and mixed reality enable companies to collect and analyze consumer data. The main objective is to provide personalized recommendations that offer end users immersive and interactive experiences (Ameen et al., 2020; Chylinski et al., 2020; Flavián et al., 2019; Holmlund et al., 2020). Although, Blockchain , the Internet of Thing (IoT), Artificial Intelligence, 5/6G networks, Augmented Reality/Virtual Reality and industry 4.0 are among the top ten most important emerging technologies in 2019 (Rayome, 2019), it is noticed that the industrial metaverse improves company performance and facilitates informed decision-making by providing access to real-time data and analytics (Kumar et al., 2023). It is remarkable that companies implementing industrial metaverse applications have achieved significant advantages by reducing investment costs (15%), improving sustainability (10%), and increasing safety standards (9%) compared to their competitors (ET-Telecom, 2023). Countries like the United Kingdom and South Korea have presented long-term government plans for the manufacturing sector to ensure that they can the benefit from what Industry 4.0 offers. Approximately 27% of manufacturers in South African estimate their level of digitalization is high, and that percentage should rise to 64% within the next five years (Lu et al., 2024).

Supply Chain Management ensures that products and services reach consumers in a timely and cost-effective manner. Meanwhile, performance measurement drives continuous improvement. Technological advancements, enables real-time monitoring, predictive analytics, and automation. However, long-term success hinges on sustainability. Integrating **supply chain management, improving performance, technology, and sustainability** is crucial for companies seeking to maintain their competitiveness in today's dynamic market.

Many recent bibliometric studies were implemented about Supply Chain Management and related topics denoting its increasing importance in industry and academia. (Al-Faouri et al., 2024) presented perspectives on the smart strategies that organizations use to enhance supply chain processes and increase overall performance but did not address sustainability.

(Leyva Ricardo & Pancorbo Sandoval, 2024) highlighted the role of circular supply chain, however, performance and technology advancements were out of scope. (Zhang et al., 2024) considered digital finance, circular economy and blockchain technology as emerging research topics in the digital SCM framework. (Hassam et al., 2024) presented an extensive review of blockchain-based supply chains. (Balcıoğlu et al., 2024) presented the dominant emerging research trends at the intersection of SCM and blockchain. (Hartanto & Apriani, 2024) analyzed and outlined the implications of supply chain financial management. (Esmaeilian et al., 2020) highlighted the relationship between Blockchain technology and Industry 4.0 and focused on its important role into the supply chains sustainability enhancement. (Manavalan & Jayakrishna, 2019) studied the different aspects of SCM, enterprise resource planning (ERP), the Internet of Things (IoT) and Industry 4.0, exploring the potential opportunities available in the sustainable supply chain integrated with IoT to transform Industry 4.0. The objective of this bibliometric analysis is to examine the global research landscape on Supply Chain Management, Sustainability, Performance and Technology by retrieving relevant publications from the Web of Science database. A growing interest is advocated to recent development in technology advancements and industry 4.0. They are key trends whose development has significant impact on supply chain management; hence, the actual bibliometric study has the following objectives:

1. To analyze publication and citations trend.
2. To identify influential journals and articles.
3. To map the geographical and institutional research productivity.
4. To examine authors contributions and collaboration networks.
5. To explore emerging research themes using keywords clustering.

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The subsequent sections are structured as follows. Section 2 introduce the research method for retrieving articles. In section 3, results concerning key contributions, collaboration analysis, keywords analysis and underexplored themes are presented and discussed and finally section 4 concludes the paper.

METHODOLOGY

The actual study undertakes a quantitative bibliometric approach to analyze the dataset retrieved from the Clarivate Analytics Web of Science database on January 27, 2025 to examine a global research landscape on Supply Chain management, Performance, Technology and Sustainability. Bibliometric method is a robust quantitative approach allowing scientific knowledge mapping and uncover relationships among research areas, scholars, and their publications (Balcıoğlu et al., 2024). Bibliometrics provide valuable insights into fundamental research focuses, academic collaborations, and networks driving knowledge advancement (Hartanto & Apriani, 2024). Figure-1 explains the screening process of articles on Web of Science database. The search strategy included the terms (((TS=("Supply Chain Management")) AND TS=(Sustainability)) AND TS=(Performance)) AND TS=(Technology).The initial search resulted in 774 published documents between 2005 and 2025. The year 2025 was excluded using a year filter. From publication type filter, only articles and journals were selected. Documents other than articles and reviews were also discarded. Hence, 13 published records during 2025, 1 editorial, 36 proceeding papers, 7 book chapters, 2 retracted paper and 56 papers (early access) which will be published in final version during 2025 are excluded. Finally, 659 articles are considered for the bibliometric analysis. Microsoft Excel (v. 16, Microsoft Corporation, Redmond, Washington) and VOSviewer (v. 1.6.10) were used for data visualization and analysis. The impact factor of each journal is considered according to the Journal Citation Reports (JCR) of 2023. The Citation Impact represents the average number of citations per publication. It is calculated by dividing the total citations by the number of publications, which indicates the overall citation impact of the journal.

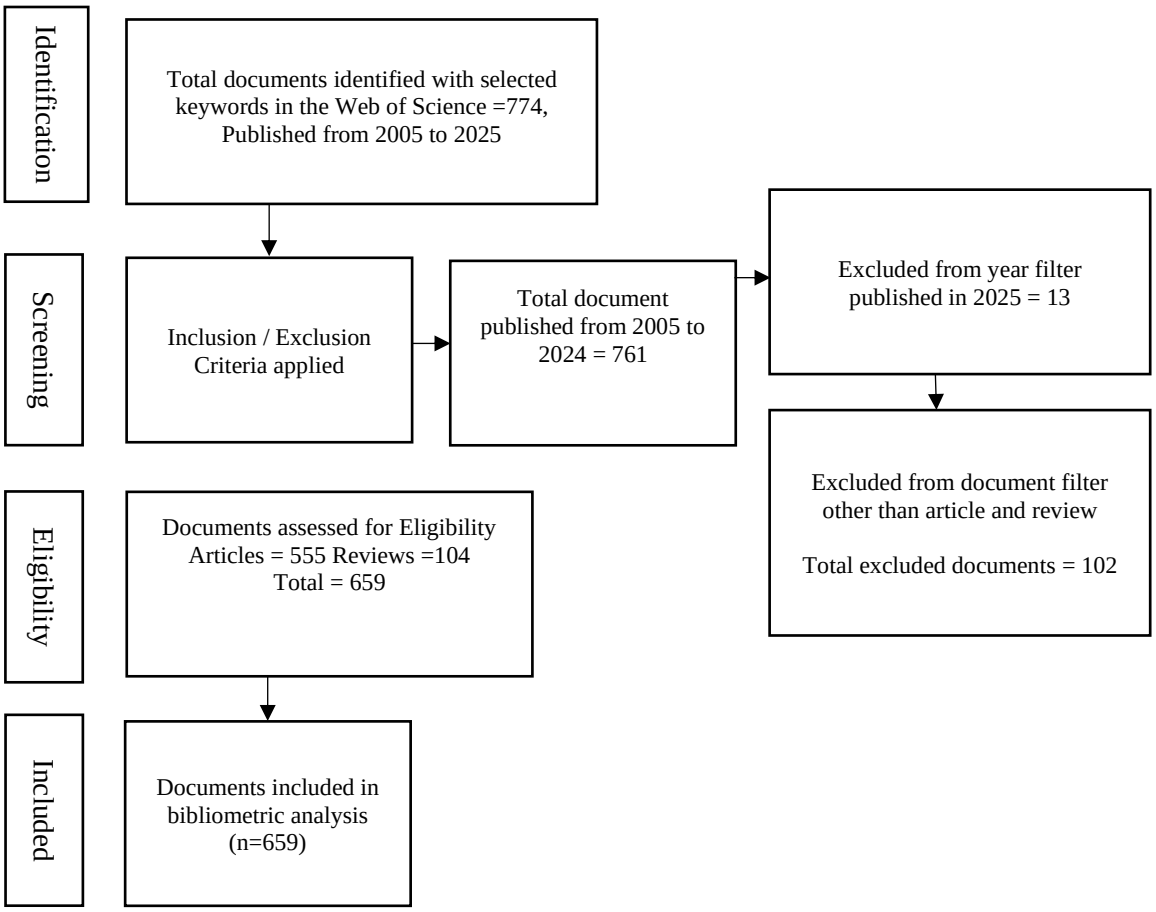

Figure 1. Screening process of articles on Web of Science database.

RESULT AND DISCUSSION

Growth of Articles and Citations by Years

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The evaluation of academic research output is based on tracking publication activity over a defined period and across specific entities such as journals, institutions, or countries. By analyzing these publication metrics, it becomes possible to quantify research trends, identify leading contributors, and highlight key themes explored during the study period**.**

A bibliometric analysis was conducted to examine the evolution of literature on SCM, Performance, Technology and Sustainability between 2005 and 2024. The study identified prominent institutions, influential countries, and leading authors, demonstrating a significant increase in research interest over the years. As illustrated in Figure 2, Web of Science publication activity is knowing an exponential increasing trend from 2016 until 2024 with a maximum of 138 published articles in 2024. Total citations had the same trend and peaked 5145 citations in 2020, however the citation impact was higher in 2019. Since 2020 total citations is declining although the total number of articles is continuing to increase exponentially. These trends highlight the difficulties to deal with new and unexpected issues like pandemics, geopolitical tensions, Energy provision (Russia-Ukraine conflict) and prolonged maritime disruptions in the Red Sea and the Gulf of Yemen. SCM and Performance Sustainability deeply underpin companies' success, however, they are risk sensitive and there is an urgent need for an effective and successful risk management to support a planned technology driven Supply Chain resilience. The increasing importance of supply chain and related topics research continues to drive scholarly interest. In total, 659 articles have been analyzed, accumulating 28750 citations, averaging an overall citation impact of 43.6 and 1513.16 citations per year.

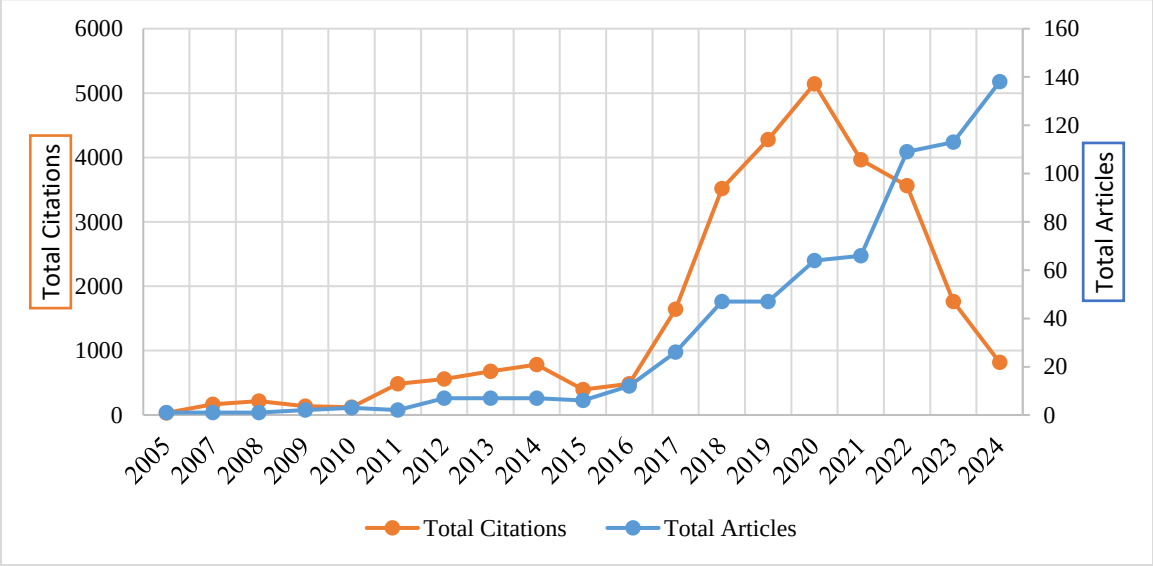

Figure 2. Total Articles and Total Citations Evolution from 2005 to 2024.

Key Contributions

All articles were published in 221 sources, 140 (63.34%) sources published only one article each and the remaining 81 sources published more than a single article. Table-1 summarizes top 20 journals contributions. Sustainability is the journal which published the most in the last 20 years on the SCM, performance, technology, and sustainability with a special focus on sustainability; 86 articles were published in Sustainability with 862 citations and a citation impact of 10.02. Moreover, Table-2 shows that Sustainability journal has published (in 2019) a single article among the top 20 most cited articles in the last two decades with a total citation of 263. However, the International Journal of Productivity and Performance Management and the Journal of Manufacturing Technology Management published only 7 articles each with total citations of 2036 and 4155 respectively and citation impacts of 290.86 and 593.57 respectively. Table-2 shows that the Journal of Manufacturing Technology Management has published a single article among the top 20 most cited articles with a total citation of 523. Business Strategy and the Environment journal climbs at the top 5 journals in Table-1. It has the best Impact factor (12.5) among the other Top 20 journals and probably the best balance between total published articles and Citation Impact. Table-2 shows that Business Strategy and the Environment journal published a single article among the top 20 most cited articles in the last two decades with a total citation of 250. Among the 221 sources, the top 5 journals in Table-1 published 30.8% of the articles with an average citation impact of 15.67. Only 11 journals among the top 20 best publication activity journals have published at least one article in the top 20 most cited articles.

Table 1. Top 20 Journals.

Serial No.	Source	Impact Factor	Articles	Citations	Citation Impact
1	Sustainability	3.3	86	862	10.02

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2	Journal of Cleaner Production	9.8	58	862	14.86
3	International Journal of Production Economics	9.8	24	364	15.17
4	Business Strategy and the Environment	12.5	20	898	44.90
5	Supply Chain Management-an International Journal	7.9	15	196	13.07
6	Environmental Science and Pollution Research	No	14	117	8.36
7	Benchmarking-an International Journal	4.5	12	402	33.50
8	Computers & Industrial Engineering	6.7	12	74	6.17
9	Production Planning & Control	6.1	12	829	69.08
10	Sustainable Production and Consumption	10.9	12	775	64.58
11	International Journal of Production Research	7.0	11	486	44.18
12	Management of Environmental Quality	4.6	10	332	33.20
13	Technological Forecasting and Social Change	12.9	10	1169	116.90
14	Environment Development and Sustainability	4.7	9	858	95.33
15	Journal of Enterprise Information Management	7.4	8	279	34.88
16	International Journal of Logistics Management	7.2	7	321	45.86
17	International Journal of Productivity and Performance Management	3.6	7	2036	290.86
18	Journal of Manufacturing Technology Management	7.3	7	4155	593.57
19	Operations Management Research	6.9	7	123	17.57
20	Resources Conservation and Recycling	11.2	6	220	36.67

Table 2. Top 20 Most Cited Articles.

	Authors	Titles	Journals	Year	Total Citations
1	Kamble, SS; Gunasekaran, A; Gawankar, SA	Sustainable Industry 4.0 framework: A systematic literature review identifying the current trends and future perspectives	Process Safety and Environmental Protection	2018	689
2	Manavalan, E; Jayakrishna, K	A review of Internet of Things (IoT) embedded sustainable supply chain for industry 4.0 requirements	Computers & Industrial Engineering	2019	535
3	Nascimento, DLM; Alencastro, V; Quelhas, OLG; Caiado, RGG; Garza-Reyes, JA; Lona, LR; Tortorella, G	Exploring Industry 4.0 technologies to enable circular economy practices in a manufacturing context A business model proposal	Journal of Manufacturing Technology Management	2019	523
4	Esmaeilian, B; Sarkis, J; Lewis, K; Behdad, S	Blockchain for the future of sustainable supply chain management in Industry 4.0	Resources Conservation and Recycling	2020	419
5	Dubey, R; Gunasekaran, A; Childe, SJ; Papadopoulos, T; Luo, ZW; Wamba, SF; Roubaud, D	Can big data and predictive analytics improve social and environmental sustainability?	Technological Forecasting and Social Change	2019	404
6	Dao, V; Langella, I; Carbo, J	From green to sustainability: Information Technology and an integrated sustainability framework	Journal of Strategic Information Systems	2011	370
7	Awasthi, A; Govindan, K; Gold, S	Multi-tier sustainable global supplier selection using a fuzzy AHP-VIKOR based approach	International Journal of Production Economics	2018	367
8	Jia, F; Yin, SY; Chen, LJ; Chen, XW	The circular economy in the textile and apparel industry: A systematic literature review	Journal of Cleaner Production	2020	336

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9	Shahzad, M; Qu, Y; Zafar, AU; Rehman, SU; Islam, T	Exploring the influence of knowledge management process on corporate sustainable performance through green innovation	Journal of Knowledge Management	2020	309
10	Fatorachian, H; Kazemi, H	Impact of Industry 4.0 on supply chain performance	Production Planning & Control	2021	308
11	Jabbour, CJC; Jabbour, ABLD; Sarkis, J; Godinho, M	Unlocking the circular economy through new business models based on large-scale data: An integrative framework and research agenda	Technological Forecasting and Social Change	2019	306
12	Centobelli, P; Cerchione, R; Del Vecchio, P; Oropallo, E; Secundo, G	Blockchain technology for bridging trust, traceability and transparency in circular supply chain	Information & Management	2022	285
13	Kamble, S; Gunasekaran, A; Dhone, NC	Industry 4.0 and lean manufacturing practices for sustainable organisational performance in Indian manufacturing companies	International Journal of Production Research	2020	274
14	Nosratabadi, S; Mosavi, A; Shamshirband, S; Zavadskas, EK; Rakotonirainy, A; Chau, KW	Sustainable Business Models: A Review	Sustainability	2019	263
15	Di Vaio, A; Varriale, L	Blockchain technology in supply chain management for sustainable performance: Evidence from the airport industry	International Journal of Information Management	2020	257
16	Khan, SAR; Razzaq, A; Yu, Z; Miller, S	Industry 4.0 and circular economy practices: A new era business strategies for environmental sustainability	Business Strategy and the environment	2021	250
17	Zhang, YL; Sun, J; Yang, ZJ; Wang, Y	Critical success factors of green innovation: Technology, organization and environment readiness	Journal of Cleaner Production	2020	245
18	Rogerson, M; Parry, GC	Blockchain: case studies in food supply chain visibility	Supply Chain Management-An International Journal	2020	227
19	Wu, GC	The influence of green supply chain integration and environmental uncertainty on green innovation in Taiwan's IT industry	Supply Chain Management-An International Journal	2013	220
20	González, P; Sarkis, J; Adenso-Díaz, B	Environmental management system certification and its influence on corporate practices Evidence from the automotive industry	International Journal of Operations & Production Management	2008	217

In what follows VOSviewer software is used to illustrate co-occurences. Since its introduction in 2010, its growth has been literally exponential (Kirby, 2023). The total number of authors identified by VOSviewer software is 1955. 1736 (88.79%) authors contributed to a single article, 219 contributed to two or more articles. Among the 219 authors, 114 authors relate to each other's in 14 different clusters shown in Figure-3.

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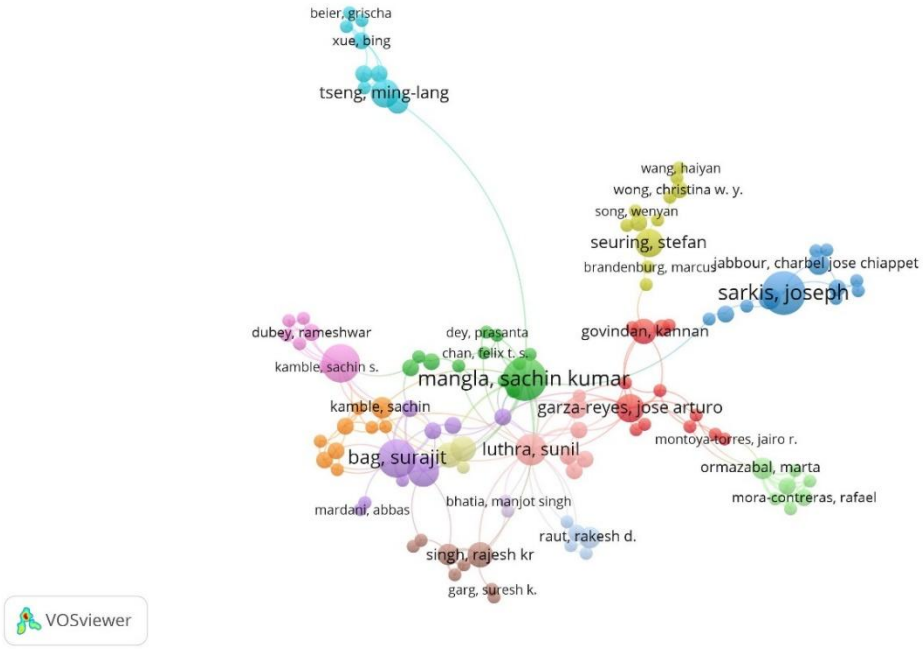

Figure 3. Authors co-occurrences.

Moreover, Table- 3 lists the top 20 authors who published more articles on SCM, performance, technology, and sustainability during the last two decades. Sarkis, Joseph has the highest number of publications (11 articles) and 3 of them are listed among the top 20 most cited articles. Mangla, Sachin Kumar, is leading one of the most important clusters in Figure-3. However, Gunasekaran, Angappa published only 9 articles and has the highest number of citations and the highest citation impact (192.33). Moreover, three of Gunasekaran, Angappa's articles are listed among the top 20 most cited articles. Gunasekaran, Angappa and Sarkis, Joseph are identified as the authors with the most impactful contributions in the last two decades.

Table 3. Top 20 Authors.

Serial No.	Author's Name	Total Articles	Total Citations	Citation Impact
1.	Sarkis, Joseph	11	1035	94.09
2.	Khan, Syed Abdul Rehman	11	852	77.45
3.	Yu, Zhang	11	847	77.00
4.	Mangla, Sachin Kumar	11	430	39.09
5.	Gunasekaran, Angappa	9	1731	192.33
6.	Bag, Surajit	9	717	79.67
7.	Gupta, Shivam	7	447	63.86
8.	Luthra, Sunil	7	424	60.57
9.	Umar, Muhammad	7	417	59.57
10.	Garza-reyes, Jose Arturo	6	788	131.33
11.	Centobelli, Piera	6	666	111.00
12.	Cerchione, Roberto	6	666	111.00
13.	Seuring, Stefan	6	516	86.00
14.	Tseng, Ming-Lang	6	345	57.50
15.	Govindan, Kannan	5	562	112.40
16.	Wang, Ying	5	443	88.60
17.	Chatterjee, Sheshadri	5	186	37.20
18.	Chaudhuri, Ranjan	5	186	37.20
19.	Singh, Rajesh KR	5	127	25.40
20.	Jabbour, Charbel Jose Chiappetta	4	499	124.75

The most productive authors are the core of collaborative network and coauthor clusters. They have proficiency know how to take benefit from connections and collaborations. Reliable funding from grants and the attractiveness of accredited academic institutions have a significant impact on authors' performance (Vidiasratri et al., 2024).

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Collaboration Analysis

Figure-4 depicts the 1955 authors patterns. Most articles (186) were written by three authors, and they collected 7890 citations. However, articles written by four, five, six or seven authors have higher citation impacts. The highest citation impact is reached for articles written by seven authors. The largest proportion of the top 20 most cited articles (25%) were written by only three authors.

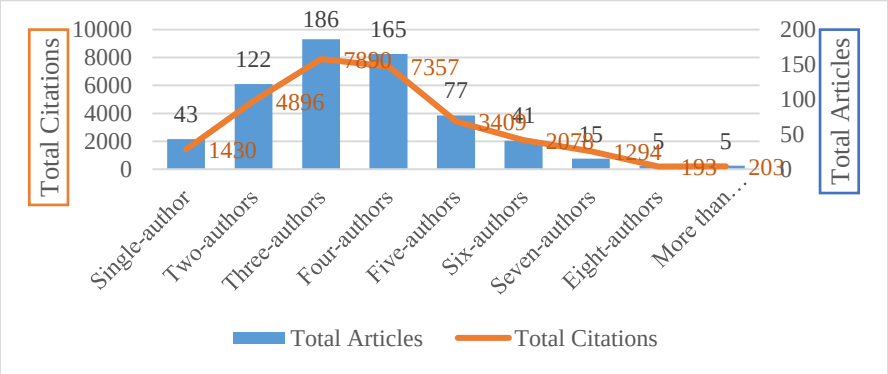

Figure 4. Authorship Patterns.

The authors belonged to 83 countries, 21 (25.30%) countries contributed to a single article and 62 countries contributed to more than one article. Top 20 most productive countries contributed more than 12 articles each and they are listed in Table-4. People's Republic of China is the most productive country, and England collected the highest citations, while the United States has the highest citation impact. Currently, People's Republic of China and India account for more than a third of all articles published on supply chain management, sustainability, technology, and performance.

Table 4. Top 20 Countries.

Rank	Country	Articles	citations	Citation Impact
1	Peoples R China	150	6565	43.77
2	India	129	5799	44.95
3	England	99	7283	73.57
4	USA	71	6383	89.90
5	Malaysia	46	1805	39.24
6	France	37	2481	67.05
7	Italy	37	2218	59.95
8	Australia	35	1563	44.66
9	Brazil	32	2026	63.31
10	Iran	30	612	20.40
11	Pakistan	29	1604	55.31
12	Germany	27	1907	70.63
13	Taiwan	25	972	38.88
14	Spain	24	1086	45.25
15	Canada	22	1258	57.18
16	South Africa	15	874	58.27
17	Saudi Arabia	15	336	22.40
18	Netherlands	14	700	50.00
19	Vietnam	14	684	48.86
20	Bangladesh	13	295	22.69

Figure-5 illustrates that all countries relate to each other's and consisted of eight clusters. Top 4 most productive countries are leading the most important clusters.

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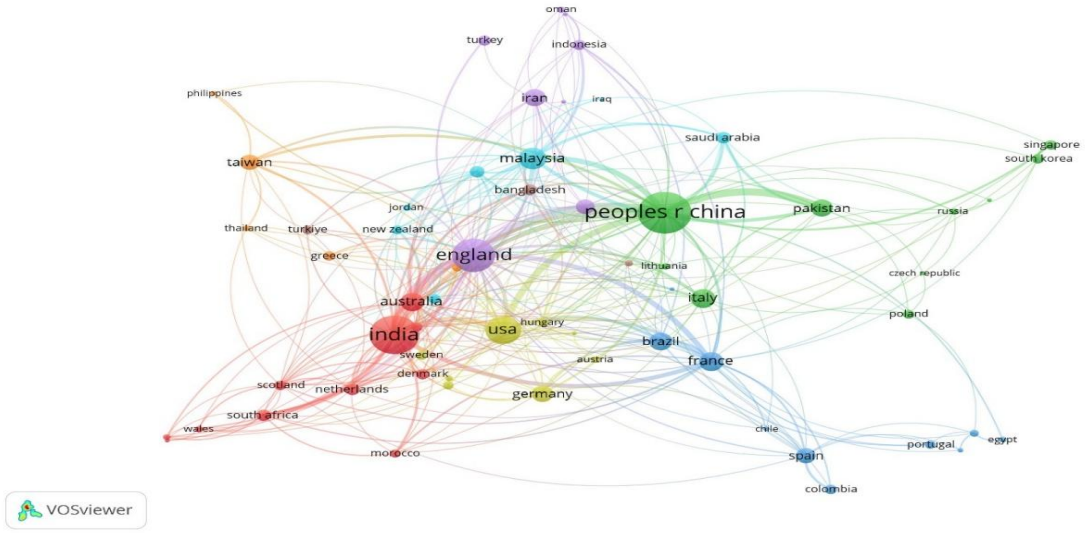

Figure 5. Countries Clusters.

A total number of 1029 organizations published articles on SCM and the studied related fields. 746 (72.50%) organizations contributed to a single article. The remaining 283 organizations contributed to two or more than two articles. Top 20 most productive organizations contributed to seven and more than seven articles each. Table-5 lists the top 20 most prominent institutions.

Table 5. Top 20 Organizations.

Rank	Organization	Articles	citations	Citation Impact
1	Changan Univ	16	1002	62.63
2	Ilma Univ	12	752	62.67
3	Univ Plymouth	12	707	58.92
4	Xuzhou Univ Technol	11	882	80.18
5	Hong Kong Polytech Univ	11	795	72.27
6	Worcester Polytech Inst	10	1339	133.90
7	Dalian Univ Technol	10	856	85.60
8	Univ Johannesburg	10	796	79.60
9	Neoma Business Sch	10	240	24.00
10	Indian Inst Technol	10	222	22.20
11	Islamic Azad Univ	10	182	18.20
12	Natl Inst Ind Engn Nitie	9	1339	148.78
13	Univ Naples Parthenope	8	1021	127.63
14	Univ Kassel	8	917	114.63
15	Univ Malaysia Terengganu	8	612	76.50
16	Univ Naples Federico II	7	673	96.14
17	Coventry Univ	7	506	72.29
18	Univ Fed Rio Grande Do Sul	7	430	61.43
19	Asia Univ	7	351	50.14
20	Management Dev Inst	7	154	22.00

224 organizations relate to each other and consisted of 23 clusters shown in Figure-6. Changan University (China) and Ilma University (Pakistanis private university) are the most productive, they are part of the same cluster. The National institute of Industrial Engineering (India) and the Worcester Polytech Inst. (private university in the USA) are the organizations with the highest citation and the highest citation impact. The university of Plymouth (England) climbs at the third position and is leading one of the most important clusters.

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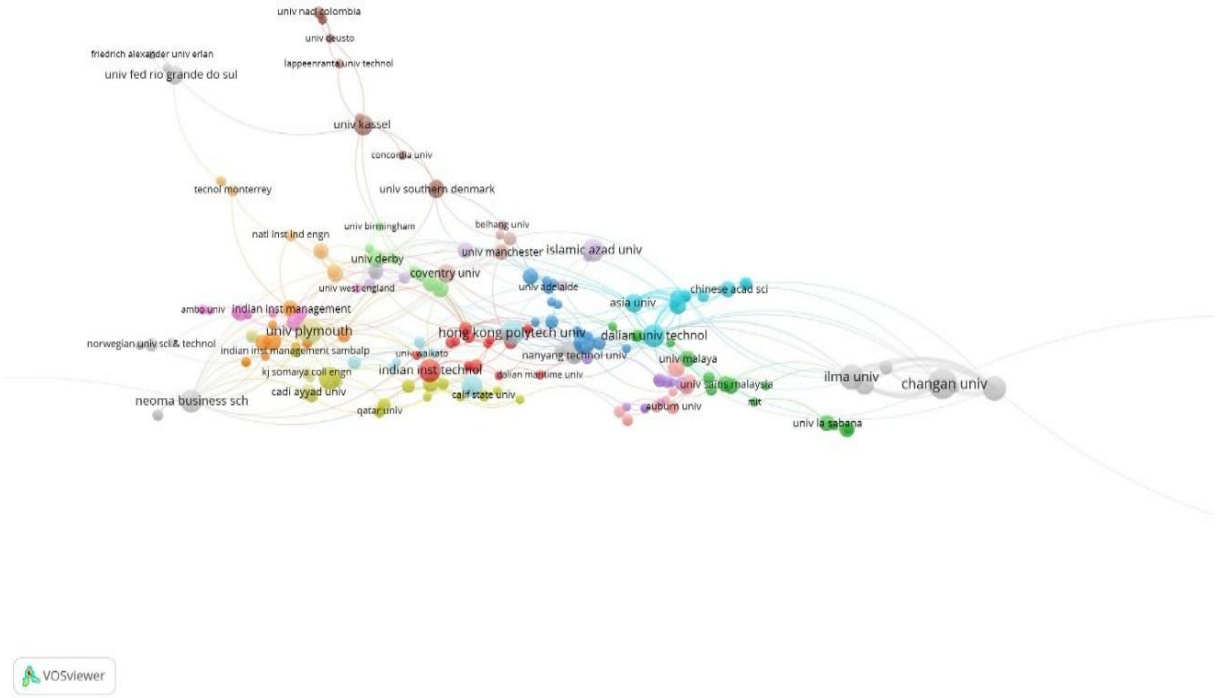

Figure-6. Organizations Clusters.

Keywords Analysis

Keywords Clustering is used to identify emerging research trends (Tanveer et al., 2022). The **Total Link Strength** is used to identify and prioritize keywords. The Link Strength represents the strength or intensity of the relationship between two items. For example, if two keywords often appear together in a group of documents, their link strength will be greater. The Total Link Strength of a particular item is the total of all link strengths it has with other items in the network. This measure reflects the overall connectedness or "significance" of that item within the network. It is helpful for identifying key or central nodes, as items with a higher Total Link Strength are more interconnected with other items and play a more dominant role in the network.

A total of 1889 keywords have been used by authors. 1496 (79.19%) keywords have been used once. 393 keywords used two or more than two times, consisted of 22 clusters depicted in Figure-7.

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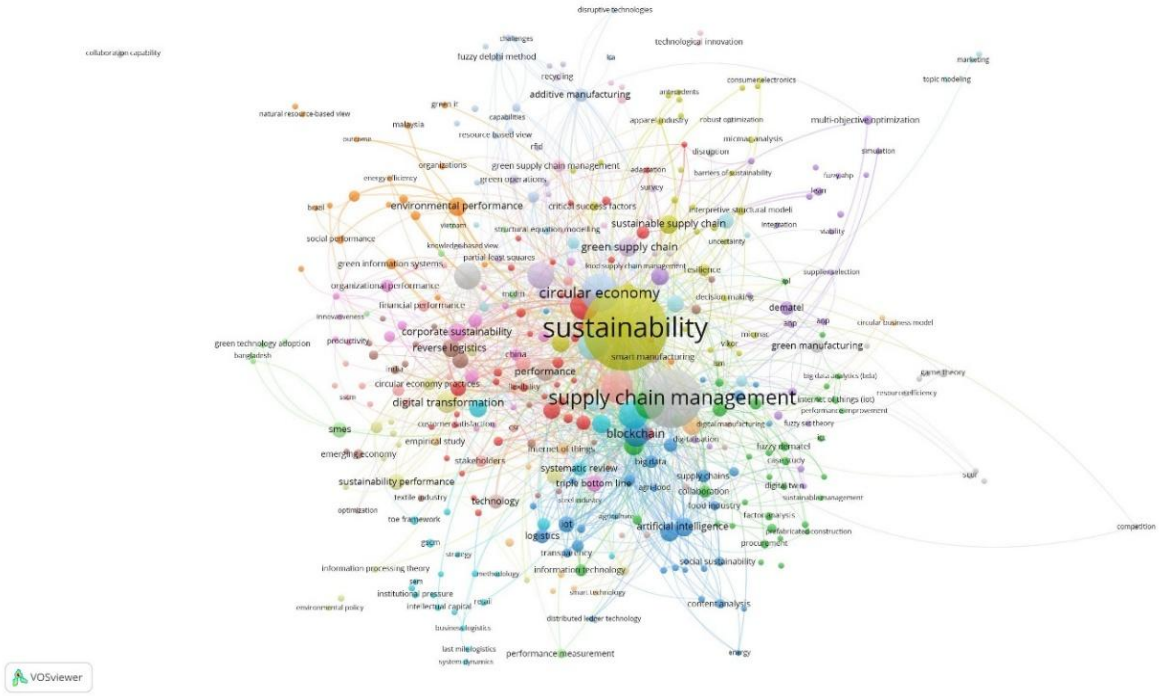

Figure 7. Keywords Clusters.

It is obvious that Sustainability and SCM are the most important clusters. Nevertheless, Figure-7 illustrates clusters that do not have equivalent weights. In what follows, based on the total link strength, keywords are prioritized, and Table-6 lists the most prominent keywords. SCM and sustainability are among the top 20 keywords, however, emphasis was on environmental performance and block chain technology. The top 20 keywords were clustered into 3 clusters as shown below in Figure-8.

Table 6. Top 20 Keywords.

Serial No.	Keyword	Occurrences	Total Link Strength	Cluster
1	Sustainability	211	195	Blue
2	Supply Chain Management	113	116	Blue
3	Circular Economy	54	76	Green
4	Sustainable Supply Chain Management	40	33	Red
5	Green Supply Chain Management	35	31	Red
6	Industry 4.0	34	53	Red
7	Industry 4	33	42	Green
8	Supply Chain	32	38	Blue
9	Sustainable Development	30	46	Green
10	Environmental Sustainability	29	26	Red
11	Blockchain	28	37	Blue
12	Digital Transformation	19	27	Red
13	Literature Review	17	30	Green
14	Blockchain Technology	17	24	Blue
15	Green Supply Chain	17	20	Green
16	Systematic Literature Review	16	21	Blue
17	Artificial Intelligence	16	19	Red
18	Environmental Performance	16	14	Red
19	Bibliometric Analysis	15	26	Green
20	Sustainable Supply Chain	15	12	Green

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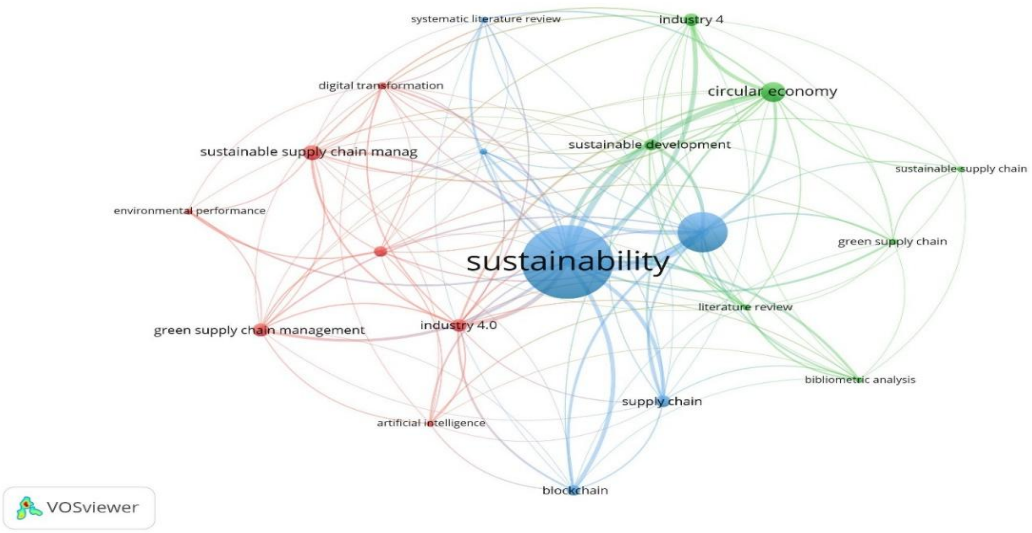

Figure 8. Top 20 keywords clusters.

The blue cluster is clearly about sustainable supply chain management using blockchain technology. It highlights the growing academic interest in how **blockchain applications improve** supply chains sustainability. Blockchain technology has certain negative impacts, but it plays a particularly important role in sustainability issues. It helps reduce product recalls and repairs due to its tracking capabilities; it facilitates tracking the actual environmental impact of products and allows for the precise calculation of the carbon tax that each company must pay; it promotes recycling behaviors by motivating and sensitizing individuals to participate in recycling programs; and improves the systems' efficiency by reducing fraud and increasing the system reliability. Furthermore, Blockchain technology helps companies improve sustainability reporting systems by allowing them to effectively monitor, manage and report on their activities. It enhances the efficiency of systems and reduces development and operational costs (Esmaeilian et al., 2020). The use of blockchain technology to connect distributed ledgers, databases and supply chain stakeholders can enhance efficiencies and ensure cost and time savings. Long and complex supply chains can be monitored with relative ease and efficiency (Upadhyay et al., 2021). Additionally, it is pointed out that blockchain technology enhances circular economy practices, which in turn promote the financial and environmental transparency of companies, ultimately resulting in better institutional performance (Khan et al., 2021).

Due to blockchain technology, the overall SCM is being reassessed, redesigned, and reshaped. In the current literature on blockchain technology, focus is only on the economic and environmental dimensions of sustainability. Another challenge for blockchain technology is the commitment to the requirement of adopting renewable energy systems (Vaio & Varriale, 2020). The presence of a **systematic literature review** among the first keyword cluster suggests a structured assessment of existing research on this topic.

The red cluster is reflecting sustainability in supply chain management driven by technological progress. It is triggered by the presence of the keywords artificial intelligence, industry 4.0, digital transformation at one hand and green supply chain management, environmental sustainability, environmental performance at the other. It reinforces the exploitation of technological progress to improve the **efficient use of resources, to reduce adverse environmental effect, and to promote sustainable strategies**. In the existing literature, the contribution of industry 4.0 to the creation of more sustainable value is attributed to the economic and environmental dimensions. In fact, Industry 4.0 has immense capacity to create sustainable value in the social dimension. Meanwhile, it is assumed that the implementation of business processes in intelligent manufacturing environments will reduce costs (Kamble et al., 2018). Indeed, it was proven that Industry 4.0 technologies have a positive significant effect on sustainable organizational performance while Lean Management Practices have a significant mediating effect on the indirect relationship between Industry 4.0 Technologies and sustainable performance (Kamble et al., 2020). Further implication of management practices and Industry 4.0 technologies on SC sustainability need to be explored (Al-Okaily et al., 2024).

However, practices of sustainable supply chain promote the use of sustainable energy. The vision of Industry 4.0 in Sustainable Supply Chain is that companies are completely digitally connected; thus, reducing their carbon emissions and helping stakeholders make dynamic decisions in real time. The Internet of Things allows for the connection of machines, components, devices, and users within the company. Not only to connect to one the manufacturing network, but by leveraging the cloud and the internet, it should be possible to link numerous networks to form many digital supply chains (Manavalan & Jayakrishna, 2019). In this way, the Internet of

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Everything (IoE) extended IoT by connecting not only physical things, but also people, organizations, and systems. In addition to IoE, the emergence of new technologies such as Edge Computing (EC), eXtended Reality (XR), and 5G/6G presented a development from industry 4.0 to Industry 5.0. The latter, goes beyond the technological development of manufacturing and production systems, focusing on humanity, sustainability, and resilience (Marinagi et al., 2023). Sustainable Supply Chain Performance topic needs to be adapted to Industry 5.0 paradigm.

The green cluster is the bibliometric insights into sustainable and technology driven supply chains. Focuses on bibliometric analysis and literature reviews that concentrate on the general theme of the **role of sustainability in development (circular economy) and digital transformation (industry 4.0)** in enhancing the supply chain sustainability. The integration of the circular economy and industry 4.0 to ensure the benefits of sustainable supply chains is a challenging task. Industry 4.0 addresses the barriers to understanding the complex mechanism within the dynamic system and enhances knowledge assessment and reflective control to adopt the Circular Economy. Industry 4.0 and the Circular Economy strengthen dynamic capabilities to integrate Sustainable Supply Chain Management; in turn, they enhance dynamic capabilities to improve knowledge assessment, develop supply chain partners, and promote joint development for Circular Economy and Industry 4.0 applications in management of operations.

In addition, the integration of industry 4.0 and the Circular Economy contributes to economic, environmental, and social sustainability. Furthermore, we are witnessing a revolution in the implementation of advanced technologies in industry, where not only economic and environmental sustainability must be considered, but also long-term social and humanitarian responsibilities (Lu et al., 2024). Circular Economy practices (circular design, circular supply, recycling and remanufacturing) significantly improve environmental and economic performance (Khan et al., 2021). However, CE practices do not always lead to a direct improvement in the organization's performance. In addition, the relationship between CSR and CE has yet to be further explored. The synergy between CSR and CE within the framework of Industry 5.0 envisions a shift toward human-centric, flexible, and regenerative production systems. By leveraging the digital technologies, businesses can enhance transparency, stakeholder engagement, and ethical governance, thereby strengthening their legitimacy in the eyes of the public. This global approach is in line with the principles of Industry 5.0, promoting a balance between economic success and social responsibility, thereby contributing to the development of sustainable and resilient supply chains, which are essential for the future of business and society (Santiago et al., 2024).

Identified Underexplored Themes

Considering the increasing academic interest in Supply Chain Management (SCM), Performance, Technology, and Sustainability, there are several topics that have been discussed little and deserve further research. Firstly, although Industry 4.0 technologies such as artificial intelligence, blockchain, and the Internet of Things (IoT) have been studied extensively, their long-term sustainability implications remain largely underexplored. Future studies should focus on the environmental and social impacts of these technologies, especially in the context of Industry 5.0, which prioritizes human-centered and sustainable supply chains. Furthermore, the integration of circular economy with Industry 4.0 technologies suffers from a lack of a comprehensive framework that links technological advancement to resource enhancement and waste reduction.

Secondly, while blockchain technology has been studied for improving supply chain transparency and efficiency, limited research addresses its trade-offs and limitations in sustainable supply chain practices. The energy consumption associated with blockchain, its adaptability to different industries, and its cost-effectiveness require further investigations. Additionally, there is a need for empirical research on how blockchain can enhance corporate social responsibility (CSR) efforts within supply chains.

A systematic bibliometric analysis of resilience-building strategies remains scarce. Future research should explore the intersection of digital transformation, risk management, and sustainability, focusing on how firms can build agile and crisis-resistant supply chains through technological and policy interventions. Ultimately, the measurement of performance in sustainable supply chains remains a fragmented area of research. Few studies assess the practical impact of innovations in the supply chain on the economic, social, and environmental performance of companies. More holistic performance measurement frameworks should be developed to assess the real-world applicability of sustainability-driven supply chain strategies.

CONCLUSION

The bibliometric analysis in this study provides an overview of research trends in supply chain management, sustainability, performance, and technology, highlighting topics that have rarely been critically explored. While there is a substantial body of literature on Industry 4.0, blockchain, and circular economy practices, research remains fragmented regarding their interdependencies and long-term implications for sustainable supply chains. A

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more integrated research approach is needed to assess how these technologies can jointly contribute to a resilient, transparent, and environmentally responsible supply chain ecosystem.

Furthermore, geopolitical, and environmental risks have amplified the urgency of supply chain resilience research. Future studies should explore strategic frameworks that combine digital innovation, sustainability principles, and risk management strategies to ensure long-term supply chain viability. The application of Industry 5.0 concepts in SCM, emphasizing human-centricity and ethical governance, also presents a promising avenue for further research. Future research should focus on the following topics:

- Long term sustainability trade-offs of Industry 4.0 technologies.
- Integration of circular economy and Industry 4.0.
- Blockchain role in enhancing CSR.
- Risk management and resilience in digital supply chains.

To maintain scholarly rigor and industrial relevance, future bibliometric analyses should incorporate qualitative assessments of research impact on industry practices. Bridging the gap between academic research and real-world supply chain applications will enhance the practical significance of bibliometric studies.

This study indicates the growing importance of supply chain sustainability in an era of rapid digital transformation and global uncertainties. Addressing underexplored topics will help pave the way towards more flexible, efficient, and environmentally friendly supply chains, ensuring that they can adapt to future challenges and opportunities.

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