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Digital Supply Chain Transformation in Industry: A Bibliometric Analysis

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Abstract

This study analyse the field of digital supply chain through bibliometric analysis to uncover trends, gaps, and potential research directions. Using the Scopus database, 224 articles related to digital supply chain transformation were examined. Findings reveal significant research gaps, particularly in AI applications and digital supply chains in industries beyond agriculture and food. The study identifies influential authors, key articles, and top keywords, as well as collaboration networks within the field. Tools such as VOSviewer and BiblioMagika visualised co-authorship networks by authors and countries, along with citation patterns, providing a comprehensive overview of digital supply chain management. Limitations include reliance on the Scopus database, potentially missing relevant publications from other sources, and a keyword-based search approach that may exclude valuable research not precisely matching chosen terms. Additionally, timeframe constraints might miss earlier or recent developments, affecting analysis comprehensiveness. Despite these limitations, the findings highlight the transformative potential of digital technologies in supply chains, offering a roadmap for future research and practical applications. The implications emphasize the need for further exploration of AI integration and digital transformation across various industries. This study is original in its comprehensive evaluation of digital supply chain transformation using bibliometric analysis. It employs quantitative methods to analyse citation patterns, collaboration networks, and top keywords, providing a holistic view of the field. By focusing on emerging technologies and managerial challenges, the study offers valuable insights for researchers and industry professionals, contributing to the advancement of digital supply chain practices.

Keywords: Digital Supply Chain, Bibliometric Analysis, Industry 4.0, Artificial Intelligence, Digital Transformation, VOSviewer

Introduction

Businesses are currently embracing digitalization, also known as digital transformation, to streamline processes through real-time information sharing made possible by digital connectivity instead of traditional production planning based on market demand (Pyun & Rha, 2021). The impact of the digital transformation on industry is undeniable, profoundly altering the entire human experience. Supply chains are no exception to digitalization. In supply chain operations, digital technology is utilized to bring innovations and generate digital outputs, products, and services. According to Kamul et al. (2022), companies are adopting new digitalization approaches to adapt to the rapidly changing technological environment, incorporating digital technologies into production and procurement processes to reduce costs, improve customer service, and enhance delivery performance and reliability. Manufacturers, suppliers, contractors, and shippers are now intertwined in real online networks within the scope of supply chains, leading to the disappearance of traditional business boundaries and increased transparency in joint activities.

In recent years, top consulting firms such as Deloitte, Ernst & Young, and PwC have highlighted the cruciality and need for supply chain digitization. Based on the studies of Ivanov et al. (2019), it was found that the understanding of the digital supply chain is still in its early stages regardless of the advancements made in digitalization. Hence, prior literature has neither organised nor discussed the digital supply chain capabilities in order to provide organisations with the support they need to digitalize their networks. Although the potential of digitalization has been proven to enhance supply chains, recent studies have found limited coverage of this topic. Based on the findings of Nguyen et al. (2020), most studies would only mention digital collaboration partially when discussing information and digital technologies in supply chains. For instance, Tonelli et al. (2024), would only refer to digital collaboration while investigating the basic features of cyber-physical systems, identifying service-oriented architecture and microservice components. Besides, there is minimal current literature that incorporates frameworks into the study to further comprehend and help both scholars and practitioners integrate state supply chains into the digital age.

In addition, over the past decade, numerous studies have explored the relationship between digital transformation and supply chains, with a particular focus on digital supply chain management. However, Pyun and Rha (2021) state that a lack of consensus still exists on the definition and understanding of digital supply chains. This has led to contradicting perspectives among researchers and industry professionals, causing confusion in discussions. To further illustrate, researchers would often view digital supply chains as a means of advancing supply chain operations through evolving technology. In contrast, consultants from renowned firms emphasise changes in business models driven by digitalization in interpreting the concept of the digital supply chain. Meanwhile, engineers within manufacturing companies may perceive digital supply chains as primarily involving the application of digital technology to production facilities and equipment. These contrasting viewpoints often hinder effective communication and knowledge exchange among experts.

On top of that, despite the growing body of research, significant gaps persist in comprehensively understanding the trends, patterns, and emerging technologies that drive digital supply chain management (Bigliardi et al., 2022). Furthermore, the rapid pace of

technological advancements outstrips the ability of current research to keep pace, leaving businesses without a clear roadmap for navigating digital transformation. This research aims to bridge these gaps by conducting a bibliometric analysis of the evolution of digital supply chain management in industry, identifying the most influential works, analysing trends over time, and pinpointing emerging keywords and technologies. By addressing these areas, the study seeks to provide a more comprehensive understanding of digital supply chain management, offering valuable insights for both academic research and practical implementation in industry.

Therefore, it is imperative to systematically review and organize the diverse research findings on digital supply chains, considering the multitude of definitions and discussions highlighted and the vagueness surrounding the topic. To address these gaps in the existing digital supply chain management research, this study conducts a bibliometric analysis and qualitative analysis of the literature to identify research hotspots and future development trends in this field.

The study aims to answer the following questions:
Research Question 1: What are the most influential and frequently cited works in the field of digital supply chain management in industry?
Research Question 2: How have trends and patterns in digital supply chain management in industry research evolved over different periods?
Research Question 3: What are the emerging keywords in recent years within the field of digital supply chain management in industry?

The findings of this study will help researchers find the right direction and identify valuable insights from fundamental research, outstanding authors and research groups, and important topics in digital supply chain management.

Method and Study Area

Bibliometric

In recent years, bibliometric analysis has surged in popularity within the context of business research (Donthu, Kumar, Pattnaik, et al., 2021). This method can be used to track the evolution of research topics and trends over time, and to provide insights into the historical development of a research field. In this section, we use bibliometric analysis to provide a general overview of the research progress on digital collaboration in supply chains. We explore the development trends of research themes, journals, and keywords in digital collaboration (He et al., 2020; He et al., 2022).

Data Collection

For this bibliometric analysis, the database used is the Scopus database, which serves as a crucial resource for the purpose of retrieving and analysing scholarly literature related to digital supply chains. Because, Scopus is a popular choice for bibliometric reviews because it has wider coverage than Web of Science, is more widely cited by academics, and offers more advanced capabilities for exporting bibliographic data (Martín-Martín et al., 2018; Zhu & Liu, 2020). Additionally, Scopus uses a consistent standard to select documents for inclusion in its index (Hallinger & Nguyen, 2020).

The search query is TITLE-ABS-KEY (("digital supply chain" OR "digital supply-chain" OR "digital supply chain management" OR "supply chain 4.0" OR "supply-chain 4.0" OR "digitalisation of supply chain" OR "digitalization of supply chain" OR "digital supply chain transformation" AND "Industry 4.0")).

To ensure thoroughness and consistency across reviews, we followed the PRISMA protocol for conducting systematic reviews. Figure 1 illustrates the literature screening process carried out using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) approach. PRISMA, established in 2009, sets standardized guidelines for systematic literature reviews, ensuring transparency and quality in reporting across various disciplines, including healthcare and environmental management. It serves as a critical tool for formulating research questions and defining criteria for study inclusion and exclusion, essential for rigorous reviews that minimize bias and ensure reliability in evidence-based conclusions.

For this research study, the systematic review process for selecting relevant articles involved three main stages. First, keywords were identified using dictionaries, encyclopedias, and prior research, leading to the development of search strings for the Scopus database on 16 May 2024. This search retrieved 225 articles. The first screening stage aimed to remove duplicates; none were found, so all 225 articles proceeded. During the second screening stage, articles were filtered based on predefined inclusion and exclusion criteria. Editorial articles were excluded for unreliability, and only articles published in English were included. The review focused on articles from 2017 to 2024 to capture recent developments in digital supply chains. All subject areas were considered to ensure comprehensive coverage. This stage resulted in the exclusion of one article, leaving 224 articles for further review. In the third stage, the eligibility stage, the 224 articles underwent a rigorous evaluation of titles, abstracts, and main contents to ensure relevance to the research objectives, focusing on the digital supply chain or supply chain 4.0. No additional articles were excluded, and 224 articles were retained for the final analysis. This process is illustrated in Figure 1 using the PRISMA Flow Diagram.

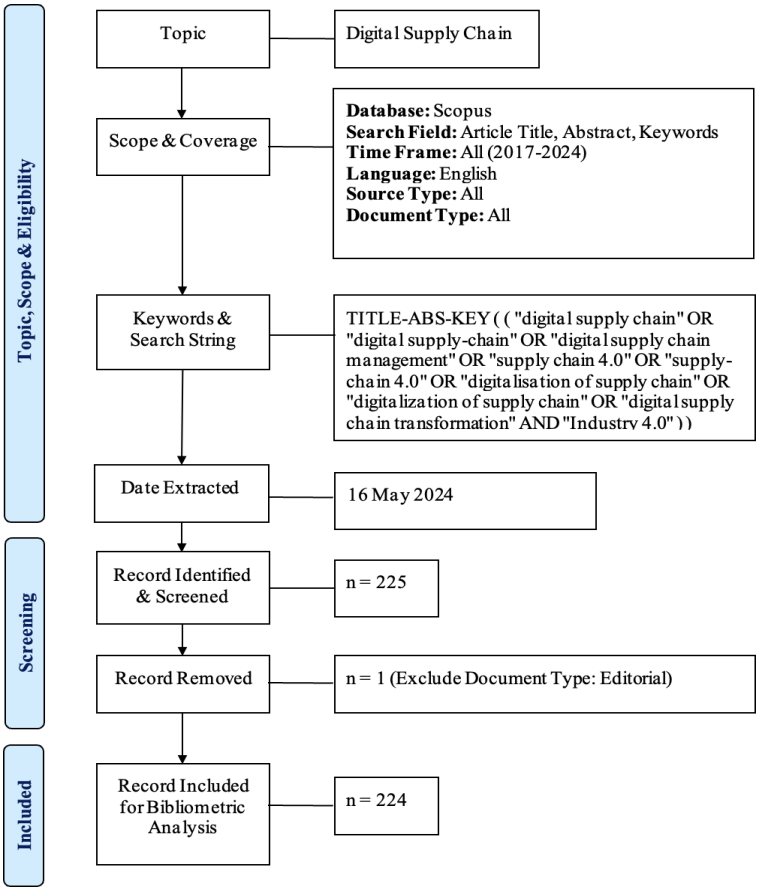

Figure 1. PRISMA Flow Diagram

Tools

We exported bibliographic data (authors, titles, affiliations, citations, etc.) related to 225 papers from Scopus into a master Excel file. The visualization and analysis, this study used several tools namely VOSviewer and BiblioMagika. VOSviewer, a powerful software, constructs and visualizes bibliometric networks, including co-authorship, co-citation, and co-occurrence networks of keywords. BiblioMagika, a bibliographic management tool, enhances the organization, citation, and sharing of academic references. Integrating with databases like Scopus, it allows direct import of citation data and supports various citation styles.

Results and Discussion

Publication Trend

The analysis of 2017-2024 publication patterns reveals growth and change in digital supply chain transformation research. In 2017, four papers had a 43.25 C/P ratio and 173 citations. In 2019, there were 4.17 publications, increasing the total to 27 (12.05%). In 2020, the total reached 55 (24.55%). In 2021, publications reached 44 (19.64%), and in 2022, they dropped to 42 (18.75%). In 2024, only 26 (11.61%) of 224 papers were published, indicating sustained research influence. Overall, there were 224 publications, 163 unique cited papers, and 5585 total citations.

Table 1
Year of Publication

Year	TP	%	Cumm. TP	Cumm. %	NCP	TC	C/P	C/C P	*h*	*g*	*m*
2017	4	1.79%	4	1.79%	8	173	43.25	173	2	2	0.250
2018	6	2.68%	10	4.46%	20	255	42.50	255	4	4	0.571
2019	17	7.59%	27	12.05%	50	844	49.65	844	10	13	1.667
2020	28	12.50%	55	24.55%	75	1434	51.21	1434	11	16	2.200
2021	44	19.64%	99	44.20%	107	1609	36.57	1609	16	22	4.000
2022	42	18.75%	141	62.95%	126	705	16.79	705	12	20	4.000
2023	57	25.45%	198	88.39%	190	523	9.18	523	12	21	6.000
2024	26	11.61%	224	100.00	89	42	1.62	42	4	4	4.000
Total	**224**	**100**			**163**	**5585**	**24.93**	**34.26**			

Notes: TP=total number of publications; NCP=number of cited publications; TC=total citations; C/P=average citations per publication; C/CP=average citations per cited publication; h=h-index; and g=g-index

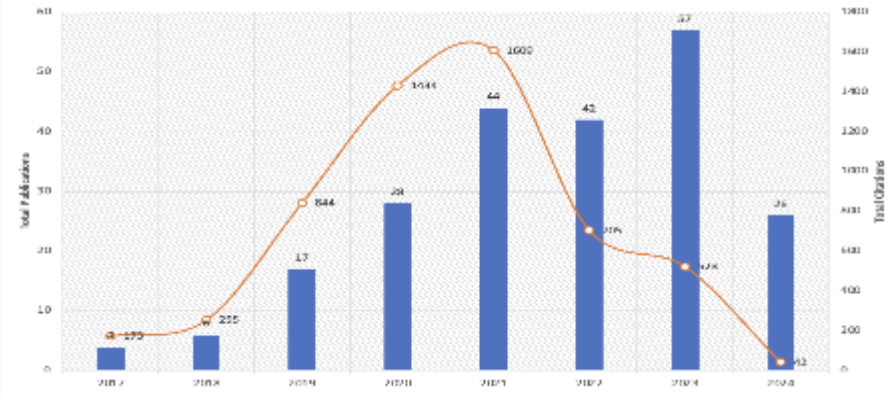

Figure 2. Total Publications and Citations by Year

Contribution of Research Area
The interdisciplinary nature of digital supply chain research is evident in 522 papers from various fields. Business, Management, Accounting, and Computer Science lead with 19.5%, followed by Engineering with 99 publications. Decision Sciences emphasize decision-making and analysis, while social sciences, energy, and environmental science show social implications. Mathematics adds 3.4%, while Chemical Engineering, Economics, and Materials Science focus on digital supply chain applications. Physics, Astronomy, Medicine, and Arts and Humanities are underrepresented, while specialized scientific subjects are underrepresented.

Table 2
Subject Area

Subject Area	Total Publications	Percentage
Business, Management and Accounting	102	19.5%
Computer Science	102	19.5%
Engineering	99	19.0%
Decision Sciences	70	13.4%
Social Sciences	37	7.1%
Energy	21	4.0%
Environmental Science	20	3.8%
Mathematics	18	3.4%
Chemical Engineering	16	3.1%
Economics, Econometrics and Finance	10	1.9%
Materials Science	7	1.3%
Physics and Astronomy	7	1.3%
Medicine	3	0.6%
Arts and Humanities	2	0.4%
Biochemistry, Genetics and Molecular B iology	2	0.4%
Immunology and Microbiology	2	0.4%
Psychology	2	0.4%
Chemistry	1	0.2%
Pharmacology, Toxicology and Pharmaceutics	1	0.2%
Total	**522**	**100.00**

Contribution of Leading Journal

The interdisciplinary nature of digital supply chain research is evident in 522 papers from various fields. Business, Management, Accounting, and Computer Science lead with 19.5%, followed by Engineering with 99 publications. Decision Sciences emphasize decision-making and analysis, while social sciences, energy, and environmental science show social implications. Mathematics adds 3.4%, while Chemical Engineering, Economics, and Materials Science focus on digital supply chain applications. Physics, Astronomy, Medicine, and Arts and Humanities are underrepresented, while specialized scientific subjects are underrepresented.

Table 3
Most active source titles

Source Title	TP	TC	Publisher	Cite Score	SJR 2020	SNIP 2020
Sustainability (Switzerland)	11	258	Multidisciplinary Digital Publishing Institute (MDPI)	5.8	1.198	0.664
IFIP Advances in Information and Communication Technology	9	3	Springer Nature	1.4	0.255	0.364
Procedia Computer Science	8	138	N/A	4	0.507	0.885
Logistics	8	199	Multidisciplinary Digital Publishing Institute (MDPI)	5.1	N/A	0.771
Lecture Notes in Mechanical Engineering	7	5	Springer Nature	0.9	0.16	0.229
Benchmarking	5	379	Emerald Publishing	9.7	1.185	1.843
International Journal of Production Research	4	347	Taylor & Francis	18.1	2.976	2.875
Computers and Industrial Engineering	3	229	Elsevier	11.9	1.76	2.238
Operations Management Research	3	40	Operations Management Research	5	0.794	1.042
IFAC-PapersOnLine	3	2	IFAC-PapersOnLine	1.8	0.354	0.519
International Journal of Logistics Systems and Management	3	25	Inderscience Publishers	2	0.322	0.523
Communications in Computer and Information Science	3	7	Communications in Computer and Information Science	1	0.194	0.241
Lecture Notes in Networks and Systems	3	1	Lecture Notes in Networks and Systems	0.7	0.151	0.19
Supply Chain Forum	3	213	Supply Chain Forum	5.8	0.749	1.147
Lecture Notes in Electrical Engineering	3	0	Springer Nature	0.6	0.147	0.158

Notes: TP=total number of publications; TC=total citations; CiteScore = average citations received per document published in the source title; SJR = SCImago Journal Rank measures weighted citations received by the source title; SNIP = source normalised impact per paper measures actual citations received relative to citations expected for the source title's subject field.

Contribution of Leading Countries or Region

Table 4 shows significant contributions from various nations in digital supply chains, with India leading with 84 publications and 1,894 citations. Brazil and the United Kingdom follow with 48 publications each, with Germany and Italy having high average citation rates. China has the highest average citation rate of 91.13 per publication, while the United States has 18 publications and an h-index of 10. Spain has moderate citation rates.

Table 4
Top 20 Countries contributed to the publications

Country	TP	NCP	TC	C/P	C/CP	*h*	*g*
India	84	1894	62	22.55	30.55	19	43
Brazil	48	2004	34	41.75	58.94	17	44
United Kingdom	48	1897	41	39.52	46.27	15	43
Morocco	44	816	38	18.55	21.47	12	28
Germany	37	2036	36	55.03	56.56	15	37
Italy	37	580	29	15.68	20.00	15	24
France	27	1408	18	52.15	78.22	12	27
Spain	22	288	19	13.09	15.16	11	16
United States	18	841	18	46.72	46.72	10	18
Iran	17	74	15	4.35	4.93	6	8
China	16	1458	16	91.13	91.13	10	16
Poland	15	71	10	4.73	7.10	3	8
Portugal	13	90	6	6.92	15.00	5	9
Qatar	13	48	10	3.69	4.80	6	6
Turkey	13	328	5	25.23	65.60	5	13
Malaysia	13	171	11	13.15	15.55	8	13
United Arab Emirates	12	58	2	4.83	29.00	2	7
Denmark	12	294	8	24.50	36.75	8	12
Canada	11	98	10	8.91	9.80	5	9
Russian Federation	11	424	9	38.55	47.11	3	11

Notes: TP=total number of publications; NCP=number of cited publications; TC=total citations; C/P=average citations per publication; C/CP=average citations per cited publication; h=h-index; and g=g-index.

Figure 3. Geographical distribution of publications used

Contribution of Leading Institution

Table 5 shows that Moulay Ismail University in Morocco leads with 24 publications, 737 citations, an average of 30.71 citations per publication, and an h-index of 12, indicating strong

research output and influence. The Berlin School of Economics and Law in Germany has 146.44 citations per publication, while Hamad Bin Khalifa University in Qatar and the University of Bolton in the UK contribute significantly. IMT Atlantique in France has 7 publications and 160.14 citations per publication.

Table 5
Most productive institutions with minimum of six publications

Affiliation	Country	TP	NCP	TC	C/P	C/CP	*h*	*g*
Moulay Ismail University	Morocco	24	737	23	30.71	32.04	12	24
Hamad Bin Khalifa University	Qatar	13	48	10	3.69	4.80	6	6
University of Bolton	United Kingdom	9	68	9	7.56	7.56	6	8
Berlin School of Economics and Law	Germany	9	1318	9	146.44	146.44	9	9
Poznań University of Economics and Business	Poland	9	18	6	2.00	3.00	2	4
Friedrich-Alexander University Erlangen-Nuremberg	Germany	8	462	8	57.75	57.75	7	8
University of Parma	Italy	8	344	8	43.00	43.00	8	8
UiT The Arctic University of Norway	Norway	7	0	0	0.00	0.00	0	0
Aalborg University	Denmark	7	39	3	5.57	13.00	3	6
Universidad de Cádiz	Spain	7	14	7	2.00	2.00	2	3
IMT Atlantique	France	7	1121	6	160.14	186.83	6	7
Sri Venkateswara College of Engineering	India	7	0	0	0.00	0.00	0	0
University of Novi Sad	Serbia	7	72	4	10.29	18.00	4	7
University West	Sweden	6	33	3	5.50	11.00	3	5
Islamic Azad University	Iran	6	21	6	3.50	3.50	3	4

Notes: TP=total number of publications; NCP=number of cited publications; TC=total citations; C/P=average citations per publication; C/CP=average citations per cited publication; h=h-index; and g=g-index.

Leading Authors and Corresponding Authors

Table 6 highlights key authors' contributions to digital supply chains, with Ivanov from Berlin School of Economics and Law leading with 9 publications and 1322 citations. Dolgui from IMT Atlantique follows closely with 7 publications and 1121 citations. Researchers from Moulay Ismail University in Morocco also contribute significantly.

Table 6
Most Productive Authors

Author's Name	Affiliation	Country	TP	NCP	TC	C/P	C/CP	*h*	*g*
Ivanov, D	Berlin School of Economics and Law	Germany	9	9	1322	146.89	146.89	9	9
Zekhnini, K	Moulay Ismail University	Morocco	8	7	194	24.25	27.71	5	8
Cherrafi, A.	Moulay Ismail University	Morocco	7	6	191	27.29	31.83	5	7
Dolgui, A.	IMT Atlantique	France	7	6	1121	160.14	186.83	6	7
Bouhaddou, I.	Moulay Ismail University	Morocco	6	6	187	31.17	31.17	5	6
Garza-Reyes, J. A.	University of Derby	United Kingdom	5	5	383	76.60	76.60	5	5
Frederico, G. F.	Federal University of Paraná (UFPR)	Brazil	4	4	112	28.00	28.00	4	4
Menon, S.	University of Bolton	United Kingdom	4	4	28	7.00	7.00	4	4
Al-Banna, A.	Hamad Bin Khalifa	Qatar	4	3	14	3.50	4.67	2	3
Shah, S.	University of Bolton	United Kingdom	4	4	28	7.00	7.00	4	4
Maryniak, A.	Poznań University of Economics and Business	Poland	3	2	7	2.33	3.50	2	2
Bulhakova, Y.	Poznań University of Economics and Business	Poland	3	2	7	2.33	3.50	2	2
Kumar, V.	Gruwitz LLP	India	3	3	266	88.67	88.67	2	3
Gupta, M.	Motilal Nehru National Institute of Technology	India	3	2	25	8.33	12.50	2	3
Bag, S.	University of Johannesburg	South Africa	3	3	198	66.00	66.00	3	3

Notes: TP=total number of publications; NCP=number of cited publications; TC=total citations; C/P=average citations per publication; C/CP=average citations per cited publication; h=h-index; and g=g-index.

Analysis of Yearly Most Cited Papers

Table 7 highlights significant research in digital supply chain management, with Ivanov D. and Dolgui A.'s (2021) paper on digital supply chain twins leading the citations. Other studies emphasize the role of digital technologies in enhancing supply chain resilience, their impact on Industry 4.0 contexts, and their transformative influence on supply chains. The field also includes studies on control theory applications and IoT in supply chains. These papers inform practical applications and strategic planning in supply chain management.

Table 7
Top 20 highly cited articles

No.	Authors	Title	Cites	Cites/Year
1	Ivanov D.; Dolgui A. (2021)	A digital supply chain twin for managing the disruption risks and resilience in the era of Industry 4.0	550	137.50
2	Li Y.; Dai J.; Cui L. (2020)	The impact of digital technologies on economic and environmental performance in the context of industry 4.0: A moderated mediation model	420	84.00
3	Ghadge A.; Er Kara M.; Moradlou H.; Goswami M. (2020)	The impact of Industry 4.0 implementation on supply chains	276	55.20
4	Spieske A.; Birkel H. (2021)	Improving supply chain resilience through industry 4.0: A systematic literature review under the impressions of the COVID-19 pandemic	210	52.50
5	Garay-Rondero C.L.; Martinez-Flores J.L.; Smith N.R.; Caballero Morales S.O.; Aldrette-Malacara A. (2020)	Digital supply chain model in Industry 4.0	186	37.20
6	Frederico G.F.; Garza-Reyes J.A.; Anosike A.; Kumar V. (2020)	Supply Chain 4.0: concepts, maturity and research agenda	185	37.00
7	Queiroz M.M.; Pereira S.C.F.; Telles R.; Machado M.C. (2019)	Industry 4.0 and digital supply chain capabilities: A framework for understanding digitalisation challenges and opportunities	175	29.17
8	Ivanov D.; Sethi S.; Dolgui A.; Sokolov B. (2018)	A survey on control theory applications to operational systems, supply chain management, and Industry 4.0	155	22.14
9	Majeed M.A.A.; Rupasinghe T.D. (2017)	Internet of things (IoT) embedded future supply chains for industry 4.0: An assessment from an ERP-based fashion apparel and footwear industry	149	18.63
10	Ivanov D. (2023)	The Industry 5.0 framework: viability-based integration of the resilience, sustainability, and human-centricity perspectives	143	71.50
11	Dolgui A.; Ivanov D. (2022)	5G in digital supply chain and operations management: fostering flexibility, end-to-end connectivity and real-time visibility through internet-of-everything	135	45.00
12	Javaid M.; Haleem A.; Singh R.P.; Rab S.; Suman R. (2021)	Significance of sensors for industry 4.0: Roles, capabilities, and applications	134	33.50
13	Ivanov D.; Dolgui A.; Sokolov B. (2022)	Cloud supply chain: Integrating Industry 4.0 and digital platforms in the "Supply Chain-as-a-Service"	132	44.00
14	Ivanov D.; Dolgui A.; Das A.; Sokolov B. (2019)	Digital Supply Chain Twins: Managing the Ripple Effect, Resilience, and Disruption Risks by Data-Driven Optimization, Simulation, and Visibility	131	21.83
15	Da Silva V.L.; Kovaleski J.L.; Pagani R.N. (2019)	Technology transfer in the supply chain oriented to industry 4.0: a literature review	122	20.33

16	Gupta S.; Modgil S.; Gunasekaran A.; Bag S. (2020)	Dynamic capabilities and institutional theories for Industry 4.0 and digital supply chain	116	23.20
17	Daú G.; Scavarda A.; Scavarda L.F.; Portugal V.J.T. (2019)	The healthcare sustainable supply chain 4.0: The circular economy transition conceptual framework with the corporate social responsibility mirror	102	17.00
18	Zekhnini K.; Cherrafi A.; Bouhaddou I.; Benghabrit Y.; Garza-Reyes J.A. (2021)	Supply chain management 4.0: a literature review and research framework	99	24.75
19	Frederico G.F.; Garza-Reyes J.A.; Kumar A.; Kumar V. (2021)	Performance measurement for supply chains in the Industry 4.0 era: a balanced scorecard approach	80	20.00
20	Choudhury A.; Behl A.; Sheorey P.A.; Pal A. (2021)	Digital supply chain to unlock new agility: a TISM approach	79	19.75

Analysis of Author's Keyword

Table 8 highlights key keywords in digital supply chain research, focusing on Industry 4.0, Supply Chain 4.0, and digitalization in industrial processes. It emphasizes optimizing operations, improving efficiency, and managing risks in global supply networks. Emerging technologies like IoT, blockchain, AI, and digital transformation drive innovation in industrial and supply chain management, enhancing decision-making and competitive advantage.

Table 8

Top author's keywords

Author Keywords	Total Publications (TP)	Percentage (%)
Industry 4.0	158	13.00%
Supply Chain Management	79	6.50%
Digital Supply Chain	72	5.93%
Supply Chains	63	5.19%
Supply Chain 4.0	46	3.79%
Supply Chain	26	2.14%
Internet Of Things	24	1.98%
Sustainability	21	1.73%
Blockchain	19	1.56%
Digital Technologies	18	1.48%
Literature Review	18	1.48%
Artificial Intelligence	15	1.23%
Digital Supply Chains	15	1.23%
Digitalization	15	1.23%
Digital Transformation	14	1.15%
Block-chain	13	1.07%
Industrial Revolutions	13	1.07%
Literature Reviews	13	1.07%
Decision Making	12	0.99%
Competition	11	0.91%

Discussion

Research Question 1

The bibliometric analysis conducted reveals several highly influential and frequently cited works that have significantly shaped the field of digital supply chain management (DSCM). The most influential and frequently cited work is by Ivanov et al. (2019)"A digital supply chain twin for managing the disruption risks and resilience in the era of Industry 4.0," with 550 citations and an annual citation rate of 137.50, underscores the critical role of digital twins in enhancing supply chain resilience against disruptions. This paper's influence is particularly significant in the context of the increasing complexity and vulnerability of global supply chains.

Li et al. (2020), in their study "The impact of digital technologies on economic and environmental performance in the context of Industry 4.0: A moderated mediation model," with 420 citations and an annual citation rate of 84.00, emphasise the dual benefits of digital technologies in improving both economic and environmental outcomes. This work highlights the importance of integrating sustainable practices within digital transformation strategies.

Next, Ghadge et al. (2020), with their research "The impact of Industry 4.0 implementation on supply chains," which has 276 citations and an annual rate of 55.20, explore the transformative effects of Industry 4.0 technologies on supply chain dynamics, reflecting a significant academic and practical interest in the operational impacts of these advancements.

Other notable works include Spieske and Birkel (2021), "Improving supply chain resilience through Industry 4.0: A systematic literature review under the impressions of the COVID-19 pandemic," and Garay-Rondero et al. (2020),"Digital supply chain model in Industry 4.0," with 210 and 186 citations respectively. These papers focus on resilience and digital models, particularly in the context of the COVID-19 pandemic, highlighting the importance of adaptability and robust supply chain structures in times of crisis.

Frederico et al. (2020), in "Supply Chain 4.0: concepts, maturity and research agenda," with 185 citations, provides a comprehensive exploration of concepts and maturity within digital supply chains, outlining a research agenda that has guided subsequent studies. Additionally, works by Dolgui et al. (2018), on control theory applications, and Majeed and Rupasinghe (2017), on IoT in future supply chains, with 155 and 149 citations respectively, demonstrate the broad spectrum of research areas and technological applications influencing the field.

These highly cited documents collectively highlight pivotal areas such as digital twins, IoT, Industry 4.0 implementation, supply chain resilience, and emerging technologies. They reflect evolving research priorities and technological advancements driving the field of supply chain management, shaping both academic discourse and practical applications.

Research Question 2

The trends and patterns in digital supply chain management research from 2017 to 2024 demonstrate substantial growth and evolving influence in the field. In the initial years, 2017

and 2018, the number of publications was relatively low, with 4 and 6 papers respectively, yet these early works had a high citation per paper (C/P) ratio of over 40, indicating significant impact despite limited quantity. The cumulative publications and citations were modest, reflecting the nascent stage of the research area.

A noticeable increase in research activity began in 2019, with 17 publications and a significant rise in total citations to 844, along with an impressive C/P ratio of 49.65. This growth trend continued into 2020, where publications surged to 28, and total citations reached the second highest peak at 1434, achieving the highest C/P ratio of 51.21. These years marked a period of intensified academic interest and substantial contributions to the field, as evidenced by rising h-index and g-index values, which highlight both the breadth and depth of impactful research.

The upward trajectory persisted in 2021, with the highest growth rate in publications (44) and peaked citations at 1609, although the C/P ratio slightly decreased to 36.57. This period reflects a broadening recognition and influence of digital supply chain management research within the academic community. However, 2022 saw a slight dip in publication numbers (42) and a more significant drop in the C/P ratio to 16.79, though the overall influence remained strong with a high cumulative h-index and g-index.

In 2023, the field experienced its highest number of publications (57), but with a further reduced C/P ratio of 9.18, indicating that while research activity was at its peak, the average impact per paper was declining. The data for 2024 shows a reduction in publications (26) and a sharp drop in citations, which may reflect the time lag required for new research to gain citations. Overall, the cumulative data illustrates solid growth and an evolving impact over the years, with notable peaks in research activity and influence around 2019-2021. The h-index and g-index values indicate sustained high-impact contributions throughout this period. This trend underscores the dynamic nature of digital supply chain management research, highlighting its increasing significance and the shifting focus towards addressing emerging challenges and leveraging new technologies in the industry.

Research Question 3

The analysis of emerging keywords provides valuable insights into the current and future directions of DSCM research. The dominance of "Industry 4.0" as a keyword covers 13% of the total percentage, followed by "Supply Chain Management" and "Digital Supply Chain". A high percentage of these keywords highlights the increasing importance of digitalisation and automation in modern supply chains. These keywords also represent a substantial portion of recent publications, reflecting a strong interest in the integration of digital technologies to enhance operational efficiency, decision-making capabilities, and overall supply chain performance.

Keywords such as "Internet of Things," "Blockchain," "Artificial Intelligence," and "Digital Transformation" have also gained prominence, indicating a shift towards incorporating advanced digital technologies into supply chain practices. To illustrate, the emergence of "Blockchain" as a significant keyword reflects the growing interest in the potential to enhance transparency, security, and traceability in supply chains. Blockchain technology, as explored in studies by Korpela et al. (2017), is recognized for its capability to

create immutable records of transactions, which is crucial for ensuring authenticity and reducing fraud in supply chains. The adoption of blockchain is seen as a way to build trust and improve collaboration among supply chain partners.

Additionally, specific keywords used such as "sustainability" highlights the growing emphasis on building supply chains that are not only efficient but also capable of withstanding disruptions and aligned with environmental goals. The emphasis on sustainability is driven by the growing importance of environmental responsibility and the need to address the impacts of climate change. This trend aligns with broader industry goals of achieving greater agility, sustainability, and resilience in response to global disruptions and market dynamics.

These emerging keywords indicate that the field of DSCM is rapidly evolving, with researchers increasingly focusing on advanced technologies and their applications to create smarter, more resilient, and sustainable supply chains. The dynamic nature of these research trends underscores the importance of continuous innovation and adaptation in the field of digital supply chain management. The focus on blockchain and artificial intelligence systems points to a future where supply chains are more interconnected, intelligent, and capable of adapting to a rapidly changing environment. Meanwhile, the emphasis on sustainability highlights the need for supply chains to be not only efficient but also robust and environmentally responsible.

Conclusions

The study explores the impact of digital technologies on supply chains and industrial operations worldwide. It uses bibliometric analysis to identify key research trends, influential authors, frequently cited works, and publications by countries and institutions. The study employs advanced bibliometric techniques, such as co-citation analysis and network visualization, to provide a nuanced understanding of the intellectual structure and development of digital supply chain research. It offers valuable insights for industry practitioners, guiding strategic decision-making and investments in technology and skills development.

From a policy perspective, the study's findings are crucial for informing the development of frameworks and guidelines supporting digital transformation initiatives. It also identifies promising avenues for future research, such as exploring underutilized technologies like AI and examining digital supply chain transformation in specific industrial sectors.

However, the study has limitations, such as reliance on the Scopus database, potential selection biases, and timeframe constraints. Future research should focus on exploring underutilized technologies, sector-specific studies, longitudinal analyses, and interdisciplinary collaboration. It also emphasizes the transformative potential of digital supply chain management for innovation, efficiency, and competitiveness. By embracing underutilized technologies, interdisciplinary collaboration, and focusing on human aspects, the academic community can continue to advance knowledge in this critical field.

In addition to these insights and limitations, this research advances both theoretical and contextual understanding in the field. Theoretically, it contributes to the literature by

synthesizing a fragmented body of knowledge through bibliometric analysis, highlighting the intellectual structure, dominant themes, and evolving paradigms in digital supply chain management. It further identifies underexplored areas, such as the role of emerging technologies and interdisciplinary approaches, which can guide the development of future theoretical frameworks. Contextually, the study provides valuable insights for practitioners and policymakers by mapping global trends, country-level contributions, and institutional collaborations, thereby underscoring the significance of digital supply chain transformation in enhancing competitiveness, efficiency, and sustainability. By bridging academic knowledge with practical relevance, the study strengthens the dialogue between theory and practice, offering a roadmap for future research and actionable strategies in diverse industrial and policy contexts.

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