

Digital Supply Chain Management: A Comprehensive Review Using Cluster Analysis, with Future Directions and Open Challenges

Janmejai Kumar Shah ^a, Manu Sharma ^{a,b} and Sudhanshu Joshi ^{b,c*}

^a Department of Management Studies, Graphic Era Deemed to be University, Dehradun India

^b Australian Artificial Intelligence Institute (AII), University of Technology, Sydney, Australia

^c Operations and Supply Chain Management Research Lab, School of Management, Doon University, Dehradun-248001, Uttarakhand, India

Abstract

Value chain operations have significantly improved due to rapid technological advancements, leading to a positive impact on the lifestyle of end users. The advent and widespread availability of the internet have had a profound influence on numerous industries, compelling them to shift from manual to automated operations and from offline to online activities. The digitalization of the supply chain plays a crucial role in enhancing business planning and execution, thereby facilitating the achievement of various organizational objectives in the future. This review focuses on assessing the significance of supply chain digitalization by extensively analysing literature published between 2018 and 2022. The study investigates the impact of digitalization on manufacturing operations and identifies new avenues for future research through a thorough content analysis. To evaluate the level and nature of supply chain digitalization in the industrial sector, the authors conducted a comprehensive review of 115 research articles. Various techniques, including bibliometric analysis, network data analysis, cluster analysis, and content analysis, were employed by the authors. Through this study, the authors successfully identified the changes and advancements associated with the implementation of digital supply chains (DSC) in the manufacturing industry. Moreover, by examining the literature review, the authors pinpointed emerging issues that require attention and investigation in the future. These insights will serve as valuable guidance in determining the appropriate research directions moving forward.

Keywords: Digitalization; Supply Chain; Manufacturing; Manufacture; Digital Transformation.

1. Introduction

In recent years, supply chain management has made great strides. Although, in the recent past, manufacturing and shipping consumer products has become the main operational priority. (Nayal et al., 2022). Firm start deputing exclusive teams to manage their supply chains (Menon & Shah, 2020). Digital technologies, particularly on a worldwide basis, has become critical to maintain their competitiveness and build sustainable relationships with other businesses based on shared values. Nearly all corporate processes and procedures are projected to eventually be impacted by the ongoing development of digital technology, influencing business functions (Leea et al., 2021). Firms are managing the supply chain disruption through technological interventions. Both, academic researchers and policymakers have shown significant interest in digitalization due to the emergence of recent technological advancements (Faruquee et al.,2021). In the order to maintain the competitive and to remain adoptive to changes, businesses need to transition from their current methods of managing supply chains (SCs) to embrace digital supply chains (DSCs). This shift towards DSCs enables organizations to achieve higher performance levels

*Corresponding author email address: sudhanshujoshi@doonuniversity.ac.in and sudhanshu.joshi@uts.edu.au
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(Khan et al., 2021). The recent advancements in digital technologies has brought enormous changes in the manufacturing industry. In order to retain their competitive advantages, firms are rapidly adapting to the digital transformation of their operations and procedures. (Archidiacono et al., 2022).

The existing scientific and commercial literature extensively addresses digitization, which is formally referred to as Fourth Industrial Revolution (IE 4.0) (Ho et al., 2022). Digital technologies have become more significant in manufacturing. Flows of material, information and money are the essential elements of SCM. Digital technologies have become an important tool for improving supply chain functions like purchasing, shipments, planning, and scheduling (Bejlegaard et al., 2021; Joshi and Sharma, 2022). Digital manufacturing has the potential to transform traditional centralized production model to a distributed production model (Arcidiacono et al., 2022; Weerabahu et al., 2021). Digitalization, along the new advancements in the technology collectively affect the supply chain operations and enhance its performance. The present study is the first attempt to assess the literature growth in the area of DSC's, its significance for manufacturing firms in developing and developed economies (Kumar et al., 2022). It provides valuable support to managers and decision-makers as they assess the stages and levels of their adoption of digital supply chains (DSC) (Khan et al., 2021). This investigation aims to evaluate three research questions to understand this behavior better.

RQ1: What are the critical factors behind firms' adoption of digital supply chain technologies?

RQ2: To determine the current state of development in the area of digital supply chain management.

RQ3: Identify new and emerging trends of digital technologies that influence supply chains.

The remaining article is structured into six sections. Section 2 discussed the literature. Section 3 explains the bibliometric Analysis. Section 4 discusses the network analysis and shows the current trends in the digital supply chain in manufacturing firms. Section 5 summarizes the study in the form of conclusions and future research.

1.1. Systematic Literature Review (SLR)

Systematic Literature Review (SLR) is a popular method employed to conduct an extensive analysis of past and ongoing research within a specific domain. It facilitates the evaluation and exploration of current trends, enabled the identification of limitations and potential avenues for future research (Hellweg et al., 2021). Although SLR is different from other forms of review due to its logical, simple, and repeatable procedure. It effectively conveys the analysis of past works while presenting the quality and their key findings. By evaluating and investigating previously directed research work, the current study employs the SLR. SLR is based on the philosophy to obtain a thorough grasp of the previously specified research point (Gharaibeh et al., 2022). Figure 1 depicts the research framework.

2.1. Selecting a database

Choosing a database to search through the current and prior work is the first step in beginning a literature review. In the present research, Scopus has been used as the source database, with the wider coverage from multiple publications including IEEE, Springer, Emerald, and Elsevier. The timeframe for the study is 2018-2022.

2. Choosing keywords

Based on the literature, the article examines the adoption methods in the industrial sector. Choosing the right keywords is crucial for article gathering in every area. The search items for secondary data for searching "digital supply chain" AND "digital manufacturing" AND "digital transformation" OR "digitalization" AND "Manufacture" OR "manufacturing."

Acceptance and rejection Criteria

The specific subjects (Business, Management, and Accounting) and the Calendar Year (2018 to 2022) are the only items provided. The total number of papers discovered was 115. Applying all the search parameters in the "Scopus" database will be used for future research.

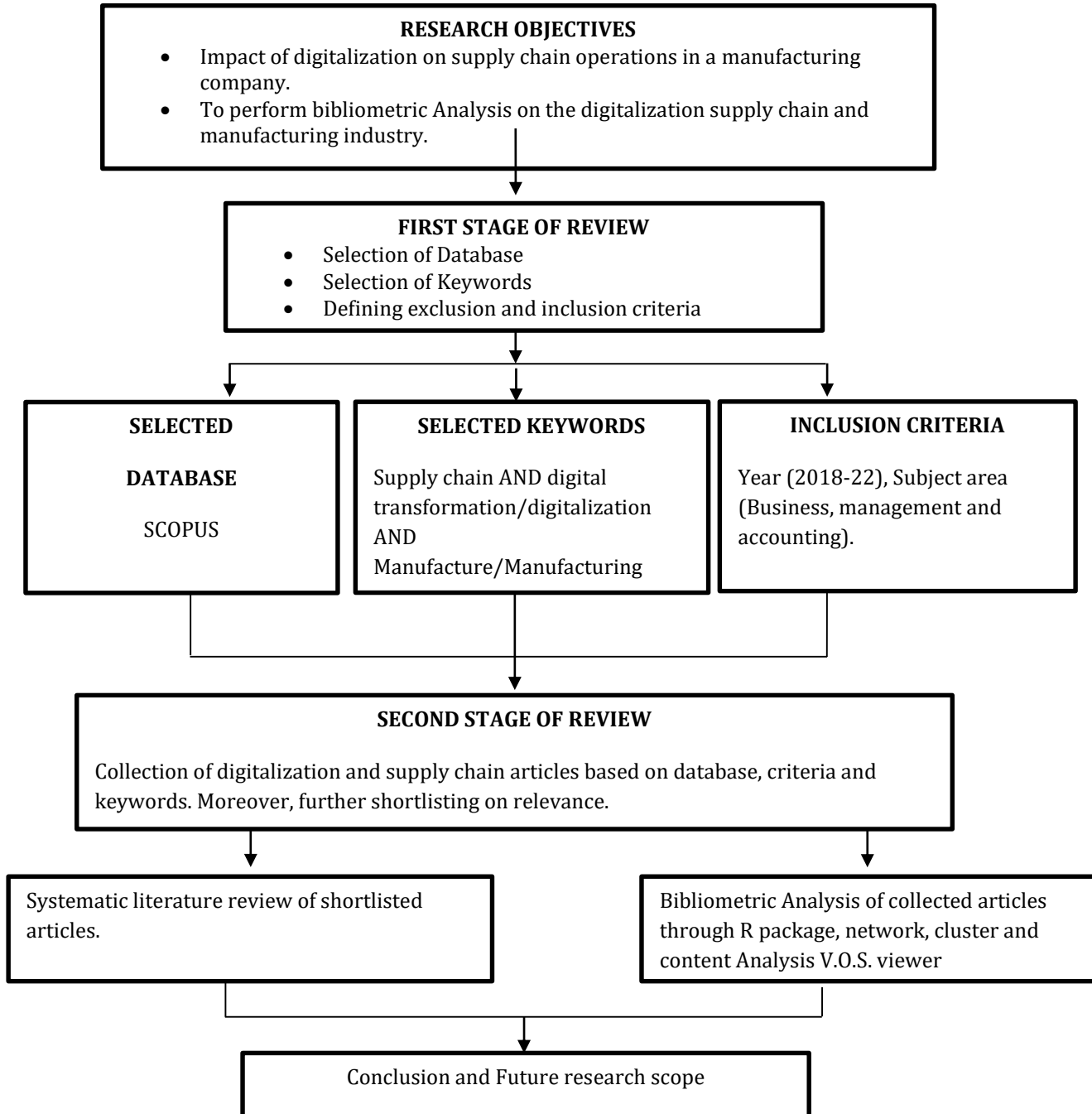


Figure 1. Research review framework

3. Bibliometric Analysis

The bibliometric Analysis incorporates various applications of quantitative methods on bibliometric data, that is, the usage of different citation analyses on units of production (Linnenluecke et al., 2020). Since the earlier studies held in 1950s, bibliometrics has been used in review studies. According to Scopus, 13655 review articles were published using bibliometrics, with total 10319 review articles between 2013-2023. Notably, In the domain of "business, management and accounting", "social sciences and economics," and "management science", bibliometric studies are growing in recent times (Donthu et al., 2021; Rojas-Sánchez et al., 2023). The bibliometric method has been used in a number of business research areas, including business strategy, Operations and Supply Chain Management (Ali & Shoaib, 2023; Sharma et al., 2021), people management (Dincer & Dincer, 2023; Mathushan et al., 2022), information management (Liu et al., 2020; Susanti and Reza, 2023), international studies (Nazzal et al., 2023), project management (Lalmi et al., 2022) and advertising and marketing (Boateng, 2022; Wasiq et al., 2023).

The present study aims to assess the design of the available documents on the subject cited. The bibliometric evaluation allows a researcher to conduct a repeatable, simple, and intentional writing survey. It has produced more thorough and fair examinations than other methods, unlike them in any way.

It is reasonable to use several indicators, such as diaries, creators, nations, educational institutions, and generally referred to dispersed papers, to evaluate the present significance of a particular topic. It also enables one to examine research collaborations across governments, foundations, and scholars (Gharaibeh et al., 2022).

Table 1. Data Overview

Description	Results
Key information	
Research time frame	2018:2022
Published sources	69
Research documents	115
Per annum growth rate in percentage	55.41
Average published documents	1.33
Average citation published per document	21.13
Total references	7300

3.1. Overview of selected Scopus data used for Analysis

The vital information for the previously described subject is shown in Table 1. The authors took the literature documents from the "Scopus" database, and the data displayed is for the Indian area from 2018 to 2022. The sources, authors, co-authors, and document data are also listed in the table. Until 2022, authors discovered 115 documents related to this topic, and all published articles were. These 115 articles were sourced from a total of 69 sources. There are 551 keywords used in all. There were 364 researchers in all whose publications were chosen from the Scopus data collection; 10 were single-author papers.

Table 2. Annual scientific productions

Year	Articles
2018	6
2019	17
2020	21
2021	36
2022	35

Table 2 depicts, total number of publications produced each year. Based on statistics, the abovementioned issue shows a trend shift across the whole region. From 2018 to 2021, there was a rise in work (6,17,21, and 35, respectively), and 35 articles were published in 2022.

Table 3. Most relevant sources

Sources	Articles
International Journal Of Production Economics (I.J.P.E.)	7
International Journal Of Supply Chain Management (I.J.S.C.M.)	7
Production Planning And Control (P.P.C.)	5
International Journal of Production Research (I.J.P.R.)	4
Business Strategy And The Environment (B.S.E.)	3
Industrial Management And Data Systems (I.M.D.S.)	3
Journal of Cleaner Production (J.C.L.P.)	3
Journal of Manufacturing Technology Management (J.M.T.M.)	3
Proceedings of The International Conference On Industrial Engineering And Operations Management	3

3.2. Journal Data

I.J.P.E. holds the top spot according to the journal statistics in Table 3, along with the I.J.S.C.M. with 7 papers.

3.3. Institutional Analysis

Table 4 of the study lists the top ten Institutions based on production in the Manufacturing and Digitalization Sectors. Table 4 demonstrates that the N.I.T.I.E. is the institution that has the most articles in the Scopus database, with a total of seven papers. The KTH Royal Institute of Technology comes in second with six reports published. The Politecnico di Milano is third, with six works that have been published.

Table 4. Most relevant affiliations

Affiliation	Articles
National Institute Of Industrial Engineering (N.I.T.I.E.)	7
Kth Royal Institute Of Technology	6
Politecnico Di Milano	6
Suan Sunandha Rajabhat University	6
South Ural State University	5
Swiss Federal Institute Of Technology Zurich	5
University Of Sharjah	5
Friedrich-Alexander University Erlangen-Nürnberg	4
Magna SteyrFahrzeugtechnik Ag And Co Kg Leitung Total Cost Of Ownership-Projekte	4
Norwegian University Of Science And Technology	4

3.4. Author's Statistics

The top 10 authors in Table 5, are grouped by the number of publications they have generated in the manufacturing and supply chain digitalization domains. The order of authors is based on how much research they have also accomplished in this field and the number of times it has been published in reputable journals. The entire publication is mentioned in Table 5. This indicates that Gupta H., who has three publications, is at the top list, followed by Kusi-Sarpong S.

Table 5. Author’s production over time

Authors	Articles	Articles Fractionalized
[No Author Name Available]	4	4.00
Gupta H	3	0.57
Kusi-Sarpong S	3	0.57
Pessot E	3	0.57
Sacco M	3	0.57
Shah S	3	1.00
Zangiacomì A	3	0.57
Battini D	2	0.50
Bertetti M	2	0.40
Chauhan C	2	0.83

3.5. Country Analysis

This section explained digitalization’s impact on manufacturing firms' supply chain, considering the highly productive and influential countries based on bibliometric indicators. Based on country analysis suggested by Merigó et al. (2016), the section aims to discuss the country perspective to see how publications evolve. Secondly, it discusses the global perspective to analyze the countries with the most articles and citations. The main benefit of this approach is that it gives a broad picture of the countries that are doing the most innovative research.

The study uses data from every country that participated in this field between 2018 and 2022, as shown in Table 6. Also, it depicts the country of origin of the key contributors, their contributions, single country publications (S.C.P.) in which all authors belong to the same country and such publications represent intra-country collaboration, and multiple country publications (M.C.P.) in which authors belong to different countries. According to table 6, Germany and India are the two most significant and vital countries in the region, as shown in Figure 5.

Table 6. Author’s country analysis

Country	Documents	SCP	MCP	Freq	MCP_Ratio
	51	44	7	0.443	0.137
GERMANY	9	6	3	0.078	0.333
INDIA	9	3	6	0.078	0.667
CHINA	6	2	4	0.052	0.667
ITALY	5	2	3	0.043	0.6
USA	5	2	3	0.043	0.6
BRAZIL	4	2	2	0.035	0.5
UNITED KINGDOM	4	0	4	0.035	1
S.W.E.D.E.N.	3	3	0	0.026	0
AUSTRALIA	2	1	1	0.017	0.5

Based on a review study by Sáez-Ortuno et al. (2023), highly cited countries are analyzed in the study. Brazil is the most referenced nation globally, followed by Germany and the U.K., according to statistics on citations for all countries (Table 7) on the basis of country-associated data for the original writer. The digital supply chain is transforming the manufacturing industry in Brazil, Germany, and the U.K. In Brazil, manufacturing firms are adopting digital technologies to improve their supply chain management, reduce costs, and enhance customer experience (Hellweg et al., 2021; Reis et al., 2021). German firms leverage data analytics and Automation to optimize production processes, increase efficiency, and enhance

Sustainability (Doetzer, and Pflaum, 2021). Meanwhile, U.K. manufacturers use digital technologies to improve inventory management, enhance product quality, and reduce lead times. In all three countries, the digital supply chain enables manufacturers to achieve operational excellence, strengthen collaboration with suppliers and customers, and create new business models that drive growth and innovation in the industry. In Italy, digital supply chain technologies drive innovation, improve product quality, and enable companies to respond faster to changing customer demands (Rasool et al., 2022). In the U.S.A., digital supply chain technologies are enhancing collaboration, improving inventory management, and reducing logistics costs (Büyüközkan and Göçer, 2018). In China, digital supply chain technologies enable companies to optimize production, reduce waste, and enhance customer experience (Fu et al., 2023). In Australia, digital supply chain technologies enable companies to improve supply chain visibility, reduce costs, and enhance Sustainability (Nakandala et al., 2023). In India, digital supply chain technologies enhanced operational efficiency, reduce inventory costs, and enhance customer experience (Sharma and Joshi, 2023; Joshi et al., 2023). In Thailand, digital supply chain technologies improve supply chain agility, reduce lead times, and enhance collaboration (Kittipanya-Ngam, and Tan, 2020; Supranee, and Rotchanakitumnuai, 2017). In Norway, digital supply chain technologies enhance supply chain visibility, reduce logistics costs, and improve Sustainability (Sharma et al., 2022; Liu et al., 2023).

Table 7. highly cited countries

Country	T.C.	Average Article Citations
BRAZIL	826	206.50
GERMANY	744	82.67
UNITED KINGDOM	127	31.75
ITALY	87	17.40
USA	82	16.40
CHINA	58	9.67
AUSTRALIA	55	27.50
INDIA	22	2.44
THAILAND	13	6.50
NORWAY	9	4.50

Although Due to the dearth of empirical evidence, it is difficult to measure the exact degree of digital supply chain (DSC) penetration into these countries as it can vary depending on the industry and company size. Based on literature review, Brazil, India, Thailand, and Australia are considered to have moderate to high DSC. penetration levels, as companies in these countries are increasingly adopting digital technologies to improve their supply chain processes. Germany, Italy, the United Kingdom, and Norway are also considered to have high levels of DSC penetration, as their manufacturing industries are well-established and have been quick to adopt advanced technologies. China and the United States have high levels of DSC penetration due to their large and competitive manufacturing industries, with many companies investing heavily in advanced digital technologies. Overall, it can be said that digital supply chain penetration is increasing across all of these countries as companies realize the benefits of adopting DSC technologies such as improved efficiency, reduced costs, and enhanced customer experience.

3.6. Document analysis

The Top 10 journal publications in the region, in terms of most influential papers, are shown in Table 8. Systematic literature research is conducted using this data to find modern practices in the field (Table 9).

Table 8. Highest cited documents

Paper	DOI	Total Citations	TC per Year	Normalized TC
Frank Ag, 2019, Int J Prod Econ	10.1016/j.ijpe.2019.01.004	825	206.25	8.96
Ivanov D, 2019, Int J Prod Res	10.1080/00207543.2018.1488086	553	138.25	6.01
Ivanov D, 2018, Int J Prod Res	10.1080/00207543.2018.1457813	83	16.60	3.92
Weking J, 2020, Int J Prod Econ	10.1016/j.ijpe.2019.107588	78	26.00	5.75
Kurpjuweit S, 2021, J Bus Logist	10.1111/jbl.12231	76	38.00	7.52
Caiado Rgg, 2021, Int J Prod Econ	10.1016/j.ijpe.2020.107883	67	33.50	6.63
Zangiacomi A, 2020, Prod Plann Control	10.1080/09537287.2019.1631468	63	21.00	4.64
Holmström J, 2019, J Oper Manage	10.1002/joom.1073	62	15.50	0.67
Hartley JI, 2019, Bus Horiz	10.1016/j.bushor.2019.07.006	58	14.50	0.63
Seyedghorban Z, 2020, Prod Plann Control	10.1080/09537287.2019.1631461	54	18.00	3.98

Of the 115 articles discovered by Scopus, some contemporary patterns have been discovered. These contemporary terms will affect the organization's industrial industries' supply chains which include:

Digital supply Chain: In order to help each participant, make better decisions about the sources of materials they require, the demand for their goods and all the relationships between them, a digital supply chain is a set of procedures that makes use of cutting-edge technologies and gaining insight into the roles of each stakeholder all along chain. Utilizing data science from current data sets, the digital supply chain in manufacturing may assist firms in enhancing the efficiency of the supply chain. They can collect data from monitors and other linked assets, use machine learning to glean insights from this machine data, and do prescriptive Analysis of those findings (Seyedghorban et al., 2019).

Among available studies, Seyedghorban et al. (2020) provide a comprehensive overview of the evolution of supply chain digitalization and its potential impact on the Future of supply chain management. Although the article has certain limitations, there are potential drawbacks, such as the impact on employment and privacy concerns related to collecting and using large amounts of data. While the article briefly mentions the potential role of government in promoting digitalization efforts, there is room for further exploration of how policy and regulation might impact the adoption and implementation of digital supply chains. Considering the limitations, there is a need for a strong foundation for understanding the evolution and potential Future of digital supply chains. Thus, the authors attempt to bridge the research gap and discuss several areas where further research could provide valuable insights.

Table 9. Literature review of highly cited documents

Author (s)	Observation	Findings	Objectives	Research Gaps
Frank et al. (2019)	The authors proposed a theoretical structure for these innovations, which separated them into front-end and base innovations.	The results demonstrate how difficult it is for manufacturers to use foundational technologies. They also demonstrate a pyramid of the layers of Industry 4.0 technologies, illustrate the levels of adoption, and talk about the impacts on manufacturers.	Evaluate supply chain operations and manufacturing using Industry 4.0 technology.	The effect of the technologies on industrial performance was not considered.

Ivanov et al. (2019)	The authors aim to explore how new technologies and Industry 4.0 are changing the nature of the ripple effect in supply chains and to assess the impact of these changes on supply chain risk analytics.	The authors addressed insights into the effects of digital technology and Industry 4.0 on risk management in supply chains. It is best to consult the original publication for the most accurate and comprehensive information.	The authors aim to explore how new technologies and Industry 4.0 are changing the nature of supply chains and assess these changes' impact on supply chain risk analytics.	The study's conclusions are based on an examination of practical models. However, more empirical studies are required to be carried out.
Ivanov et al. (2018)	Development in assembling, administration and storing network frameworks are among the arising issues that are being analyzed by firms trying to develop proficiency and strength in their activities further.	Authors believe that the S.I. will inspire new ideas and insights for study on the critical capacity of flexibility and related topics.	A summary of the significant research problems and a review of the works in this special issue address them is provided.	An empirical study can be done.
Weking et al. (2019)	Progress toward Industry 4.0 is essential for manufacturing companies to get the upper hand and seize new opportunities immediately. The mechanical components of I4.0 and its item and cycle upgrades have received the most attention.	Archetypal patterns demonstrate that businesses might benefit from I4.0 principles & establish a conceptual framework for further studies.	The study highlights trends in business models for Industry 4.0	Future research can create ideas and go deeper into the digitalization of industries using this concept of I4.0 B.M.s as just a basis.
Kurpjuweit et al. (2019)	This study combines inductive bottom-up discussions with the Delphi method to examine how the combination of these two potentially dangerous advancements will affect supply chains, what difficulties businesses should anticipate during the acknowledgment cycle, and what opportunities blockchain development in additional content creation may present.	To examine the influence of block chain technology on additive manufacturing and its impact on supply chains. The authors aim to explore how block chain technology is affecting additive manufacturing processes and supply chain operations.	The authors' emphasize on determining the processes on how companies can leverage block chain technology to manage supply chain operations in additive manufacturing better and to ensure greater transparency and security in these processes.	More similar studies are required to determine the usage of block chain technology for smart manufacturing processes
Caiado et al. (2020)	Industry 4.0 aims to integrate challenging developments into manufacturing frameworks, combining clever jobs and store networks throughout the board (O.S.C.M.).	This paper suggests a unique approach using a fuzzy probabilistic intelligent system to evaluate the I4.0 maturity of manufacturing businesses.	This study addresses how to assess the preparedness of industrial businesses for digitalization.	A business from a certain industry has indeed been assessed to determine whether there are any differences in the maturity of corporate procedures across various situations.

<p>Zangiacomi et al. (2019)</p>	<p>The paper gives a wide-ranging situational investigative analysis to illuminate a managerial viewpoint for implementing an Industry 4.0 transformation approach in the manufacturing value chain.</p>	<p>This study intends to further this field of study by providing a preliminary yet in-depth analysis of the management challenges industrial companies face as they move to digitalization.</p>	<p>Which of the most important factors to consider while designing the management strategy for a manufacturing business' digital transformation</p>	<p>Upcoming studies are required to elaborate on the discussion regarding implementing one or more technologies' functions, impacts, and distinctiveness.</p>
<p>Holmström et al. (2019)</p>	<p>The authors identify three mechanisms through which digital encapsulation influences O.S.C.M. theory and practice.</p>	<p>Various perspectives of Operations and Manufacturing processes are covered in light of Industry 4.0 and digitalization.</p>	<p>Firstly, digital encapsulation makes it possible for O.S.C.M. platforms to operate on each distinct digitally encapsulated artifact independently.</p>	<p>Digital encapsulation makes designing, monitoring, and managing any single item possible. The aggressive participation that helps in creating goods for long-term adaptation to changing customer requirements is facilitated by the capacity to manage an individual product's life cycle from design to manufacture to usage to withdrawal or servicing.</p>
<p>Janet et al (2019)</p>	<p>The authors highlight the potential of each technology based on a qualitative study of substantial established manufacturing and service companies.</p>	<p>The authors aim to develop an electronic technology roadmap for procurement.</p>	<p>Determine whether essential business supply chain operations are bottlenecks or have gaps in problems and improvement. Next, consider which digital technologies will solve those issues or bring new possibilities.</p>	<p>Which ethical concerns are there with using digital technology to create a connected supply chain and allow new functionality?</p>

Seyedghorban et al. (2019)	Authors sought to comprehend what forms the fundamental framework of its research as well as the areas that were looked at. Issues addressed include classifying the available research and identifying areas that require more study.	Using Omni channel commerce, businesses may offer products or services through as many channels as they like.	Explore various upcoming areas in the domain of Operations and Supply Chains.	Studies can examine authors' distribution and professional networks within academic settings. Information was gathered from WoS, which may have different indexed journals than S.C.O.P.U.S.
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Block chain is a technique for preserving records that makes it hard to fake or hijack any network or the data stored on it, making it safe and unchangeable. It is a particular kind of distributed ledger technology (D.L.T.), a digital system for simultaneously record keeping and associated data in several locations. Block chain can increase transparency and trust at every stage of the contemporary value chain, starting with acquiring unprocessed components that carry the finished good. Trouble spots that it might help with include inventory network monitoring for more outstanding efficiency, the origin of the material and bogus place (Kurpjuweit et al.2021).

Industry 4.0 is the cyber-physical transformation of production. The phrase "Industry 4.0" refers to a government project in Germany that promotes networked manufacturing and a digital convergence of commerce, industrial, as well as other operations. By establishing factories where cyber-processing systems connect through the Internet of Things, aiding people and machines to perform their work in the quickest time feasible, Industry 4.0 seeks to transform the production and engineering industries. Firms can control and improve every area of the supply chain and production operations with industry 4.0 technologies (Frank et al. 2019).

A *digital twin*, who will improve apps supporting strategic goals, is a digital counterpart of any process, system, or physical asset. Digital twins could be created for assets, specific production lines, finished goods, or any other "real world" situation inside a supply chain in the manufacturing sector. A digital twin can be used in industrial operations to model complicated processes completely and either simulate them to enable switch analysis or improve them in genuine using tools like deep learning (Hartley and Sawaya,2019).

Artificial intelligence refers to machine intelligence, or when machines imitate or can take the place of educated human activity, like issue or learning. It can be used in two different ways: automating procedures and actions so they can run without assistance from people. In the field of supply chain, A.I. is assisting provide the powerful optimisation tools needed for more precise capacity management, higher efficiency, higher quality, lower costs, and more output, all while encouraging safer working conditions (Hartley and Sawaya, 2019). These are certain technical applications that have been identified while doing the literature review of the top 10 highly cited articles founded through bibliometric Analysis.

3.7. Keyword Analysis

The keyword data that was retrieved to analyze the top keywords in the study topic of carbon emission and green supply chain in India is shown in Table 10 and Figure 2. It demonstrates that the terms "supply chains" and "industry 4.0" turned up 33 and 32 times, respectively during the search.

4.1. Authors' collaboration

We analyzed our 115 publications that have been chosen, which already had 363 authors, to establish how authors collaborated together to create research contributions in the subject of study that's been selected (Table 1). The number of writers is then decreased to 26 through selecting authors who have at least two papers to their credit. As a consequence, after removing writers who had minimal connection with other authors, 1 cluster of 4 authors was created. Last but not least, the constructed network contains 1 cluster with 6 links totaling 16 link strengths. The single and biggest cluster in red, as seen in Figure 10, includes four writers.

4.2. Keyword network

A maximum of 801 keywords were gathered from the articles selected for the keyword network. The amount of keywords is decreased to 40 by grouping together all terms that occurred at least four times. Finally, 5 clusters of 40 keywords with 406 links and 878 total link strengths were established.

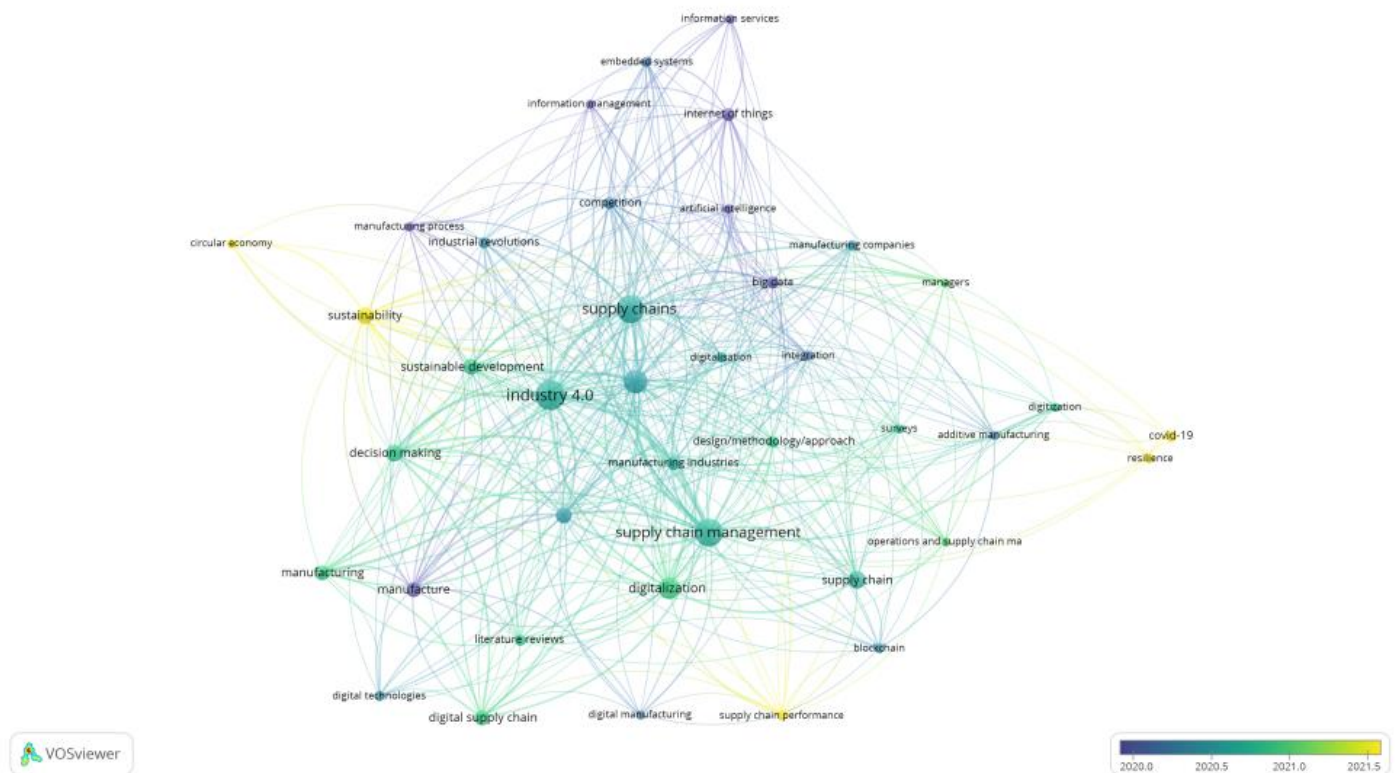


Figure 3. Keyword network

According to a keyword network analysis, Clusters 1, 2, and 3 and Cluster 4 each included 12, 10, 8 and 5 keywords. The 5th cluster, which has 4 items, is the smallest cluster.

4.3. Country collaboration

54 nations are represented in the 115 publications that have been chosen for our research's national collaboration. When only nations having a minimum of three articles are factored, a cluster of 19 nations is formed. Only 17 nations are represented in the 5 clusters that were created. All other nations were cut from the collaborative network due to their poor connection. The created network, with nine clusters and 132 total link strengths, had about 63 linkages. The cluster with the most countries includes four.

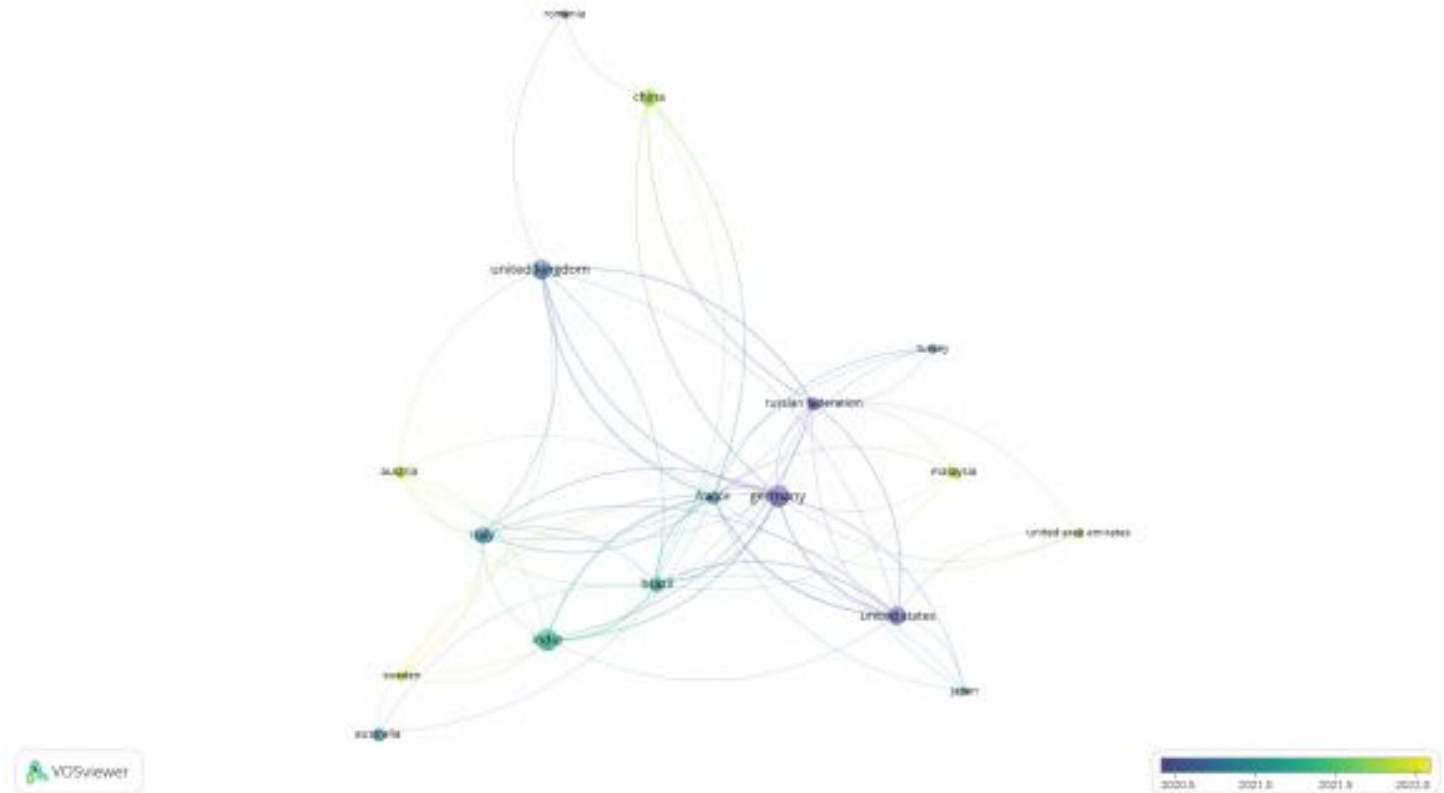


Figure 4. Country collaboration

5. Cluster analysis

A multidimensional analysis technique called cluster analysis, aims to group things (such goods, responders, or other entities) based on the set of user-selected attributes or characteristics. Data processing, deep learning, pattern recognition, information retrieval, and other areas all use this essential and crucial phase of data mining, which is also a widely used method for Analysis of data.

Cluster analysis shows the various types of tasks that are being done in a certain field. There was a bibliographic coupling analysis done to find different groups of keywords. It helps the researcher find different groups of authors who worked in similar research areas. With a total of 40 entries, 5 clusters were constructed. **Cluster 1**, shown in red color with 12 items includes research keywords artificial intelligence, big data competition, design/methodology/approach, digital transformation, embedded system, industrial revolution, information management, information services, internet of things, manufacturing process and supply chains in it. Thus, it states that there has been work done taking digitalization drivers as applications of supply chain in various industries all over the world. **Cluster 2** shown in green color with 10 items consist block chain, digitalization, digitalization, integration managers, manufacturing industries, operations and supply chain managements, supply chains, supply chain performance and surveys as the elements. **Cluster 3** shown in blue color with 9 items consist decision making, digital manufacturing, digital supply chain, digital technologies, industrial research, literature reviews, manufacture, manufacturing and supply chain management as keywords. **Cluster 5** in purple color includes consist additive manufacturing, Covid 19, digitization and resilience as keywords. 5 themes, applications for digital supply chain in manufacturing industry in India, Sustainability through Digital supply chain, Improvements and modernization in supply chain, Industry 4.0 and circular economy in manufacturing sector in India and Resilience post covid in Supply chain were discovered by cluster analysis and were then used for content analysis.

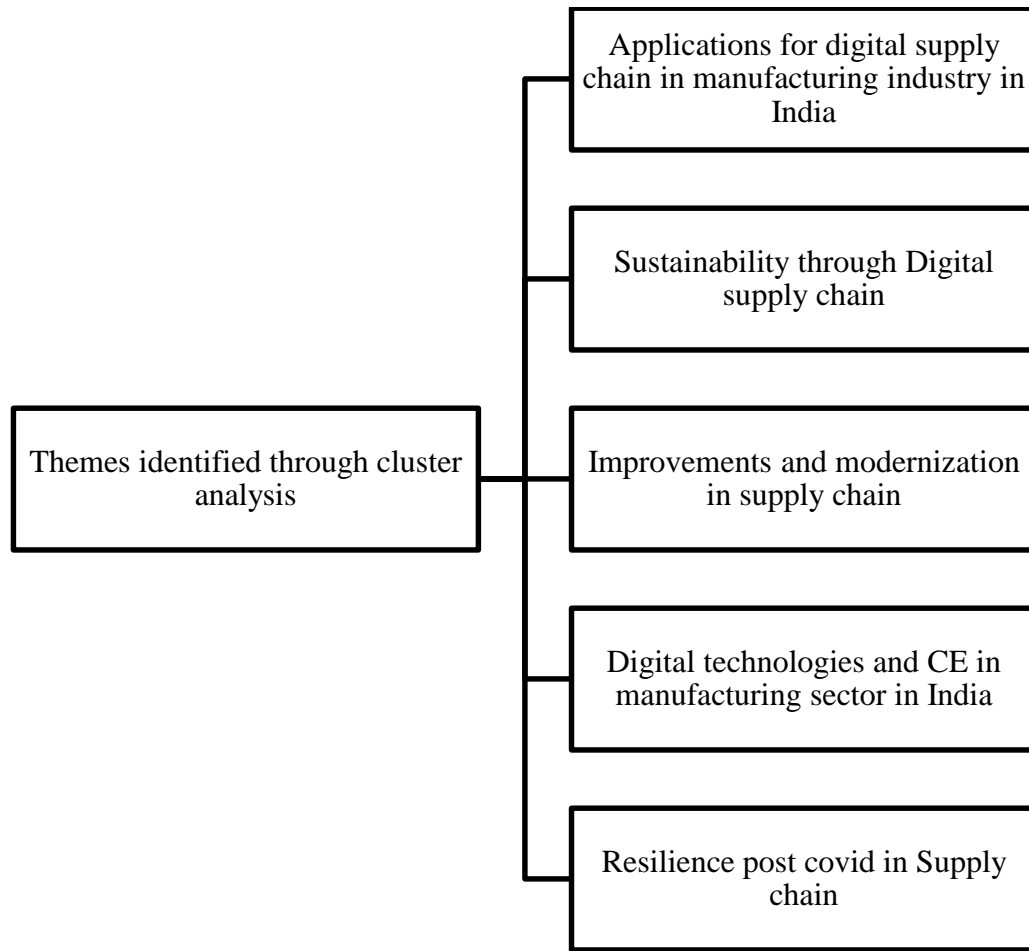


Figure 7. Emerging research themes

6. Content Analysis

Content analysis is used here to identify the concepts and propositions in a given set of qualitative data (i.e. text). The cluster analysis helped in the identification and grouping of the keywords, resulting in the creation of five clusters, each of which is given a theme— "Applications for digital supply chain in the manufacturing industry in India", "Sustainability through Digital supply chain", "Improvements and modernization in supply chain", "Industry 4.0 and circular economy in the manufacturing sector in India" and "Resilience post covid in the Supply chain" are found based on the cooperation of the keywords within that cluster

6.1 Theme 1: D.S.C. and its application in manufacturing firms

Many digital technologies have already been employed to maintain the procedure without noticing which technology solutions are best suited to managing production flows (Amejwal et al., 2022). The production industry has changed in the current digital era. The digitization of society has various technological and fiscal benefits. Along with the economic gains, industrial companies, particularly small and medium-sized businesses (S.M.E.s), need to leverage digitization to improve their social performance (Kumar et al., 2022). Digital technology may be used to improve numerous supply chain processes (such as smart metering, purchasing, assembly, storing, and logistics). Many businesses have equipped IOT devices to track and trace real-time data across the supply chain and use advanced data analytics to make their S.C.M. Analysis more efficient

and precise (Yang et al., 2021). A digital twin of any process, process, or real asset is a digital duplicate that will enhance apps serving strategic objectives. Assets, particular production lines, finished items, or any other "real world" scenario inside a distribution chain in manufacturing might all have digital twins built for them. A.I. is assisting Supply Chains in delivering the powerful enhancing capabilities required for more accurate capacity management, improved efficiency, exceptional service, reduced costs, and increased production, all while promoting a safer workplace (Hartley & Sawaya, 2019). Businesses have been compelled to concentrate on creating more flexible supply chains due to the rising environmental business risks. One crucial strategy for gaining this agility is the technological revolution (Enrique et al., 2022).

In order to effectively embrace sustainable practices in the manufacturing industry, a supply chain network instead of a typical supply chain allows for expansion, streamlines operations, and enhances customer service while lowering expenses and working capital. In order to provide ongoing planning capabilities and automatic reactions to predetermined situations, a successful supply network uses information-intelligent industrial automation like artificial intelligence (A.I.) and machine learning (ML). The system may be trained to differentiate between minor changes and circumstances that call for re-planning, which results in short iterative periods and the capacity to react to demand and supply dynamics more quickly. Based on the discussion the following proposition is developed.

Proposition (P1): *The practical adaptation of digital applications in the traditional supply chain to attain efficiency.*

6.2 Theme 2: Sustainability through Digital supply chain

Various trends in supply chain management, logistics, and production have enhanced productivity and efficiency while reducing adverse environmental effects (Begum et al., 2022). Sustainability is one of the trends identified and seen by several studies as something that every industry should consider to ensure a positive outcome for the environmental and profitability in most industries (Shetty and Henderson 2019). Meanwhile, the industrial sector is advancing Sustainability as mentioned above, thanks to various new technologies and contemporary digitization (Ojo et al., 2019). Resources are few, hence sustainable techniques are necessary to ensure sustainable performance. However, many scholars have examined how digital technologies might enhance Sustainability during globalization and digitization. However, there needs to be more research on how collaboration and coordination in a supply chain with digital capabilities might be used to accomplish Sustainability (Nayal et al., 2022). The industry's shift to digital transformation creates opportunities to use data to improve industrial operations' Sustainability and develop skills for resilient and circular operations (Chavez et al., 2022).

Effective digital application acceptance facilitates the development of long-term collaborative projects amongst many stakeholders. This would support the economic, social, and ecological aspects of manufacturing's sustainable growth, and data-driven decision-making facilitates efficiency, transparency, accountability and a sense of ownership to attain Sustainability in the manufacturing sector.

Propositions (P2): *Identifying, analyzing and applying various digital supply chain applications to be adopted in manufacturing sector to attain Sustainability.*

Propositions (P3): *Utilizing data-driven decision-making (D.D.D.M.) methods to create supply chain operations in the manufacturing industry more steady and sustainable.*

6.3 Theme 3: Improvements and modernization in the supply chain

Performance, effectiveness, and negative environmental effect have all grown as a result of trends being applied to industrial production, logistics, and supply chain management. In order to ensure a better destiny for the ecosystem and success in most industries, durability represents one of the movements that has been discovered and perceived (Nayal et al., 2022). Meanwhile, the use of various technological innovations and the present digitization are assisting the industrial sector in accomplishing the Sustainability above trends (Ojo et al., 2019). Digitalization is significant advance that have properly attracted the attention of practitioners and academics in terms of how they may assist and enhance efficiency (Cifone et al., 2021). New possibilities and difficulties are brought about by technological improvements for the majority of businesses. S.C.'s digitization provides numerous answers to these problems, enabling businesses to capture prospects in the market's shifting dynamics (Gharaibeh et al., 2022). Some advantages anticipated when making the strategic choice to undergo digitization include better service, better connectivity with customers and partners, improved revenue, and overall corporate expansion (Matthess & Kunkel, 2020). Several definitions have evolved due to the recent literature's active discussion of digitalization, with the key distinctions pertaining to the sorts of technology used and the purpose of the transition. As stated, "a process that tries to better an object by causing material changes to its attributes using combinations of information, computation, networking, and network technology" is how we define digitalization (Abdalla and Nakagawa, 2021). Collaboration with other parties is marketed to foster invention, yet creation is the end product of interaction. Companies often look for either synergies/complementarily or expansion and pricing power when constructing the cooperative network. One of the most typical complimentary agreements is S.C. collaboration, or collaboration with S.C. members like suppliers and customers (Faruquee et al., 2021). By pooling or swapping the assets, these collaborations aim to obtain access to various

assets owned by multiple parties. Economies of scale, expertise, and asset allocation often aim to strengthen the competitive position in mutual cooperation with competitors where resources and issues are broadly comparable (Maltagliati et al., 2020). Better inventory planning and supply chain forecasting are made possible by digitization. To effectively predict future demand or changes in the supply chain, businesses may access large volumes of data and evaluate it very instantly. Planning, sourcing, and logistics teams are better able to work together, automate processes, and use analytics to gain a competitive advantage. Additionally, it has been shown to promote growth, lower risk, and reduce expenses.

Propositions (P4): *Application and usage of digital innovations in area of supply chain to evaluate it in the manufacturing industry.*

6.4 Theme 4: Industry 4.0 and circular economy in the manufacturing sector in India

This pace of change occurring around the world is predicted to accelerate due to unanticipated technical advancements, and more internationalization, and utilized to portray that impact the political, economic, social, and environmental spheres (Nudurupati et al., 2022). The transition of production into a cyber-physical process is known as "Industry 4.0" A government initiative in Germany known as "Industry 4.0" supports networked production and a technological merger of commercial, industrial, and other processes (Jamwal et al., 2022). Industry 4.0 aims to alter the manufacturing and engineering sectors by developing factories where cyber-processing tools communicate through the Internet of Things, assisting people and robots to complete their task in the fastest time possible (Das and Dey, 2021). An economy known as a "circular economy" aims to reduce resource use and waste. A closed-loop system is created by circular systems, which use re-use, sharing, repair, refurbishing, re-manufacturing, and recycling to decrease resource inputs and lower waste, pollution, and carbon emissions (Rabaia et al., 2022). The two key sectors in the present industrial sector are industry 4.0 and the circular economy. Yet, the acceptance and use of Industry 4.0 and the circular economy are still in their infancy globally (Sahu et al., 2022). The circular economy, a hotly debated issue, aids in identifying the various advantages that Industry 4.0 and environmentally sustainable might create.

In contrast side, the circular economy is explored concerning a variety of disruptive technologies resulting from industry 4.0. (Xin et al., 2022). Despite the Indian government's numerous initiatives, legislation, and international strategic alliances, implementing a circular economy (C.E.) is still in its infancy (Nudurupati et al., 2022).

Technologies like the internet of things, intelligent sensor networks, business intelligence, information exchange, 3D printing, etc. are rapidly emerging and provide enormous potential for more sustainable supply chains. Manufacturing has had a significant influence from digital transformation, which has improved safety, quality, throughput, efficiency, revenue, and Sustainability while lowering costs to stay competitive in the market.

Propositions (P5): *Identifying future developments in area of digital supply chain of manufacturing industries in India.*

6.5 Theme 5: Resilience post covid in Supply chain

Throughout, the epidemic has had a serious impact on many sectors of society and commerce. With the exception of necessities like food and medication, most production and service sectors were shut down across the world during the pandemic. Because of the continuing COVID-19 epidemic, it was difficult for micro, small, and medium-sized businesses (M.S.M.E.s) to remain competitive and thrive inside the marketplace (Baralet al., 2022). The function of logistics and supply chain is heightened in the event of pandemic or other interruptions. However, for emerging economies, digital revolution presents some challenges to cutting-edge digitalization technology that prevent the digital elevation of supply chain logistics during a pandemic. Digital revolution of procurement and supply system is regarded as an essential tool for logistics and distribution resilience in such scenarios (Gupta et al., 2022). Due to the COVID-19 scenario, industrial companies have been forced to put their production processes on pause while they look for long-term solutions to ensure straightforward delivery and collaboration from both a business and customer side. The referendum covers a number of supply and demand-related topics as well as issues with production and consumption in the COVID-19 era. The production system must be repaired, and the ideal raw material source must be identified. Owing to mass manufacturing, the effort had been concentrated on commodity inventory management systems, but due to pandemics, it is no longer in need, and vice versa (Begum et al., 2022) Lockdowns and shutdowns due to the COVID-19 epidemic have been brought on by changes in supply and demand, social isolation and the requirement of remote employment, as well as shifts in customer patterns of behavior. Production remarketing, remote work, design and workspace reconfiguring, personnel reorganizing, and a new business model with accompanying strategy adjustments have been the adaption measures to battle the pandemic. The COVID-19 pandemic amplified pre-existing supply chain problems and highlighted goals including visibility, resilience, and digitalization.

Propositions (P6): *Identifying, analyzing and understanding the impact of covid 19 pandemic in supply chain of manufacturing sector in India.*

Overall, the impact of digitalization on the supply chain of manufacturing firms is likely significant in the coming years, driving greater efficiency, transparency, and Sustainability throughout the industry. Based on the review, the following trends remain prominent in the near Future:

1. Increased use of artificial intelligence (A.I.) and machine learning: A.I. and machine learning are expected to play a more significant role in supply chain management, enabling manufacturers to make faster and more informed decisions based on real-time data.
2. Greater adoption of block chain technology: Block chain technology can revolutionize supply chain management by providing greater transparency and security throughout the supply chain, from sourcing to delivery.
3. Integration of the Internet of Things (IOT): Integrating IOT devices such as sensors and intelligent machines into the supply chain will enable manufacturers to monitor and optimize their operations in real-time, improving efficiency and reducing costs.
4. Focus on Sustainability and circular economy: As Sustainability becomes a significant concern for consumers and businesses alike, manufacturers must reduce waste and improve their environmental footprint. Digitalization can enable manufacturers to adopt circular economy models and reduce reliance on scarce resources.
5. Increased collaboration and partnership: As supply chains become more complex and globalized, manufacturers must work more closely with suppliers, partners, and customers to ensure that their operations are efficient, reliable, and responsive to changing market demands.

The Future of digitalization on the supply chain of manufacturing firms is likely to be marked by ongoing innovation and experimentation as companies seek to stay ahead of the curve and meet the demands of an increasingly dynamic marketplace. The firms are expected to be transformative, with new technologies and approaches continuing to emerge and evolve. Overall, the Future of digitalization is in the supply chain of manufacturing firms. Firms embracing and leveraging digital technologies to improve their operations will be best positioned for success in the years ahead.

7. Conclusion, Limitations and Future Scope

The review paper aims to synthesize the existing literature on the topic, identify gaps in current knowledge, and provide insights into the potential future directions of digital supply chains. It aims to address questions including: to determine key motivation of manufacturing firms to adopt digital supply chain technologies; to determine current development in digital supply chains; to identify new and emerging trends of digital technologies impacting supply chains. The review paper aims to provide a valuable resource for researchers, practitioners, and policymakers seeking to understand the potential benefits and challenges of digitalization in the supply chain of manufacturing firms, as well as the key strategies and approaches that can help firms to successfully navigate this rapidly evolving landscape.

By answering the research questions, a thorough literature review, bibliometric Analysis, network cluster and content analysis were done, on 115 publications about D.S.C. and the manufacturing sector, the authors conducted a thorough literature review, bibliometric Analysis, network analysis, cluster analysis, and content analysis. Through a study of publications about D.S.C. in the manufacturing sector, concentrating on diverse viewpoints including block chain, digital twins, industry 4.0, and artificial intelligence, the study helps readers comprehend the latest instruments in D.S.C. to sustain growth. These have a large influence on industrial businesses, and several researches on related subjects have demonstrated its significance.

Digitalization can significantly improve supply chain efficiency and reduce costs through enhanced visibility, Automation, and real-time data analysis. The review discussed key technologies driving digitalization in the supply chain include the Internet of Things (IOT), artificial intelligence (A.I.), block chain, and cloud computing. It discussed benefits of digital supply chains extend beyond efficiency and cost savings, including improved quality control, increased agility, and better customer service. Various perspective including implementing digital supply chains requires significant investment in technology, infrastructure, and talent, as well as a willingness to change organizational processes and culture are discussed. Among the future research areas, Effective collaboration between supply chain partners is critical for successfully implementing digital supply chains, with data sharing and real-time communication being key components. Areas like Sustainability will continue to be a key concern in digital supply chains, with firms seeking to reduce their carbon footprint and minimize waste. Also, the potential Future of digital supply chains includes increased use of predictive analytics, Greater adoption of cloud computing, and The integration of augmented and virtual reality technologies. Overall, the review paper's key findings highlight the potential benefits and challenges of digitalization, as well as the key strategies and approaches that can help firms successfully navigate this rapidly evolving landscape. By leveraging the latest technologies and techniques, manufacturing firms can improve their supply chain efficiency, reduce costs, and stay ahead of the curve in an increasingly dynamic marketplace.

Based on the literature, there are many potential areas for future research on digitalization on the supply chain of manufacturing firms, including further exploration of the impact of technology, culture, and policy on the adoption and implementation of digital supply chains. Future studies could explore: how digitalization affects small and medium-sized manufacturing firms versus larger corporations, or how digitalization differs across different industries within the manufacturing sector; how organizational culture and leadership impact the implementation of digital supply chains, and identify strategies for promoting a culture of innovation and digital adoption; Investigate how digital tools and platforms can be leveraged to mitigate risks and increase supply chain resilience, as well as potential drawbacks such as increased vulnerability to cyber-attacks; how the implementation of digital supply chains affects employment in the manufacturing sector, including potential job losses or the creation of new roles and skills; Explore the impact of government policy on digitalization in promoting or hindering the adoption of digital supply chains, and identify strategies for addressing potential barriers to adoption; Investigate the potential for digitalization to enhance Sustainability for digital tools and platforms to reduce waste, increase efficiency, and promote Sustainability within the manufacturing supply chain. Future studies can further extend to develop a framework for an empirical inquiry. Also, the existing study only considered the top 10 referred publications; additional papers may still be considered. This research is confined to manufacturing sector with the possibility that other countries may be considered in the Future. The proposed themes can also be used by the researchers to do additional Analysis.

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