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Industry-4, Big Data, and Blockchain Research Prospects in Supply Chain Domain: A Bibliometric Review

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Research Article

Abstract

Purpose: *Utilizing technologies becomes a prerequisite in the operations of supply chain management. Research in digitalized supply chain management (SCM) is now trending as a new arena of research. This study investigates and summarizes the research that has been performed so far in this area, and also explains what the future research scopes in the integration of digitalization and supply chain management are.*

Method: *To execute this study, we carry out a systematic literature review by using numerous software (i.e., BiBexcel, Gephi, and VOSviewer) for clustering existing literature in digitalized SCM from the Web of Science.*

Result: *Our findings suggest that Industry 4.0, Big data, Blockchain, and supply chain resilience are the four key categories in the research on digitalized SCM.*

Implications: *This study explains the reasons behind the research in these four categories. This literature review helps researchers to build a comprehensive knowledge of the research status of digitalized SCM and contributes to the direction of future research in digitalized SCM that helps researchers to explore their further investigations in the combination of SCM and Industry 4.0, Big data, Blockchain, and supply chain resilience.*

Keywords: Digital supply chain, Industry 4.0, Big data, Blockchain, Supply chain resilience, Systematic literature review

1. Introduction

Digitalization in the business world is a process that enhances business automation through the usage of technologies. In the last few years, organizations have been using it more rigorously to increase their productivity and competitiveness. Technological advancement in Supply Chain Management (SCM) refers to the application of upgraded digital tools used in the value chain steps of SCM from procuring supplies from suppliers to sending finished goods to end users. Thus, digital technology in SCM consists of using smart inventory management, tracking production flows, and collaborating with all related parties' digital forms, thereby, enhancing the efficiency of supply chain management.

Moreover, companies competing in a global market context suffer an overflow of data and information exchanged inside the operational business processes including in their supply chain departments.

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Businesses must efficiently use the data that is already accessible, transform it into useful information for decision-making, and coordinate purchasing and supply chain management (SCM) in order to improve their competitive position. Even businesses can gain a better outlook in the capital market if they show improved SCM in operation. Because firms produce better corporate performance like better earnings per share if more institutional and foreign investors get attracted to invest in those firms (Ali et al., 2023). A business firm might get more investor attention if it manages the data of operations better and shows improved SCM in its business process. Moreover, one of the main goals of SCM is the "optimization of goods and materials' flows" in both internal and external business transactions by exchanging and analyzing information about supply chain operations. Real-time information exchange between systems in the supply chain is essential to achieve this goal (Calatayud et al., 2019). On the other hand, a lack of such real-time information management can result in inefficient management that affects the firms differently based on the nature of the business. For example, banking companies suffer from piling up of non-performing loans when the management cannot act timely to control or operate the flow of loans (Ahammed & Saha, 2018). As a result, over the last few years, digitalization in SCM has encouraged researchers to find numerous findings that help organizations for their insightful thinking. In this study, we perform a systematic literature review on the integration of digital technology in SCM based on published articles in the Web of Science database. Finding author and keyword influences, clustering related prior literature based on their research areas, and suggesting future potential research are the fundamental objectives of this study. Importantly, remarkable existing literature and research gaps are also presented in this study.

To analyze the literature on this domain from different perspectives, we use numerous software (such as Gephi, BibExcel, and VosViewer). After determining the scope of the domain, first, we download all the relevant papers from the Web of Science. Second, we investigate authors' names and keywords' influences associated with digitalization in supply chain literature to show the best contributors and key research topics in this field respectively. Then, we discover the most connected articles and keywords through bibliographic coupling. Subsequently, we cluster all the relevant papers topic-wise to know which research areas are now more influential in this research area. Lastly, we provide various future research prospects.

Analyzing business data is important for identifying the difficulties that businesses face (Uddin & Mazumder, 2016). This systematic literature reveals that the key subareas of research in digitalized supply chain management are Industry 4.0, Big Data, Blockchain, and Supply Chain Resilience. We scrutinize the logic of each sub arenas of research states in this field. The common reason for all categories of research in digitalized SCM is that the business environment becomes more sophisticated in the utilization of digital technologies, which creates a huge amount of electronic data, thus, leading to Big data analysis. Most importantly, SC managers are willing to get connected digitally, thereby, increasing the use of blockchain. This literature review has numerous contributions to the SCM literature. For example, this study consolidates the state of literature knowledge in digitalized SCM and provides a comprehensive summary of research that has been performed. It also identifies key research areas through employing numerous software such as BiBexcel, Gephi, and VOSviewer. Further, this literature guides future researchers to explore new research phenomena in the areas of SCM and Industry 4.0, Big Data, Blockchain, and supply chain resilience that enriches future knowledge in digitalized SCM.

We organize our study as follows: Section 2 and Section 3 present methodology and Bibliometric analysis respectively. Section 4 discusses clusters of this study and future research, and section 5 presents the conclusion of this study.

2. Methodology

2.1 Study Design

We perform our study in five steps. Firstly, we define search terms (such as "Digital ecosystem," "supply chain," and "digitalization) to determine the scope of this study. Using the search terms, secondly, we download all the related papers published in the business domain from the Web of Science database. Using

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BibExcel, thirdly, we analyze author names and keywords to find out the key contributors and the most influential words respectively in the digitalized supply chain management. Subsequently, we perform bibliographic coupling that ranks published articles based on their interconnected relationship (in terms of citation and topic link). Finally, based on highly connected articles from bibliometric coupling, we cluster or classify 51 articles to group them in their central research areas and provide numerous future research prospects. Figure 1 presents the steps of this study.

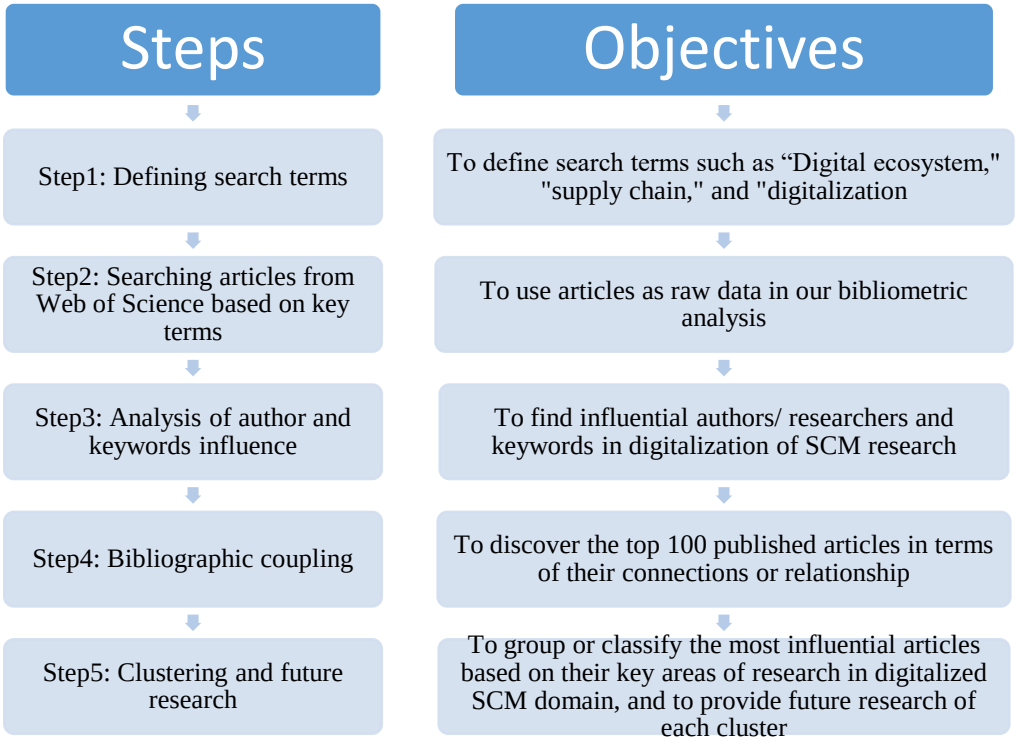

Fig. 1: Steps of the study

2.2 Defining search terms

Before going to scrutinize our desired terms related to digitalized SCM (i.e., ‘supply chain’, ‘digitalization’, ‘digital ecosystem’), we first search previously published articles in this domain. The scrutinization of these terms enables us to recognize the language of researchers employed in this subject. Due to upgrading the technologies, the operation patterns of SC have been changing from the initial stage to the end stage, thereby, the functions of buyers and sellers (customers and suppliers’ sides) are also responding to the upgradations of the digitalized SCM. Bearing this evolution in the SC and previous researchers' language, we come up with some keywords for our next step (“initial search result section”) supply chain”, “digital eco-system”, “digital ecosystem” and “digital supply chain”.

2.3 Initial search results

Supply chain”, "digital eco-system", "digital ecosystem" and "digital supply chain" directed by the previous section of this study are considered to search published articles, On March 8, 2023, we used "title, abstract, keywords" search option of the Web of Science database, we got 1936 published articles as our initial sample of data of our study. To specify the data for this systematic literature review, we only considered

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the articles that were published under the umbrella of business, operation management, and management science, resulting in 566 articles as a final dataset. Table 1 presents the search outcome by providing a detailed breakdown from the initial search to the final selected papers.

Table 1: Search outcome

Particulars	Result
Search for "**supply chain" AND "digital eco-system**" OR "**supply chain" AND "digital ecosystem**" OR "**supply chain" AND "digital**" OR "Digitalization" in titles, keywords or abstracts in Web of Science database	1936
Excluded all fields except business, management and operation research, and management science	(1370)
Selected for final analysis	566

The publication trend of supply chain digitalization is shown in Figure 2, which indicates that research on digital supply chain is in an early stage as most of the research has been performed in 2021 and 2022. However, Figure 2 also suggests that the research in this field is increasing substantially.

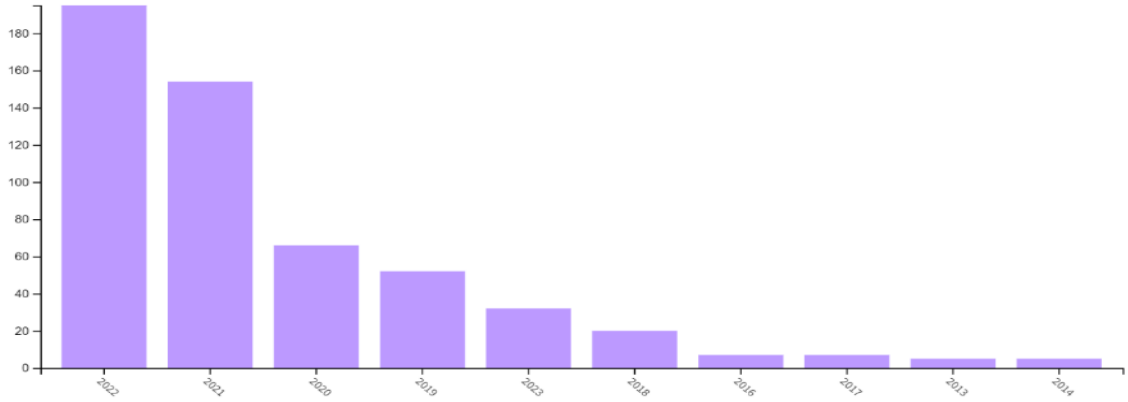

Fig. 2: Publishing trend from 2014 to 2022

3. Data analysis

Bibliometric analysis and bibliographic coupling are the two main parts of data analysis in this section. In order to acquire a comprehensive knowledge of research activities and their impact, bibliometric analysis entails summarizing data based on authors and keywords to determine the most influential authors and the most influential keywords. To get the most influential authors, we utilize BibExcel, which is particularly helpful for handling huge datasets and is interoperable with a variety of computer software, to carry out the bibliometric analysis. Subsequently, using Gephi software, we find out the most interconnected published articles in our final dataset.

3.1 Bibliometric analysis

in this section, we present and analyze the findings of my preliminary bibliometric study, which gives us information on author and affiliation statistics. As mentioned earlier, we utilize an open-source tool, named BibExcel, to carry out this bibliometric analysis because it not only allows us to run statistical analyses but also gives us data used on our additional network analysis, thus, we get the authors' names and keywords.

3.1.1 Influences of Author and Keywords

Using the author field of a document file generated by BibExcel, we find author influences on our sample of 566 articles. The findings suggest that the influences of a single author are not so significant as Table 2 shows that two authors (Ivanov D and Gunasekaran A) published 10 articles each. Most of the articles are

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published with co-authorship presented in Table 3. However, table 2 and Table 3 also show that Ivanov D and Gunasekaran A are the key contributors in this research domain as they have the highest research publication in terms of single authorship as well as co-authorship.

Table 2: Number of publications of authors

Name of author	No. of papers	Name of author	No. of papers
Ivanov D	10	Kumar A	5
Gunasekaran A	10	Holmstrom J	5
Dolgui A	8	Raut RD	5
Sharma M	6	Kumar M	4
Bag S	6	Zekhnini K	4
Tsolakis N	6	Joshi S	4
Hartmann E	6	Cherrafi A	4
Belhadi A	6	Khan SAR	4
Singh RK	5	Ravi V	4
Kamble SS	5		

Table 3: Co-authors list

First author	Second author	No. of studies	First author	Second author	No. of studies
Gunasekaran A	Ivanov D	67	Dolgui A	Sharma M	32
Dolgui A	Gunasekaran A	53	Gunasekaran A	Tsolakis N	32
Hartmann E	Ivanov D	49	Belhadi A	Dolgui A	31
Ivanov D	Singh RK	46	Dolgui A	Raut RD	31
Bag S	Ivanov D	46	Ivanov D	Jabbour CJC	30
Gunasekaran A	Hartmann E	43	Bouhaddou I	Gunasekaran A	30
Ivanov D	Raut RD	41	Ivanov D	Kamble SS	29
Ivanov D	Sharma M	41	Dolgui A	Zekhnini K	29
Belhadi A	Ivanov D	40	Gunasekaran A	Sharma M	29
Dolgui A	Hartmann E	39	Cherrafi A	Dolgui A	29
Bag S	Dolgui A	38	Bouhaddou I	Ivanov D	29
Cherrafi A	Ivanov D	37	Dolgui A	Kumar A	28
Bag S	Gunasekaran A	37	Bag S	Raut RD	28
Ivanov D	Zekhnini K	37	Ivanov D	Tsolakis N	27
Gunasekaran A	Zekhnini K	36	Hartmann E	Singh RK	26
Ivanov D	Kumar A	36	Ivanov D	Kumar M	26
Dolgui A	Singh RK	36	Bag S	Hartmann E	26
Cherrafi A	Gunasekaran A	36	Belhadi A	Hartmann E	26
Gunasekaran A	Kumar A	32			

We use the keyword field of the same doc file extracted from BibExcel and conduct our next step analysis to find out the frequency of keywords associated with the research of digitalized SCM. Our result shows

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that industry-4, digitalization, blockchain, and digitalization are the most influential terms or subdomains in the research of digitalized SCM as shown in Table 4.

Table 4: Influential words

Keywords	Frequency	Keywords	Frequency
Supply chain management	83	logistics	24
Industry 4	72	Industry 4.0	23
Supply chain	63	circular economy	22
Digitalization	46	Blockchain technology	21
Blockchain	46	Digital supply chain	21
COVID-19	43	Supply chains	18
Digital transformation	37	Innovation	17
Sustainability	33	Digital twin	17
Resilience	28	Additive manufacturing	14
supply chain resilience	25	Digital technologies	14

3.3.3 Bibliographic coupling:

A method used in bibliometrics and scientometrics to gauge how closely two or more scientific articles are related is called literature coupling. It is predicated on the notion that two articles are probably connected in terms of subject matter if they mention many of the same references. In literature coupling, the number of shared references between two pieces serves as a proxy for the strength of their relationship. The higher the literature coupling score between two articles, the more references they both share. Based on their references, bibliographic coupling mapping creates groups of works with similar intellectual underpinnings. These clusters describe the predominant research fields (sometimes referred to as "topics") and contemporary trends within a given field of study (Jarneving, 2005). Out of 566 publications, I provide in Figure 2 approximately 100 papers that have the strongest relationships with one another and the eigenvector value.

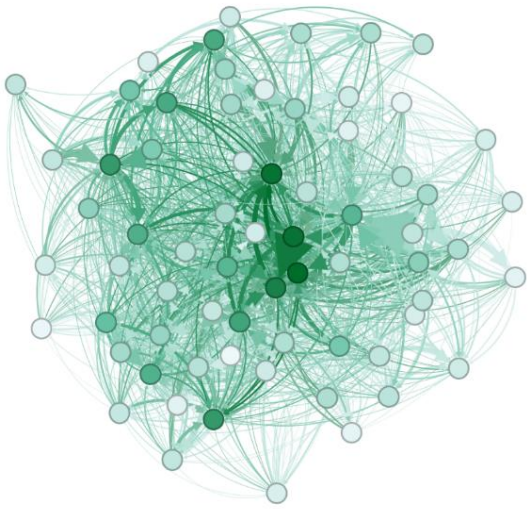

Fig. 3: Bibliographic coupling

3.2 Literature cluster

A literature cluster is a collection of scientific articles that are connected by topic matter in the context of bibliometrics and scientometrics. We use Gephi software to find out the key topics. Many underlying clustering algorithms work in the software to identify literature clusters. These algorithms compare and

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contrast articles based on a variety of criteria, including some specific words used in the titles, abstracts, and/or full text of articles, the keywords, the references cited, and the co-citations.

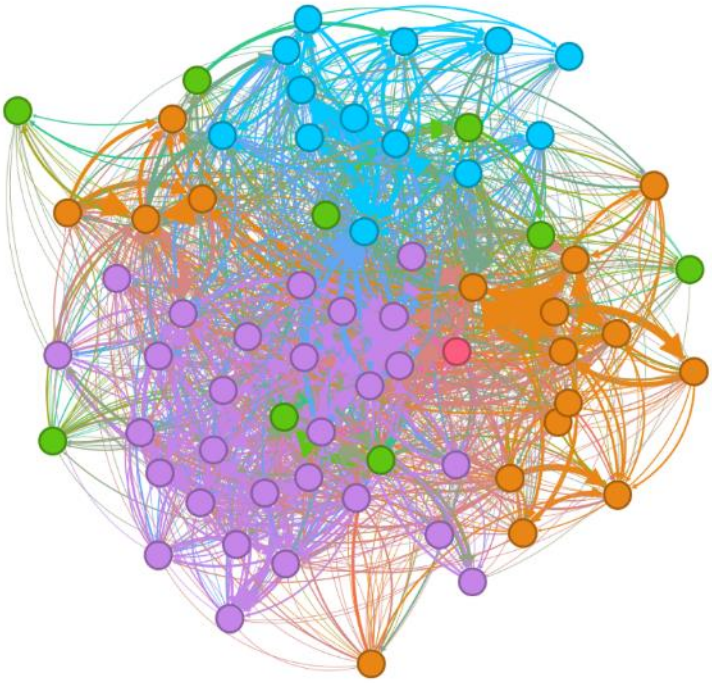

Fig. 4: Literature cluster

Table 5: List of papers of each cluster

Cluster 1	**Cluster 2**	**Cluster 3**	**Cluster 4**
Zekhnini et al., 2022	Spanaki et al., 2018	Yang et al., 2019	Zouari et al., 2021
Zheng et al., 2021	Zeng et al., 2021	Vivaldini & Sousa 2021	Ye et al., 2022
Yang et al., 2022	Zhu et al., 2022	Zhou et al., 2023	Zhou et al., 2022
Yu et al., 2021	Talwar et al., 2021	Xu et al., 2022	Song et al., 2022
Yu et al., 2022	Pfaff 2023	Vafadarnikjoo et al., 2021	Tortorella et al., 2022
Weerabahu et al., 2022	Wohlleber et al., 2022	Tsolakis et al., 2021	Shi et al., 2023
Zangiacomi et al., 2020	Song et al., 2021	Wang et al., 2019	Zaman et al., 2023
Weisz et al., 2023		Yang 2019	Yan et al., 2022
Wehrle et al., 2020		Tokkozhina et al., 2023	Zighan 2022
Tripathi & Gupta 2023		Saberi et al., 2019	Wycislak 2022
Umar et al., 2022		Son et al., 2021	Papanagnou et al., 2022
Sharma & Joshi 2023		Wang et al., 2020	Queiroz et al., 2022
Voipio et al., 2020			Reyes et al., 2023

The goal of constructing literature clusters is to aid academics in identifying areas of research that have received a lot of attention or that are underdeveloped by giving a visual depiction of the relationships between publications. The influence of various study domains or subfields can be assessed as well as trends, knowledge gaps, and future collaborations using literature clusters. Using the modularity value, documents were clustered in Gephi based on their connections. Nodes within the same cluster are heavily interconnected, but nodes in separate clusters are not, and modularity is a measure of how effectively a network's structure can be organically divided into clusters. Greater modularity suggests that creating these clusters inside the network will be simpler. The silhouette score, which gauges the level of average resemblance within each cluster (Chen et al., 2010), is also used to assess the clustering. Figure 3 represents the clusters based on different colors where each color shows an individual cluster, Tables 7 and 8 represent the articles based on the cluster and keywords of those clusters respectively.

Table 6: Influential words of each cluster

Cluster 1	**Cluster 2**	**Cluster 3**	**Cluster 4**
challenges	big data analytics (BDA)	Supply chain resilience	big data
barrier	digitalization	Resilence	capabilities
impact	dynamic capabilities	performance information	Performance
implementation		Integration	digital technology
industry 4	innovation	sustainability	digitalization
industry 4.0	logistics	Technology	dynamic capabilities
information	management	Visibility in the Supply chain	framework
innovation	supply chain		implementation
Internet	transformation		information
logistics	value creation		innovation
supply chain			integration
supply chain management			operations
sustainability			

4. Discussion and future directions

4.1 Cluster 1: Industry 4.0 in Supply Chain

Due to its significant position in the co-occurrence network shown in the purple color of Figure 3, the first cluster is referred to as "Industry 4.0 in the supply chain." Based on the output from Figure 3 that identifies highly correlated articles in this cluster, we run all articles of this cluster in VOSviewer to observe which words are mostly interconnected. Figure 5 generated from VOSviewer, we can see that the supply chain, digital supply, and Industry 4.0 are highly connected to each other.

Day by day the business environment is becoming complex because of globalization and dynamic business competition, and managers need to tackle complex business scenarios with the aid of digitalization. As a very crucial part of business operation, SCM is now emphasizing its activities in Industry-4.0, which helps the supply chain's activities in many ways such as prompt delivery of goods and services, automation process in productions with customer-desired customized products and services (Zheng et al., 2021), thus, supply chain capabilities can be achieved because of the sustaining economies of scale through the mechanisms of I4.0 that ultimately leads to the success of the business as a whole (Yu et al., 2022). Moreover, I4.0 is used in planning, forecasting, and executing business activities, and evidence that sharing data, business specialists, technological tools, and features can be easier through the adoption of I4.0 due to the flexible connectivity among business managers and policymakers, leading to effective SCM.

Despite its potential advantages, the I4.0 may also lead to some issues, which make it difficult for practitioners to comprehend how to practically benefit from this new revolution. Future research can offer

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perspectives to assist businesses in better understanding and evaluating the best strategic decisions to make and the potential consequences (Zheng et al., 2021). Besides performing research on potential problems associated with I4.0, there are numerous potential research scopes that are provided in Table 7.

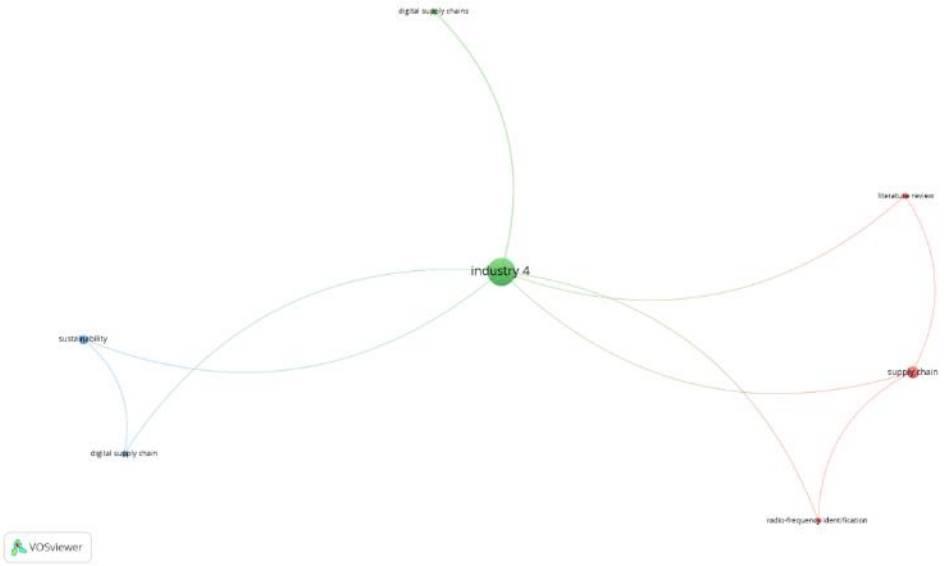

Fig 5: Industry 4.0 in supply chain

Table 7: Current literature status and future research aspects of Cluster 1 (Industry 4.0 in Supply Chain)

Current literature status	Future aspects of research
-examine the interconnection between SCM and digital technologies (Zekhnini et al., 2022) -provide a systematic literature review to find numerous executions of industry-4.0 in manufacturing business processes (Zheng et al., 2021) - the impact of service modularity, platform development, and digitalization on system complexity, and Industry 4.0's influences on enhancing the practices of economy and supply chain capabilities to bolster firm execution (Yu et al., 2021) -Examine the factors supporting and impeding digital supply chain (DSC) implementation and crafting a model of a digitalized supply chain maturity (DSCM) (Weerabahu et al., 2022) -Analyze multiple case studies to illustrate the managerial viewpoint in implementing a roadmap to I4.0 within the value chain of manufacturing (Zangiacomi et al., 2020) -Assess India's present preparedness to transition its supply chain ecosystem toward more intelligent systems aligned with the Fourth Industrial Revolution (Tripathi & Gupta 2023) -Application of mathematical models in manufacturer resource allocation (Bhuiyan & Mazumder, 2024)	- Outlining a strategic roadmap for the implementation of SCM 4.0 in various industries - Exploring the educational system's roles in preparing graduates in new generations for Industry 4.0 and its impact on reshaping the job market - Addressing SCM 4.0 applications across diverse industries - Analyzing the contributions of Industry 4.0 in assisting customer-centric processes. - Investigating the impact of Industry 4.0 on green practices of supply chain and overall sustainability. - Understanding and supporting the influences of I4.0 technology adoption on the supply chain through empirical studies. - Prioritizing the alignment of different I4.0 tools utilized in all stages of SC processes. - influence of leadership traits and skills on the adoption of Digital Supply Chains (DSC) in I4.0 viewpoints - Investigating the correlation between Industry 4.0 readiness and the dynamic capabilities of supply chains

4.2 Cluster 2: Big data in the supply chain

The purple color in Figure 3 indicates our second cluster by grouping some other articles from our sample. Subsequently, we run these articles in VOSviewer to find the interconnected word in this cluster. Figure 6 shows that 'supply chain', 'big data', 'analytics', and 'sustainability' are highly connected to each other which indicates that big data has great influences on digital SCM. That is why we name the cluster "Big Data Contributions in Supply Chain". Due to digitalization, the variety and volume of data are created substantially. Therefore, businesses have experienced substantial changes in their operations and partnerships with partners in several industries since the introduction of digitization. The dynamic capabilities of Big Data predictive analysis and analytics show how better efficiency has resulted from increased access to and analysis of information. Talwar et al. (2021) explore that these skills could improve the agility, sustainability, coordination, awareness, consumer insights, and visibility of supply chains. E-business and e-supply chains generally generate a huge amount of data stored in their cloud-based storage, and this big amount of data can be interpreted through big data analytics (Zeng et al., 2021). Table 8 shows the research that has been performed and numerous future research prospects in this subdomain of digitalized SCM.

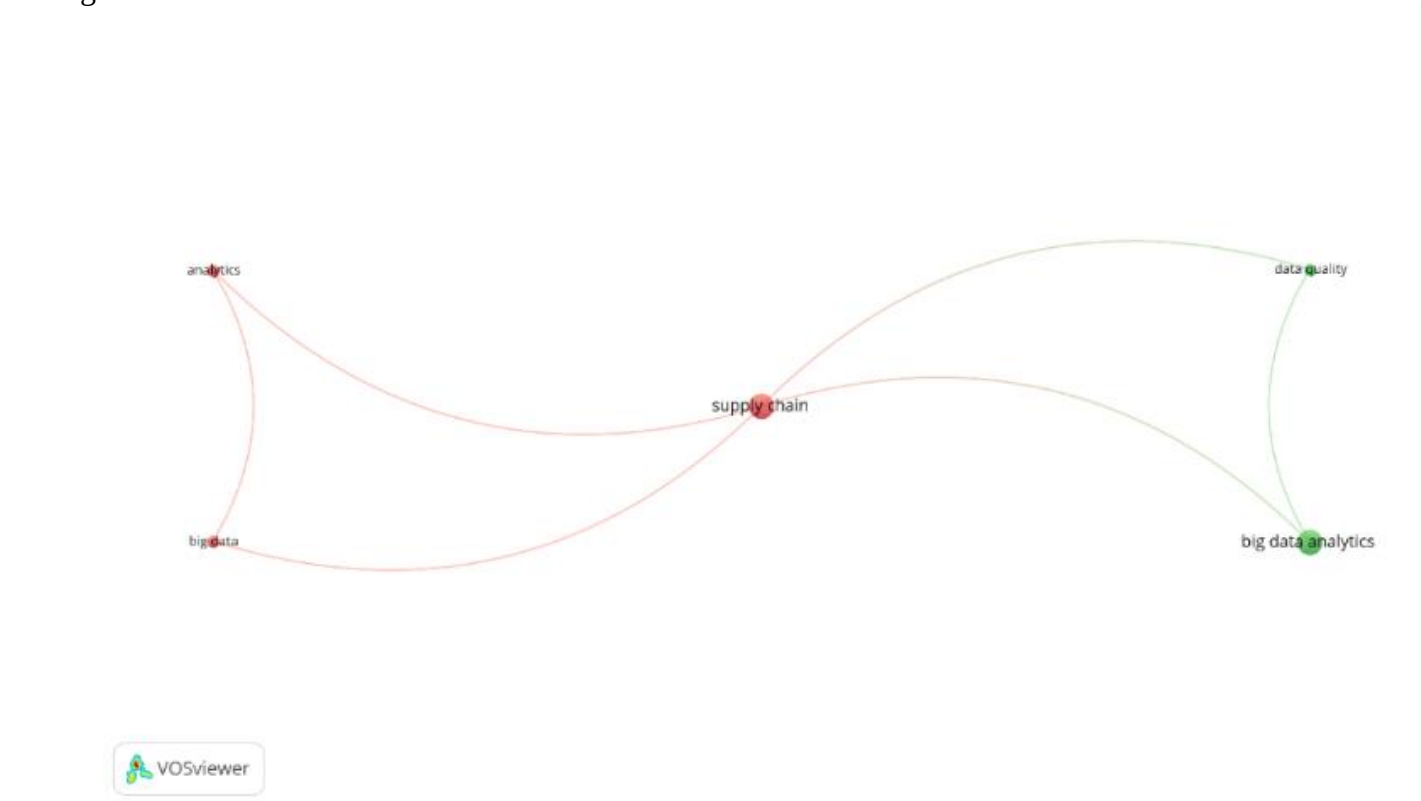

Fig. 6: Big data contributions in the supply chain

Table 8: Current literature status and future research aspects of Cluster 2 (Big data in the supply chain)

Current literature status	Future aspects of research
-provide conclusive knowledge divide between information system adoption and specific e-booking system implementation in the maritime supply chain context (Zeng et al., 2021) -Identify the identity of the digital supply chain (Spanaki et al., 2018) -Scrutinize difficulties and innovation for controlling DSC (Spanaki et al., 2018)	- Exploring data processing methods and manufacturing approaches to enhance data quality - Examining the data privacy in digital supply chains, particularly focusing on the significant risks shared by these datasets among external third parties - Conducting research associated with data collection, processing, storage techniques, and methodologies

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-Discuss advanced packages for the improvement of SCM performance (Spanaki et al., 2018) -Explore the integration of online purchasing mechanisms and online channel management influencing competitive advantages Zhu et al -explore the utilization of financial service providers for evaluating credit associated with SCM in SMEs through BDA platforms (Song et al., 2021)	- Conducting empirical studies through surveys across various companies associated with BDA - Reviewing studies of BDA techniques employing keywords like 'Big Data', 'predictive analytics', 'machine learning', and 'prescriptive analytics' - Exploring the difficulties associated with adopting BDA in developing economies - Evaluating quality standards by analyzing BDA associated with receivable default rates, cash management systems, and supplier payment procedures - Examining and discussing external factors such as market dynamics, competition, and business cycles

4.3 Cluster 3: Blockchain in Supply Chain

Figure 3 shows purple color through accumulating other types of articles. We again run these articles in VOSviewer to know the interconnected words in this group. Figure 7 generated by VOSviewer shows that 'blockchain' and 'supply chain' are highly interconnected, indicating that the articles in this cluster are related to blockchain technology (BT) influencing SCM. That is why we name the cluster "Blockchain in the supply chain,". Numerous difficulties posed due to globalized supply networks have made managing and controlling them more difficult. Blockchain technology, on the other hand, has the potential to resolve numerous problems related to international SCM as it is a distributed electronic ledger system, that ensures traceability, transparency, and data security (Kibria & George, 2022; Saberi et al., 2019). Although still in their initial stage, blockchain technologies are continuously gaining ground in supply chain operations. Therefore, Wang et al., (2019) posit that extended versions of visibility and traceability, digitalization and supply chain integration, smart contracts, upgraded data security, and smart contracts are considered as four areas where these technologies certainly enhance the activities of SCM. Taking another perspective into consideration, adopting a more improved version like blockchain in managing the supply chain can reduce the scope of manipulating the business process to the personal advantage of the employees and improve the reliability of overall supply chain operations. Chakraborty et al. (2018) suggest that employees tend to use the existing loopholes or opportunities in any part of the business process to commit fraud if situations permit. Moreover, such holes in any form of operations of the firms might impair the performance of the firms due to the reasons like the scope of disagreement or conflict of interest among the employees in the firms (Saha et al., 2019) or the option to manage the earnings using free cash flows that are not efficiently used in the business (Saha, et al., 2016).

Conceptualizing blockchain technology's application to SCM is crucial, but future studies should keep a close eye on the changes in this area and collect more empirical data to further investigate the prospects that have been highlighted. In order to help managers foresee and handle some of the problems and uncertainties in projects of this sort, Vivaldini & de Sousa (2021) suggest conducting more research on the factors that affect blockchain connectivity in supply chains. Once blockchain technology has developed as a supply chain technology, it would be beneficial to return to this field and carry out another round of research study (Wang et al., 2019). Numerous potential future research ideas are mentioned in Table 9 with remarkable current research (that has already been conducted) ideas.

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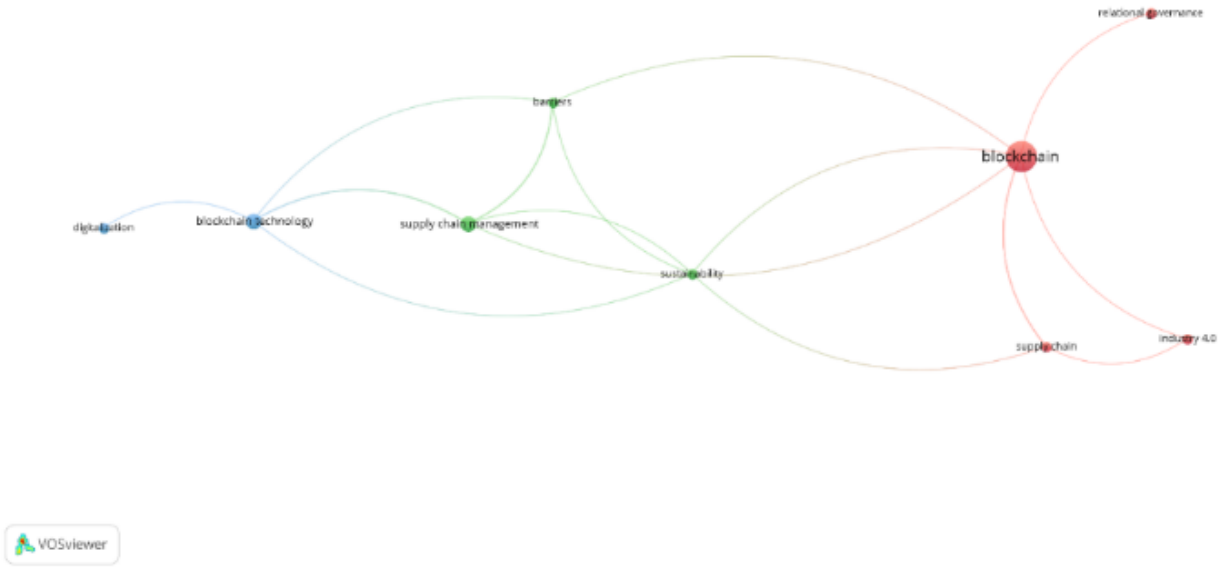

Fig. 7: Blockchain in the supply chain

Table 9: Current literature status and future research aspects of Cluster 3 (Blockchain in the supply chain)

Current literature status	Future aspects of research
-Conduct a thorough survey on blockchain applications and potential enhancements, empirically assessing their impact on the intention to use within the marine industry (Yang et al., 2019) - Highlight connectivity weaknesses (inhibitors) in technology implementation, specifically emphasizing their impact on supply chain interaction and resilience using blockchain technologies (Vivaldini & Sousa 2021) -Develop a conceptual model linking food producers' contractual governance to Digital Transformation success, contingent on relational governance within the supply chain (Zhou et al., 2023) -Explore the impact of blockchain congruence and incongruence with the norm of solidarity on buyer-supplier trust, alongside examining the moderating influence of technology uncertainty (Xu et al., 2022) -Analyze challenges in blockchain technology implementation within the manufacturing viewpoint of SCM (Vafadarnikjoo et al., 2021) -Research on the creation of blockchain-based food supply chains aimed at advancing Sustainable Development Goals, focusing on the Thai fish industry (Tsolakis et al., 2021) -investigate the process in which blockchain impacts future supply chain procedures (Wang et al., 2019) -Introduce three impact dimensions of Blockchain adoption in SCM: 'supply chain relationships', 'operations and processes', , and 'innovation and data access' (Tokkozhina et al., 2023)	- Conducting studies on blockchain technology uses in SCM in comparison across various industries - Studying supply chain agents by exploring the applications enabled in blockchain platforms - Examining the perceived connectivity barriers experienced by managers during the implementation of BT within the SC or more broadly in the adoption of digital technologies. - Evaluating companies' levels of attention to the various features offered by blockchain technology - Creating a comprehensive measurement comprising multiple items to accurately represent the governance activities associated with blockchain technology. - examining the correlation between blockchain governance and various other relational governance mechanisms. - effects of institutional factors such as legal protection and cultural distance on various outcomes. - Researching business practices concerning the implementation of blockchain technology through case studies in emerging economies - Examining ownership and analytics functions that strike a balance between privacy preservation and information loss

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4.4 Cluster 4: Supply Chain Resilience

Another group of same-nature articles clustered by Gephi shown in purple color in Figure 3 is considered to find interconnected words in the last cluster. Again, VOSviewer software is utilized to run the articles of this cluster. Figure 8 generated by VOSviewer shows that 'supply chain technology' and 'supply chain resilience' are highly connected in this cluster, indicating that supply chain resilience (SCR) has influenced SCM. In other words, one of the biggest clusters in Figure 3 is connected to "Supply chain resilience," showing that this topic has received a lot of attention in the study literature.

SCR is positively correlated to the strength of digital maturity and digital tools' utilizations in SC digitalization (SCD). To enhance resilience in the current numerous adverse economic conditions, business policymakers should concentrate on the digitalization of their supply chains (Zouari et al., 2021). Supply chain resilience plays a role as a mediator in the relationship between SCD and the success factors of SCM (Zhou et al., 2022). During severe COVID-19 situations, this mediating influence became stronger. Although supply chain resilience is not directly correlated to the extent of corporate digitization, SC can be enhanced by the use of technologies. Thus, SCR is subsequently upgraded by supply chain innovations (SCI). As a result, SCI works as a perfect mediation between the highly digital technology and SC (Shi et al., 2023).

Companies are needed to enhance trustworthy and persistent measurements to know their level of resilience and problematic areas for further improvement. Through the increases in visibility, agility, and reactivity, technology associated with SCM can significantly enhance supply chain resilience. To do this, future studies can examine the potential of technologies related to blockchain, AI, and the Internet of Things (IoT) corrected to SCM. We summarize numerous present and future research related to this cluster in Table 10.

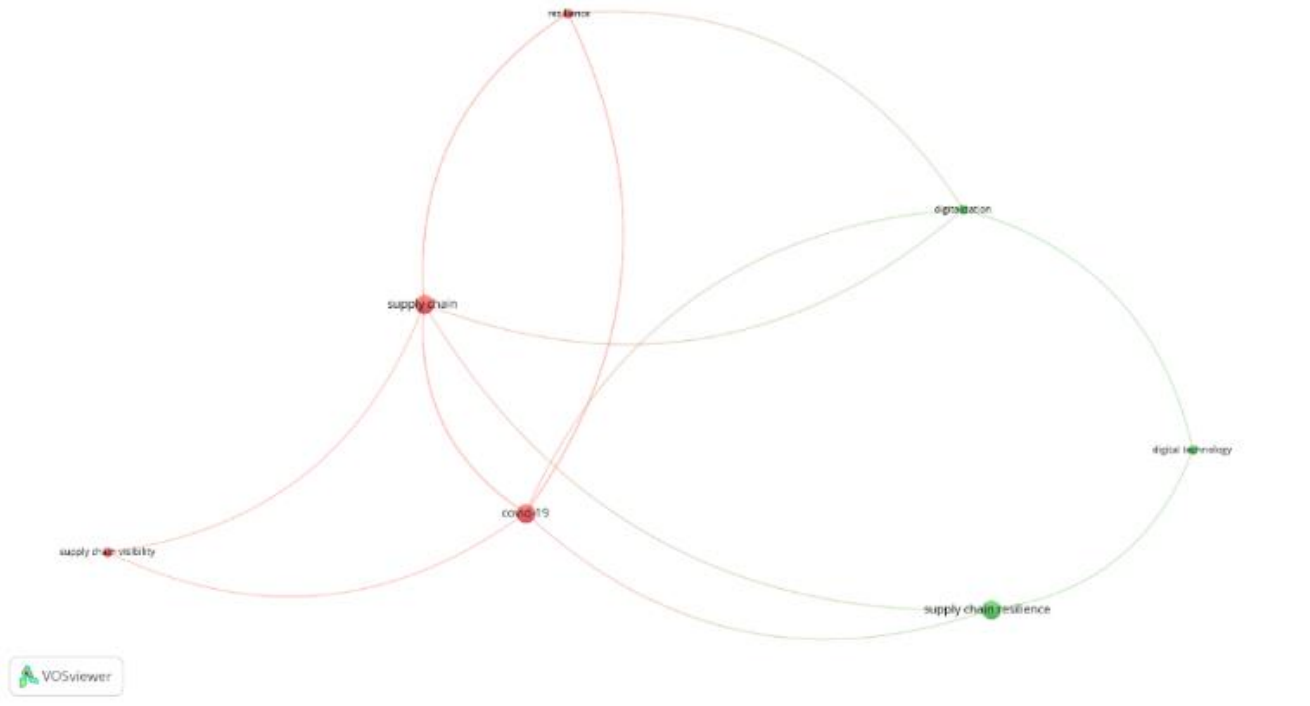

Fig. 8: Supply chain resilience

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Table 10: Current literature status and future research aspects of Cluster 4 (Supply chain resilience)

Current literature status	Future aspects of research
-explore the intensity of digital maturity and the utilization of digital tools are positively correlated to supply chain resilience (SCR) (Zouari et al., 2021) - Find evidence that Digitalization, modularization, and innovations work as mediating variables in the relationship between firm logistic capacity and SCR (Song et al., 2022) -indicate that the SCR contributes to the medical industry, and depending on the applications, SCR outcomes may be varied (Tortorella et al., 2022) -Suggest that SCI plays a role as a mediation variable in the relationship between the intensity of business digitalization and SCR (Shi et al., 2023) -Explore the important factors of SCR in the banking industry (Zaman et al., 2023)	-Scrutinizing SCR in different industries and how they differ based on different internal and external circumstances -Exploring the variables and factors of SCR -Investigating how the variables of SCR intensity work in different settings (i.e., industry, company, local firm, downward suppliers, upstream suppliers) -exploring the challenges to implement SCR in a company, especially in SME business -Examining the factors of digital maturity and how the maturity differs based on challenges companies face -Evaluating the contributions of virtual networks and their communications way impact on SCG -Creating numerous frameworks of SCG in industry-specific -Comparing the research outcomes of SCG based on different research methods (i.e., case study, survey, interview, archival research) and scrutinizing the most appropriate ways of research.

5. Conclusion

Our systematic literature suggests that although numerous research already has been conducted and contributed to digitalized SCM, research in this domain is still in the progress phase as there is a lot of rooms that need to be addressed in future research. This study also indicates that I4.0, blockchain, big data, and SC resilience are the key subcategories of digitalized supply chain research. This is because business environments are getting more complex due to the advancement of digital technologies and their uses in business operations, especially in supply chain management. Digitalized supply chain management enhances remote communications among business partners, electronic business records, and advanced data analysis tools. These digitalization practices in the supply chain operations are ongoing activities that lead to facing new challenges for supply chain managers. Therefore, research in digitalized supply chain management can be a new agenda for scholars based on the four subcategories of this area. Bearing in mind the future research prospects, this study contributes to exploring new research ideas in the combination of supply chain management and its four research subcategories (i.e., I4.0, blockchain, big data, and SC resilience).

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