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Review

A Review of Digital Transformation on Supply Chain Process Management Using Text Mining

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Abstract: Industry 4.0 technologies are causing a paradigm shift in supply chain process management. The digital transformation of the supply chains provides enormous benefits to organizations by empowering collaboration among multiple internal and external organizations and systems. This study presents a narrative review explaining the existing knowledge on digital transformation in supply chain process management using text mining. It summarizes the existing literature to explain the current state of the art in supply chain digitalization. This comprehensive review identifies the most important topics and technologies and determines the future trends in this emerging field. We investigate the articles published in Web of Science and Scopus databases and use text mining techniques (clustering and topic modeling) on the article contents. Using VOS viewer, a bibliometric analysis of 395 articles with 12,700 references is analyzed. The contents of the articles are explored using text mining approaches. The synthesized results reveal that the most important topics in digital transformation are "sustainable supply chain management" and "circular economy and industry 4.0 technologies". The study further discovers big data, data analytics, blockchain, artificial intelligence, machine learning, and the Internet of Things as the most critical technologies for facilitating supply chain digital transformation. Finally, an overlay heatmap analysis of the research articles found that digital transformation, supply chain management, industry 4.0, decision-making, and sustainability are emerging trends in supply chain digitalization.

Keywords: digital transformation; supply chain management; industry 4.0; text mining; big data; analytics

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1. Introduction

Digital transformation uses digital technologies to create new business processes and opportunities to meet the ever-increasing changes in the business environment [1]. Many organizations use digital transformation technologies (Industry 4.0) to enhance systems integrations [2]. Supply chain (SC) managers are trying to cut costs and develop more agile, flexible, connected systems to gain market value to meet the rapidly changing consumer behaviors and market volatility [3]. Digital transformation helps organizations shorten product development, increase flexibility, and generate innovation [4]. It helps people remain competitive in the Internet age [5,6]. The digital transformation uses newly integrated technologies in the industry to create the industry 4.0 realm and smarter manufacturers [7]. It leads to synchronizing production, preventing information distortion, and decreasing delivery times [8]. Industry 4.0 is an adaptable system that automatically adjusts flexible production lines for different types of products according to changing conditions. It can enhance quality, flexibility, and productivity, leading to customized goods with better resource consumption [8].

A digital supply chain (DSC) electronically delivers products from origin to destination [9]. DSC helps increase responsiveness, flexibility, and agility [10]. It uses new technologies to create a transparent, secure, and reliable supply chain management (SCM) system [11]. These technologies enable the firms to achieve the customer's dynamic needs on time. DSC benefits include cost-effective services and value-added operations, which can be used by many ecosystem actors [12]. The technologies under digital transformation, such as the Industrial Internet of Things (IoT) and cyber-physical systems (CPS), help improve SC performance by bridging the gap between the digital and physical worlds. Industry 4.0 significantly changes SC behavior towards achieving smarter and more flexible processes, driving automation and optimization measures, resources efficiency, and overall welfare of the staff and the society [13]. These emerging new technologies and emerging digitalization trends have had a tremendous positive impact on SC processes [14].

Different studies in the SC literature investigate the role of digital transformation in SCM. Tjahjono et al. (2017) [15] investigated the impact of Industry 4.0 on SC. Dolgui et al. (2018) [16] used control theory to dissolve engineering issues in SCM and Industry 4.0 to SC optimization. Ramirez-Peña et al. (2020) [17] offered a model under the perspective of Industry 4.0 to improve and sustainability of SC by considering lean, agile, resilience, and green dimensions in SC. Zimmermann et al. (2019) [18] investigated the impact of Industry 4.0 technologies on SC risks. Dallasega et al. (2018) [19] presented a framework for illustrating Industry 4.0 concepts in construction SCs. Müller and Voigt (2018) [20] examined the subject of SCM in the field of Industry 4.0 and provided challenges, potentials, and recommendations for their integration. Ghadimi et al. (2019b) [21] investigated the stable supplier evaluation and selection process for SCs in Industry 4.0. Manavalan and Jayakrishna (2019) [22] proposed a conceptual model for SC and considered trade, technology, sustainable expansion, cooperation, and dimensions of management strategy to answer the revolution provisions of Industry 4.0. De Giovanni and Cariola (2020) [23] examined the impact of innovation strategy through the technologies of Industry 4.0 in lean and green SC.

Büyüközkan and Göçer (2018) [14] proposed a framework for the implementation of DSC and provided advantages, weaknesses, and limitations. Seyedghorban et al. (2020) [24] examined the literature on SC digitalization using bibliometric analysis and meta-analysis. Queiroz et al. (2019) [25] proposed a model for DSC capabilities in Industry 4.0 that include six main enabler technologies. Nasiri et al. (2020) [26] examined the impact of digital transformation and smart technologies in improving DSC performance. Kittipanya-Ngam and Tan (2020) [27] proposed a framework for the digitalization of the food SC.

The following section describes some essential digital transformation technologies that have improved SC performance. The Internet of Things (IoT) is concerned with connecting objects to the Internet in the physical world for data sharing [28,29]. Moreover, IoT enables objects to hear, speak, act, and behave intelligently [30]. As a global network infrastructure, autonomous machines and devices can interact and collaborate [31]. IoT aims to connect different electronic devices at any time and place [32] and create commercial activities inside and outside the companies, i.e., the markets [28]. The IoT technologies support the integrations of SCs and networks [33] and create commercial activities inside and outside the companies, i.e., the markets [28]. IoT allows connection, communication, and interaction between SC drivers, thus allowing dynamic management of global network operations [32,34]. IoT has a crucial role in the SC process and leads to the automation of product flows from suppliers to customers [30]. The IoT helps real-time location tracking of goods/services and vehicles. Using the various sensors attached to the vehicles, the SC managers can track storage conditions of shipments, including temperature, pressure, humidity, and other measures linked with product quality and condition. IoT also provides a robust and secure way to exchange information in the SC, increasing operational processes, reducing risk and cost, and improving segmentation, visibility, transparency, adaptability, flexibility, and virtualization [35].

Blockchain is a digital distributed ledger [36] and a database system that records transaction data or other information, is securely encrypted, and operates through a consensus mechanism [37,38]. Blockchain cannot be tampered with concerning the use of cryptographic methods [39] and has many applications that can be used for various types of transactions, agreements and contracts, tracking, and payment [40]. As the name implies, it is made up of various blocks, each of which has specific information. In addition, each block has a unique identity with unique information. It is impossible to change, delete, or update blockchain information. If any information changes, it is necessary to create a new block to add information. This unique feature has led to the ability to track and audit anywhere in the SC, which leads to the SC's effectiveness and efficiency [41]. Chang and Chen (2020) [42] have reviewed the blockchain literature in digital SC from the year 2016 to 2021, and this study concludes that the use of blockchain in SCs will improve the performance, but organizations should focus on addressing the operations issues in implementing blockchain technologies.

Big data analytics (BDA) is "the process of collecting, organizing, and analyzing large amounts of data to discover patterns and useful information" [43,44]. Data analytics and information analysis lead to achieving goals, increasing revenue, reducing the cost of production or services, reducing fraud, and increasing accountability [45]. BDA has transformed SCs through various technologies such as sensors, barcodes, RFID, and IoT for integration and coordination. BDA enables companies to reduce operating costs, improve SC agility, and increase customer satisfaction as the market changes rapidly, and ultimately make these companies excel [46]. Using BDA, companies can better understand patterns, trends, and issues in SC [47]. Due to environmental uncertainties and complexities, managers must base their decision on data rather than intuition. BDA is very effective in changing and improving SC performance and helping managers make efficient and effective decisions [48].

Cloud computing (CC) is a set of distributed computers such as data centers and servers that provide the requested services and resources over the Internet [49]. CC has become one of the most critical technologies and ubiquitous to the increasing use of the Internet, broadband, mobile devices, superior transportation valence, and portable prerequisites for end-users [50]. CC consists of five basic features: self-service, extensive network access, resource collection, fast traction, and measured service. CC can help integrate the SC by using geographically dispersed resources and can be prepared rapidly [51].

This research examines the most critical topics in digital transformation and SCM. In addition, we identify which technologies are used in the SC to digitize and which have received more attention, and then what the trends have been in recent years. This research aims to examine the disparate pieces of knowledge published in multiple journals over the last six years to identify the key technologies that promote the integration and digitalization of SCs. This analysis aids in understanding the evolution of emerging technologies' role in improving SC performance using a literature review. The study by [25] has highlighted the need for DSCs and that many companies are searching for improving their capabilities by implementing DSCs. However, understanding of DSCs is still in its early stages. This study aims to shed light on the role of emerging technologies in improving the performance of SCs, as well as introducing some core technologies for upgrading conventional SCs. This research uses text mining techniques on the articles downloaded from Web of Science and Scopus databases to achieve the study's objectives. First, we used a VOS viewer to analyze the downloaded research articles to find the research trends. In the second stage, clustering, keywords extraction, and topic modeling approaches are used with the help of text mining approaches. Combining these methods provides a complete understanding of the current state of digital transformation and SCM research and finds the direction of research in this field. Generally, the main questions we try to answer through the present paper are:

RQ1. What are the most critical topics in digital transformation and SCM?

RQ2. Which technologies are used in the fields of digital transformation and SCM?

RQ3. What are the trends in the field of digital transformation and SCM?

The remainder of this research is as follows. Section 2 presents the proposed research framework, data collection, and the tools used for analysis. Section 3 presents the results and conclusions, and Section 4 concludes the study.

2. Research Framework

The research framework includes two major phases: data collection and data analytics by VOS viewer and text mining.

2.1. Data Collection

In this research, a systematic review is adopted to extract information from different research articles and summarize the findings using various analysis methods. The research process in this research is shown in Figure 1.

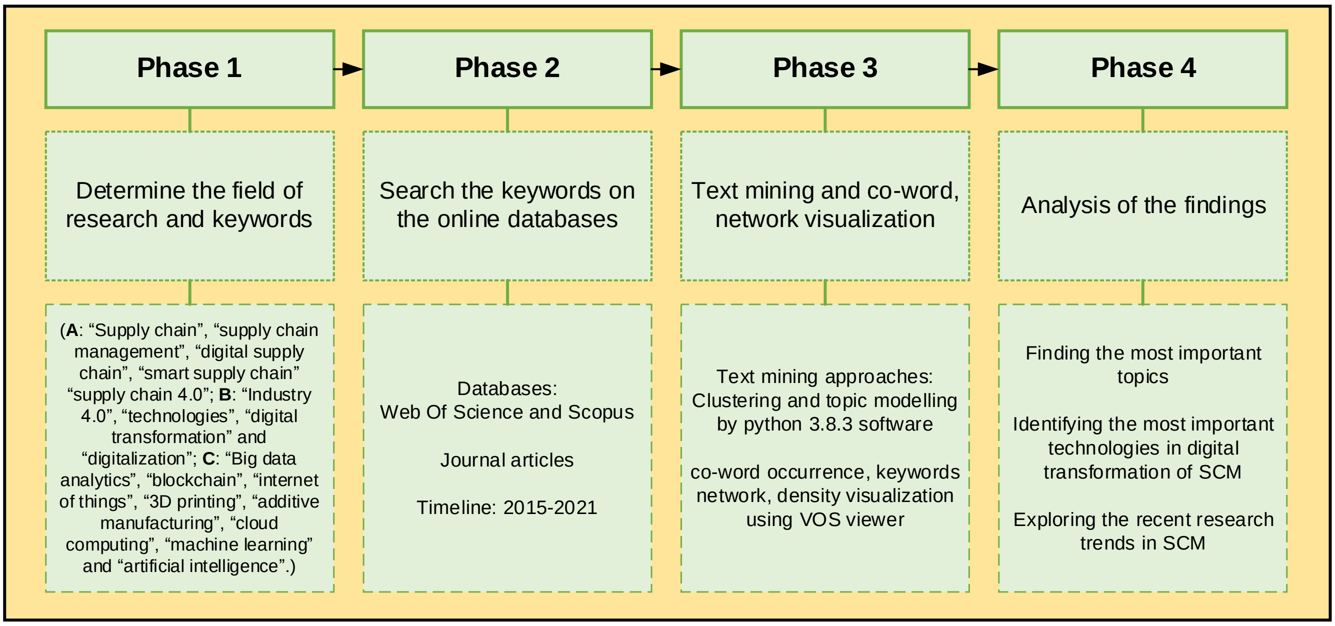

Figure 1. Research process.

Step 1 involves determining the field of research, keywords, and search terms to explore on online databases. keywords **A**: "Supply chain", "supply chain management", "digital supply chain", "smart supply chain", "supply chain 4.0"; **B**: "Industry 4.0", "technologies", "digital transformation", and "digitalization"; and **C**: "Big data analytics", "blockchain", "internet of things", "3D printing", "additive manufacturing", "cloud computing", "machine learning", and "artificial intelligence".

Step 2 involves searching keywords in online databases (Web of Science and Scopus) in the journal articles' titles, keywords, and abstracts.

Step 3 involves text mining and the co-word, network visualization-analysis on the journal articles. This step applies clustering, topic modeling, and labeling techniques to the journal articles.

Step 4 involves analyzing the interpretation of results and writing conclusions based on the findings.

To begin the analysis, we used the web of science and Scopus databases to collect the articles' information. First, we considered the timeline of 2000–2021 for searching the articles, but the search results showed that the number of articles published before 2015 was very few. Since digitalization and industry 4.0 technologies have been getting researchers' attention for the past few years, we restricted our search to the timeline 2015–2021. After the initial examination, 1340 articles were found using keywords **A–C** in 2015–2021. The 1340 articles were manually checked to remove irrelevant ones by reading the details in the title, abstract, and keywords. A total of 395 journal articles were found to be related to the study's objectives after the initial screening. Table 1 shows the summary of articles considered for further analysis.

Table 1. Number of articles collected.

	Journal Name	Number	H-Index	Impact Factor
1	*Journal of Cleaner Production*	28	173	7.246
2	*International Journal of Production Economics*	26	93	3.954
3	*Computers in Industry*	24	172	5.134
4	*Technological Forecasting and Social Change*	23	70	3.605
5	*Production Planning and Control*	21	103	5.846
6	*Computers in Industry*	19	100	3.954
7	*International Journal of Production Research*	18	125	4.577
8	*Sustainability*	18	85	2.798
9	*Computers and Industrial Engineering*	18	121	4.135
10	*Resources, Conservation, and Recycling*	17	119	8.086
11	*International Journal of Information Management*	14	99	8.210
12	*Industrial Marketing Management*	8	125	4.695
13	*Transportation Research Part E: Logistics and Transportation Review*	8	110	4.690
14	*Journal of Manufacturing Technology Management*	5	70	3.385
15	*Supply Chain Management: An International Journal*	5	115	4.725
16	*Journal of Purchasing and Supply Management*	4	80	4.640
17	*Business Horizons*	4	87	3.444
18	*European Journal of Operational Research*	3	243	3.806
19	*Future Generation Computer Systems*	3	119	5.387
20	*Applied Soft Computing Journal*	3	143	5.472
21	*Computers and Chemical Engineering*	2	139	4.000
22	*Expert Systems with Applications*	2	184	4.292
23	other	124		
	Total	395		

Figure 2 presents the articles published each year; it is observed that SC and digital transformation articles have significantly increased from 2019. It indicates that research studies in SCM focus on using the latest technologies.

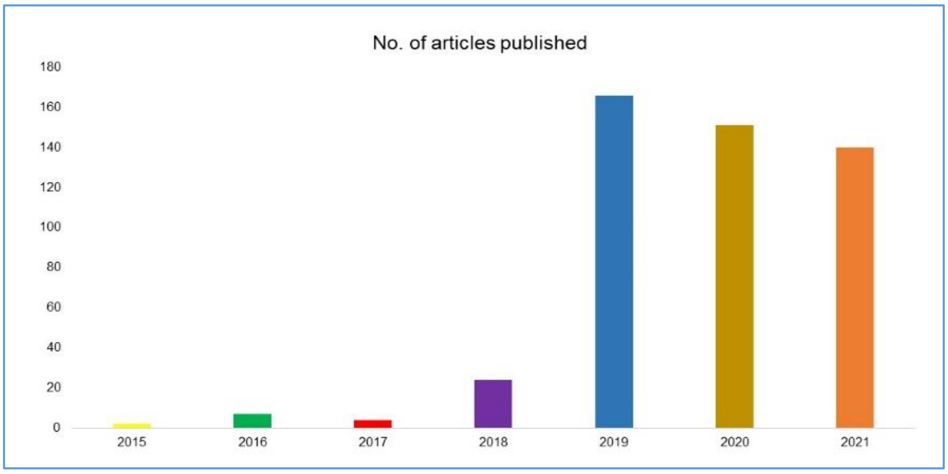

Figure 2. Number of articles published per year.

Keyword analysis of the selected papers on the digital transformation indicates that big data, blockchain, DSC, machine learning, cyber-physical systems, etc., have been frequently cited and used in the academic literature in recent years (see Figure 3). The limitation of VoS viewer is it only works on the keywords, and it cannot read article titles, abstracts, and other sections except citations co-network analysis. The keywords analysis of the academic articles might reveal some helpful information. Still, the findings are not complete because keywords only carry common words, and much of the information available in the other sections of the article is unutilized. To overcome the limitation, we have used text mining approaches to analyze the content available in the title, keywords, and abstract to find valuable insights regarding the digital transformation of SCM.

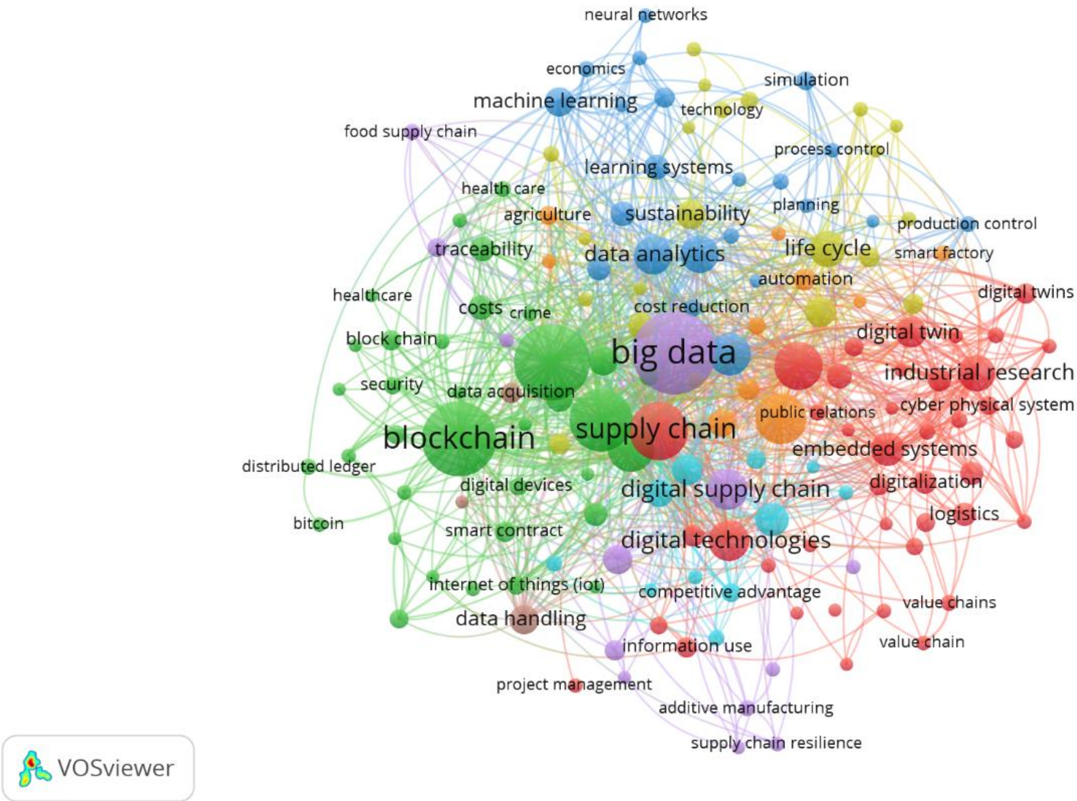

Figure 3. Keyword occurrence in the selected papers.

2.2. Text Mining

Text mining is a process to extract meaningful information from massive datasets. The efficiency of the text mining approaches depends on the quality size of the data and model training [52–54] and includes a set of linguistic, statistical, and machine learning (ML) that models and structure textual content information techniques for business intelligence and research or review [55,56]. In recent years, text mining has offered solutions to analyzing huge content of academic literature; it can save the time and effort required for analyzing the documents [57]. Some of the works that used text mining approaches in analyzing the literature of SCM are [52,58,59].

2.2.1. Clustering and Topic Modeling Techniques

Text clustering is an ML technique for unstructured learning that groups articles based on their similarity. Depending on the purpose of the study size of the documents, researchers can use suitable algorithms for finding from the document [60]. Some standard clustering algorithms include hierarchical clustering, grid-based clustering, partitioning, density-based clustering, etc. Out of the different clustering approaches, we have used the T-SNE algorithm to analyze the articles due to its advantages of handling high dimensional data and reducing it to two to three dimensions for easy visualization [61]. Clustering techniques are used to distribute the papers according to the class (content) of the papers. T-SNE clustering was applied to articles' titles, keywords, and abstract sections. After the clustering technique, we performed the topic modeling technique to reveal the hidden patterns in the generated clusters. Topic modeling is a text mining approach that is frequently used to extract patterns and useful information from unstructured data [57]. A topic includes a set of words that are often put together, and various types of approaches are available in topic modeling [54]. The Latent Dirichlet Allocation (LDA) algorithm is the most wieldy applied technique for topic modeling [62] that was introduced by [63]. LDA techniques discover a set of common frequently occurring patterns based on their co-occurrence and semantic information. In this study, we have also used text clustering techniques to present the clustered keywords in groups. The text mining process used in this research (Phases 3,4 in Figure 1) is shown in Figure 4.

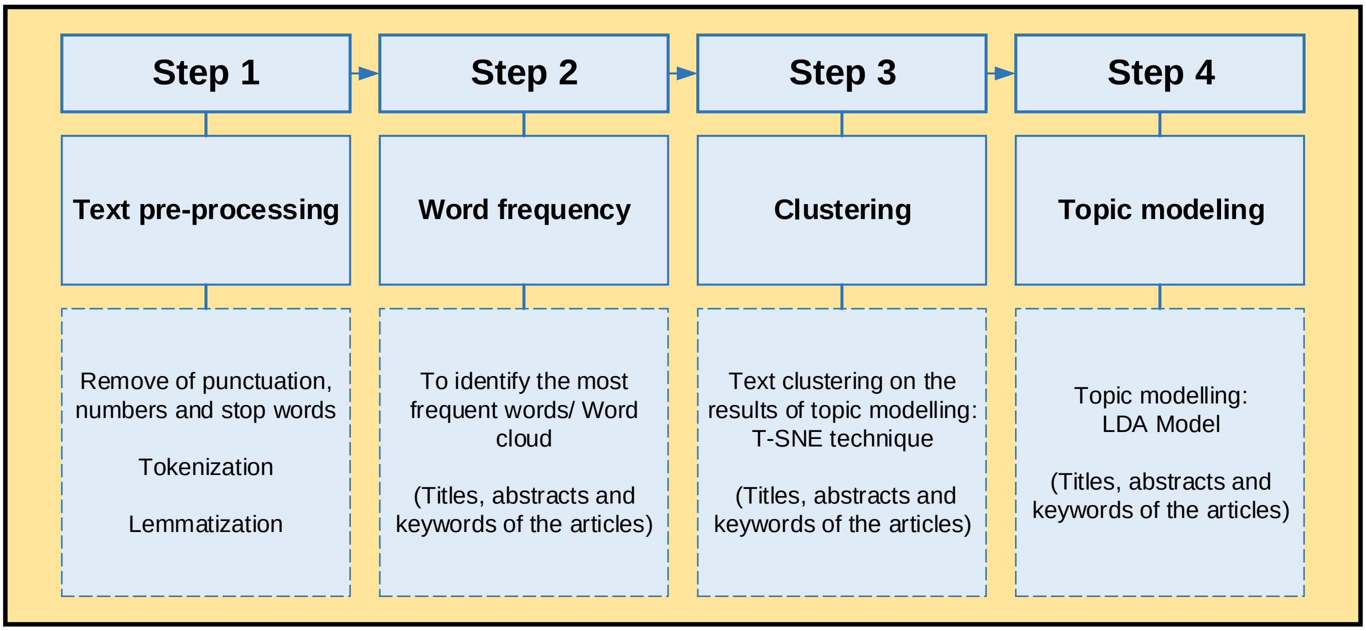

Figure 4. The process of text mining.

Step 1: This step includes text pre-processing (removing punctuation, numbers and stop words, tokenization). Tokenization is breaking down sentences into a set of words r called tokens Punctuations such as (, . ;:' ' ") are removed as they do not carry in useful information. Stop-words are removed as they occur frequently and do not carry any useful information.

Step 2: This step uses the word cloud technique to present the frequently occurring words in the documents. The size of a word represents its frequency of occurrence in the documents.

Step 3: This step applies text clustering to the titles, abstracts, and keywords to create clusters of articles discussing a similar topic. Additionally, after clustering and dimensionality reduction with the T-SNE technique, we use VOS viewer software to visualize the words. Then, we analyze the results of the text mining technique and VOS viewer software.

Step 4: This step applies LDA topic modeling on the titles, abstracts, and keywords of the articles to get an overall understanding of the text.

3. Results

In this section, we analyzed the results of 395 journal articles by text mining and VOS viewer software. We used different bibliographic information such as titles, keywords, and abstracts to extract the keywords from the list of articles. First, we used the word cloud technique using Python 3.8.3 software, and the results are shown in Figures 5–7. In the initial phase of word cloud modeling, some common words related to SCM were overfitted over other words. To reveal the hidden words from the text, we have added some standard SCM words such as "supply chain", "industry", and "system" to the standard stop-words list of NLTK to avoid their presence in the word cloud. As shown in Figures 5–7, the research article in the SC digitalization has highly used words such as "empirical study", "blockchain", "emerging technologies", "information", "forecast", big data", "manufacturing", "barrier", "digitalization", "analytics", "perspective", "internet", "things", "sustainable", "circular economy", "smart manufacturing", "digital transformation", "digital", "artificial intelligence", "machine learning", "cloud computing", and "IOT". These frequent words give us some important information about the emerging trends and recent developments in the subject domain [64].

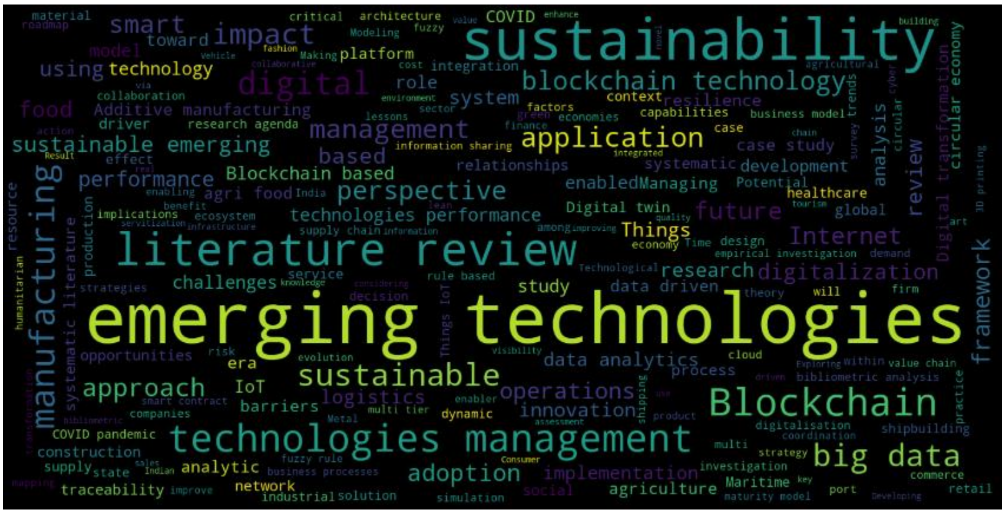

Figure 5. Word Cloud on "Title".

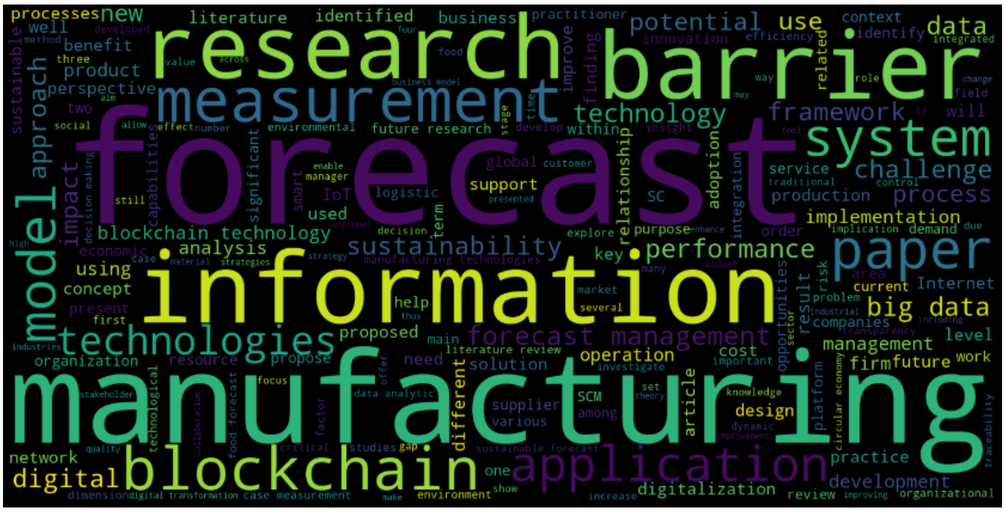

Figure 6. Word Cloud on "Abstracts".

Each keyword may give us some significant information about the emerging trends, but sometimes we cannot draw useful insights using one word's occurrence. For example, the phrase "blockchain" example has occurred 462 times, "barrier" 327 times, "sustainability" 179 times in 395 articles, which means recent studies have been discussing the use of blockchain, adaption-related barrier issues, and sustainability-related issues in SCM. An inference can be made using the word cloud in Figures 5–7—that empirical studies about the usage of emerging technologies such as blockchain, big data, and information management have been increasing in recent years. However, without further analysis, it is difficult to know the context, and the purpose of using these words is unclear. To overcome this ambiguity and find the areas or the purpose of using the above keywords mentioned in the word clouds, we have used clustering and topic modeling techniques available in text mining approaches. Clustering divides the data or information such that data points in the same groups are more similar to other data points. The topic modeling techniques are probabilistic models that analyze the word occurrence and the association between the words using the probabilities.

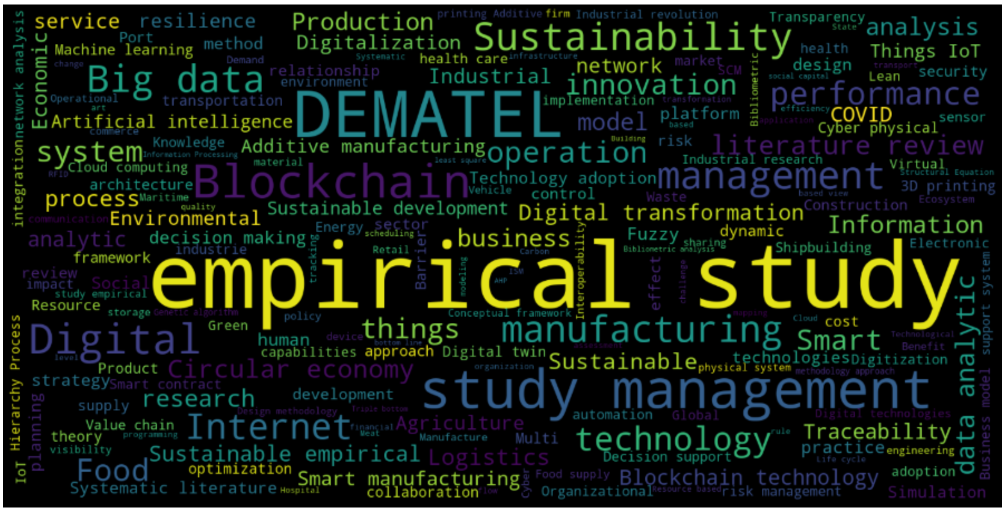

Figure 7. Word Cloud on "Keywords".

Due to the vast content and diversity of subjects discussed by academic articles, it is difficult for researchers to keep up with new information about the digital transformation of SC. The collection of literature can be represented by a scatter plot using clustering for labeling and dimensionality reduction for visualization. On this plot, publications of highly similar topics will share a label and will be plotted near each other. Topic modeling was performed to find the keywords of each cluster to find meaning in the clusters. As discussed in Section 2.2.1 of this study, clustering was applied, and an automatic label extraction algorithm for labeling the generated results using Gensim. We used the T-SNE clustering technique to similar group articles. It groups the articles based on features and semantic similarity, as shown in Figures 8–10. The clustering of the articles divided the information from titles into 3 clusters, abstracts into 5 clusters, and keywords into 4 clusters. Finally, the Gensim supported automated labeling algorithm has been used to label the clusters. The Gensim supported auto-labeling feature (see Table 2) has labeled KC4 as "*Circular economy and sustainable development in supply chains*". We have used the keywords in topics and labels generated by the genism to label the generated topics manually. Based on the automatic label generation result and manual interpretation of words in the topics, the final topic is labeled "Systematic reviews in sustainable supply chain management". The other two topics for titles are labeled "Big data, blockchain research in supply chain management" and "Digital manufacturing and supply chain management". The results are shown in Table 2. We named the clusters based on topic modeling results and analyzed the clusters according to these names.

Out of many topic modeling techniques, the Latent Dirichlet Allocation (LDA) is proven to give better results than other techniques [65]. To extract the topics (patterns of text) from research articles, we have applied LDA on the titles, keywords, and abstract of the final 395 articles individually. For this process, we have converted the required bibliometric information into a CSV file and used python programming language for the analysis. The LDA model performance depends on the tuning parameters. To identify the optimal number of topics for topic modeling, we have used coherence perplexity measures [66].

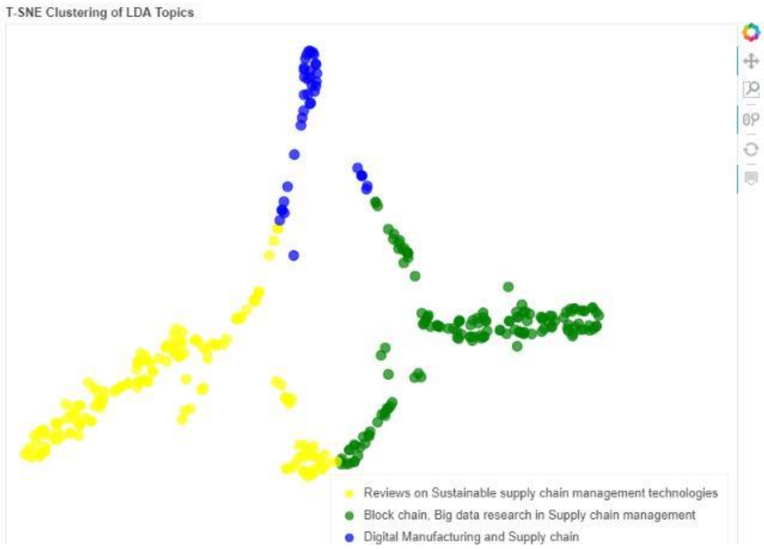

Figure 8. Clustering on "Title".

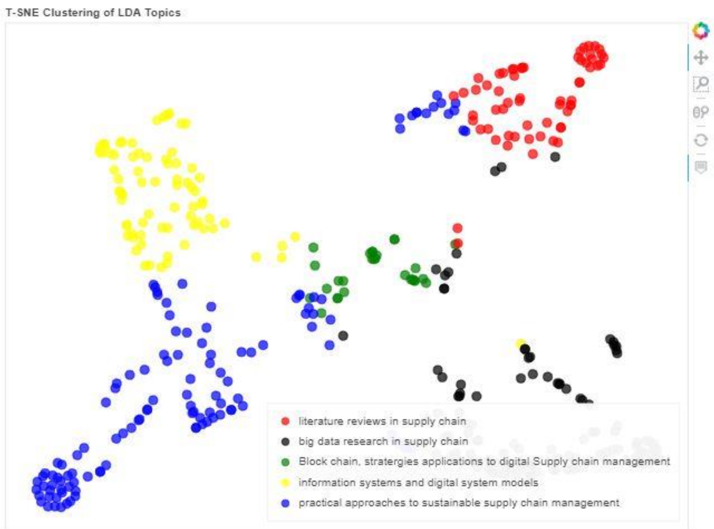

Figure 9. Clustering on "Abstract".

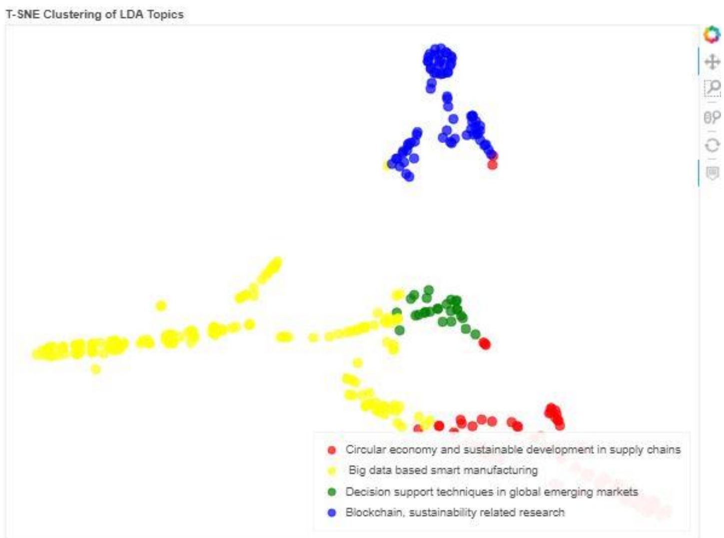

Figure 10. Clustering on "Keywords".

Table 2. Topic modeling and cluster analyzing using topic modeling technique (LDA), word embedding word2vec.

Component	Cluster Number	Automatic Cluster Label Extraction Using Word Embedding Technique	Manual Interpretation	LDA Output on Each Cluster
Title	TC1	Supply chain management integration using systematic literature reviews	Systematic reviews in the area of sustainable supply chain management	[‘0.568 * “Literature” + 0.415 * “review” + “0.027 * “sustainable” + 0.014 * “management” + ”0.016* “supply” + 0.012 * “chain” + “0.009 * “application”, “0.007 * “systematic” + “0.007* “circular” + “0.003 * “research”’]
	TC2	Big supply chain management service industry using blockchain big data analytics	Big data, blockchain research in supply chain management	[“0.412 * Big data”, “0.267 * manufacturing”, “0.051 * blockchain”, “0.046*model”, “0.026 * adoption”, “0.021 * performance”, “0.019 * industry”, “0.007 * supply”, “0.004 * chain”, “0.004 * management”]”
	TC3	Impact digital manufacturing supply chain framework research	Digital manufacturing and supply chain management	[“0.018 * digital”, “0.018 * food”, “0.016 * industry”, “0.012 * technology”, “0.009 * management”, “0.008 * framework”, “0.007 * impact”, “0.006 * smart”, “0.004 * model”, “0.004 * analytics”]
Abstract	AC1	Estimate challenges supply chain	Practical approaches to sustainable supply chain management	[‘0.023 * “provide” + 0.215 * “develop” + “0.119 * “technology” + 0.014 * “sustainability” + ”0.009 * “practice” + 0.007 * “model” + “0.006 * “company”, “0.006 * “study” + “0.004 * “industry” + “0.003 * “approach”’]
	AC2	Forecast serve basic planning	Information systems and digital transformation models	[‘0.016 * “application” + 0.011 * “digital” + “0.011 * “supply_chain” + 0.009 * “information” + “0.009 * “system” + 0.008 * “trust” + “0.008 * “cost”, “0.008 * “firm” + “0.006 * “measurement” + “0.003 * “model”’]
	AC3	Identify blockchain literature	Blockchain, strategy applications in supply chain management	[‘0.030 * “block_chain” + 0.219 * “traceability” + “0.018 * “use” + 0.016 * “system” + ”0.014 * “product” + 0.012 * “purpose” + “0.008 * “application”, “0.007 * “stratergy”+ “0.006 * “provide” + “0.005 * “market”’]
	AC4	Firm access big data analysis	Big data research in supply chain	[‘0.028 * “technology” + 0.020 * “supply_chain” + “0.018 * “big_data” + 0.012 * “impact” + ”0.012 * “research” + 0.011 * “identify” + “0.009 * “paper”, “0.009 * “industry” + “0.008 * “issue” + “0.006 * “metric”’]
	AC5	Purpose paper aim identify literature blockchain supply chain.	Literature reviews in supply chain	[‘0.568 * “review” + 0.415 * “field” + “0.027 * “paper” + 0.014 * “article” + ”0.016 * “research” + 0.012 * “challenge” + “0.009 * “supply_chain”, “0.007 * “systematic” + “0.007 * “process” + “0.003 * “concept”’]
Keywords	KC1	Emerging blockchain research	Blockchain, sustainability-related research	[‘0.294 * “block” + 0.272 * “chain” + “0.117 * “emerge” + 0.109 * “sustainability” + ”0.071 * “supply” + 0.012 * “chain” + “0.008 * “research”, “0.007 * “important” + “0.005 * “article” + “0.002 * “focus”’]
	KC2	Analytic infrastructure	Decision support techniques in global emerging markets	[‘0.030 * “decision” + 0.013 * “time” + “0.011 * “read” + 0.011 * “support” + ”0.009* “engineer” + 0.009 * “system” + “0.007 * “global”, “0.007 * “study” + “0.004 * “various” + “0.002 * “market”’]
	KC3	Big service application in supply chain management	Big data-based smart manufacturing	[‘0.036 * “data” + 0.024 * “big” + “0.020* “manage” + 0.017 * “field” + ”0.016 * “application” + 0.010 * “industry” + “0.009 * “manufacturing”, “0.008 * “outer”+ “0.007 * “analysis” + “0.007 * “role”’]
	KC4	Supply chain management	Circular economy and sustainable development in supply chains	[‘0.082 * “evidence” + 0.061 * “supply” + “0.006 * “circular” + 0.006 * “economy” + ”0.006 * “value” + 0.006 * “challenge” + “0.004 * “manage”, “0.004 * “role” + “0.004 * “progress” + “0.003 * “chain”’]

The perplexity coherence score gave optimal values for the topic modeling of research article titles for $n = 3$ topics. We have used multiple iterations and observed the generated results. At 50 no of passes, $n = 3$ topics, the generated three topics were converging meaningful results. The generated results are reported in Table 2. To interpret the output of topic modeling, we explain Topic 1 generated using titles. In Topic 1, the frequent keywords with co-occurrence of [0.568 * “Literature” + 0.415 * “review” + “0.027 * “sustainable” + 0.014 * “management” + ”0.016* “supply” + 0.012 * “chain” + “0.009 * “application”, “0.007 * “systematic” + “0.007 * “circular” + “0.003 * “research”’] (see Table 2), which implies that the above words in the braces occur frequently together in the titles of research articles. The “literature” has a high coefficient of 0.568, which indicates that this word has a high contribution to the topic. Therefore, the top 10 words which make up the topic are extracted.

Additionally, we have shown the results of clustering in Figures 8–10. These clusters are based on the topic modeling results shown in Table 2.

We have identified the important clusters based on the clustering and topic modeling results. In summary, the important topic and clusters include "*Sustainable supply chain management*", "*big data, blockchain in supply chain management and smart manufacturing*", "*Digital manufacturing and supply chain management*", "*practical approaches to sustainable supply chain management*", and "*circular economy and sustainable development in supply chains*". Due to increasing competition among the organizations at the global level, adopting sustainability in SCM is more important for production organizations [67]. Additionally, the industries are rapidly moving towards digitization. Therefore, these developments cannot be ignored and are traditionally managed by the SC [68]. Sustainability affects the whole production process, from raw materials, managing inventory, production processes, sales, and marketing to using and recycling the product or service. Therefore, manufacturers need to use novel methods to track their acts in the SC. For example, one of the dimensions of sustainability is paying attention to the environment and then reducing waste, recyclable packaging, and eco-friendly materials in the manufacturing processes. It leads to reduced cost, improved product quality, customer loyalty, and strengthening of the brand and SC sustainability.

Another trend is the circular economy in SCs. The circular economy concept is to eliminate waste by adopting appropriate resource-efficient methods from a sustainability viewpoint [69]. A circular economy as a sustainable strategy aims to maximize the use of resources. The circular flows lead to the high utilization of resources based on waste minimization approaches such as reducing, redesigning, reusing, repairing, recycling, and remanufacturing [70]. A circular economy supports SCs by the material recovery process in closed-loop and open-loop flow and increases the product life cycle, components, and useful waste outputs [71].

According to clustering results from Figure 8, it can be inferred that the blockchain and big data research in SCM is a widespread cluster. Research in this domain is constantly evolving; the topic modeling results can help us understand the emerging areas in the cluster. From keywords in Topic TC2, we found the topics of blockchain models, adoption, performance, and big data applications in manufacturing industries are the important topics in SCM in recent years.

Additionally, the text mining approaches have helped identify the emerging areas and knowledge groups that the timeline of the evolution of the new developments did not capture. The VOS viewer software plots the timeline of emerging digitalization trends in SCM. Figure 11 shows the trend of the keywords that were cited year-wise. From Figure 11, it can be observed that big data, blockchain, cloud computing, digital twin, food supply chain, and IoT have been the emerging areas since 2019. Health care, service sector, agriculture, agriculture, digital technologies, etc., are the key areas emerging in 2021. The topic modeling and VoS viewer results conclude that digital technologies such as blockchain, IoT, artificial intelligence, machine learning, cyber-physical systems, big data analytics, digital storage, and cloud computing are the main technologies considered in 2018 2021 for digital transformation and SCM.

Additionally, to show the SC and digital transformation trend, we used the articles published from 2017 to 2021. The results are shown in Figure 12. The heatmap analysis of the research articles has confirmed that digital transformation, big data, digital manufacturing, IoT, industry 4.0, decision-making, and sustainability are trending topics.

Figure 11. Keyword overlay visualization by VOS viewer software.

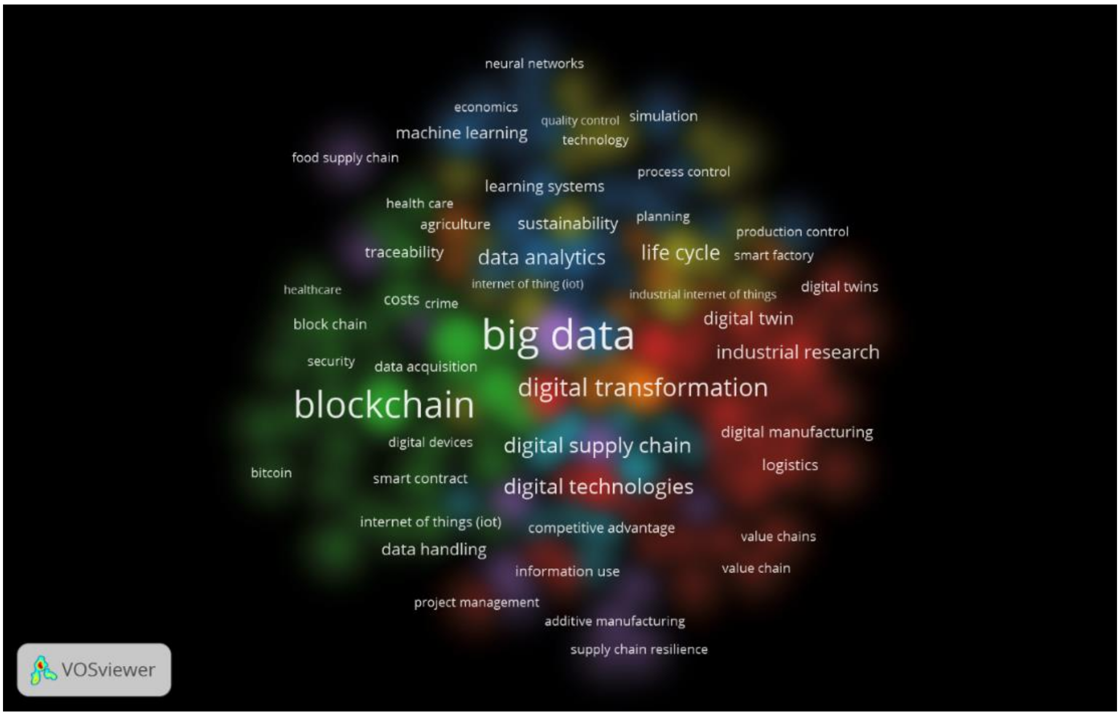

Figure 12. Cluster density visualization of trends (digital transformation and SCM).

Additionally, big data and blockchain in SCM are essential issues that have been considered in recent years. One significant feature of blockchain is that it operates on a decentralized network. That means there is nothing to control or manage the system, and the need for a third party to control the process disappears [72]. Advocators in implementing blockchain in SC have expressed that increasing efficiency and transparency through blockchain can positively affect SC activities. Inventory management, material flow, product and service design, and delivery and payment are only some SC activities affected [73].

The impacts of BD on SC include BD acquisition sources in SC: acquisitions of BD in SCM are from various sources in SC. The sources are suppliers, manufacturers, logistics, distribution, and/or retail [74]. Reducing Delivery Time: BD analysis connected the systems with customers' systems, allowing moving the data ahead of packages [75]. One way to find out about customer needs is BD. Using BD can provide services tailored to customers' needs that attract customers and increase sales [75,76]. Reducing Inventory Costs: using BD, inventory can be kept at a low level because data relating to the past can be used to predict the future [75]. Other impacts include improving efficiency, risk assessment, and reaction time [76], and improvements in the economy and competitiveness and performance [77].

4. Discussion

This study aimed to provide an overview of existing supply chain digitalization knowledge using text mining techniques. Systematic literature reviews are valuable and popular, but they are a complex task that requires a lot of time and is prone to human error [78,79]. This study uses text mining approaches to discover the latest trends in Digital Transformation in Supply Chain Process Management rather than traditional literature review analysis techniques. Our approach was to analyze 395 journal articles published from 2015 to 2021 using the text mining approach to achieve our objectives: (i) identifying the most critical topics, (ii) determining the main technologies used in SCM and how to improve SC performance, and (iii) a complete understanding of the current state of digital transformation and SCM researches and future research directions and trends.

To achieve our first objective, first, we retrieved research articles from Web of Science and Scopus databases. All the required information was downloaded in CSV format, and clustering and topic modeling analysis were performed using Python. The clustering and topic modeling results showed that literature reviews in the areas of sustainable supply chains, circular economy, big data analytics, and decision support systems are increasing, and these studies are receiving the attention of scholars in the SCM domain. This is because modern SCs are experiencing a compulsion to adopt green practices, reduce emissions, and design eco-friendly packaging and logistics operations. In a study conducted by [80], consumers are becoming cautious about the environmental impact of the product/service they are utilizing, which affects SC to improve their socio-environmental performance. These situational factors are driving the organization to adopt green practices. To aid in the decision-making process, these complex operating conditions can be achieved by deploying big data analytics and IoT technologies. Indeed, several papers in our literature review connect the adoption of those technologies and firms' sustainability performance and circular economy. A network analysis of keywords associated with circular economy revealed highly co-occurring with "big data, digital storage, automation, industry 4.0, life cycle, data analytics". The organization should focus on these areas to achieve the targets of sustainability and circular economy. A close investigation of the articles citing these keywords will give us detailed insights that can help sustain economic growth in the coming post-COVID-19 pandemic years

Our second objective was to determine the critical technologies that are used to digitalize modern SCs. A detailed analysis of keywords and abstracts sections of the research papers has revealed that big data analytics, Blockchain, IoT, AI, and ML have been considered important technologies used in modern SCM. Results also emphasized that these technologies positively impact SCM and improve SC performance and integrate SC. In general, AI analytics aid in predicting customer behaviors, target market orientation, supplier activity, delivery time, inventory requirements, and inventory costs using data. Manufacturers can use the customer's vision to predict the state of their products and make changes accordingly. Additionally, manufacturers can predict the supplier activity and the quality of their products and investigate the effect of the activities of their suppliers in the SC and the delivery time of the suppliers. In modern SCs, IoT provides flexibility and connectivity in information sharing and processing. DSCs require integrated supply chain information models, and IoT technologies can help with information integration and service automation [12]. ML is another critical technology that plays an essential role in optimizing the modern complex, agile SCs. [81] reviewed the ten years (2009–2019) of literature published, having the keywords "machine learning" and "supply chain". This study has identified some critical areas where ML can increase the SC performance, including selecting the supply chain partner using various parameters, demand forecasting, resources optimization, detecting false RFID signals, selection of manufacturing and warehousing location, etc. In addition, with the use of ML techniques, manufacturers can determine the inventory level more precisely and decrease its cost by using data obtained in the SC from the suppliers, the retailers, the distributors, and the customers [81]. Blockchain offers safety and security to all stakeholders in the SC network by offering a distributed or decentralized digital system for recording transactions in a verifiable, tamperproof way. Büyüközkan et al. (2021) [82] highlight the use of Blockchain technology in the digitalization of SC networks because this technology allows for the secure transfer of data and assets across large networks of users without the use of intermediaries.

Our final objective was to identify the latest trends in the DSC using the literature. A time-series analysis of the keywords in published articles was used to draw conclusions on the topic. It can be observed that blockchain, the health industry, digitalization, digital transformation, digital technologies, and big data analytics are some future research topics in the domain. A careful examination of the literature reveals that the majority of the papers we have analyzed are conceptual papers proposing to deploy the above-mentioned technologies in optimizing the performance of existing SCs. Based on the literature, it can be concluded that data science has a predominant role in improving SC performance. Some studies have stressed the use of these digital technologies in the health care industry. Future studies might look into areas of digital manufacturing, vaccine, and medicinal distribution networks by offering simple and efficient solutions to save costs. Agriculture and value chains are also trending buzzwords revealed from the analysis. The study by [39] is guided to achieve sustainable performance in agricultural SC using data-driven decision-making. These studies help practitioners and researchers leverage the benefits of these emerging technologies in modern SCs.

5. Conclusions and Limitations of the Study

The digitalization of SCs has been an important issue for more than two decades. This study aims to identify the role of emerging technologies in transitioning traditional SCs to DSCs. Analyzing the past six years of the literature revealed that SCs are gradually adopting emerging technologies in their day-to-day operations. One important finding is that a gap exists between the current readiness of the SCs and the new business environment. COVID-19 has brought many obstacles, such as labor, material shortages, and fall in demand and supply.

On the other hand, it helped firms adopt digital technologies and remote working quickly to meet the global demands. Blockchain, ML, and IoT are believed to be future trends in the DSCs, but the absence of case studies guiding the firms on adopting these technologies is significantly less. DSC will enable any organization to grasp the untapped potential of their existing capacity and achieve higher performance. People must be trained with the right skills and tools to create more excellent value from DSCs. Based on gaps identified in the literature, we keep the following questions open for future studies. For instance, how do different national environments impact the adoption of those technologies? Or, what industrial sectors are better prepared to take advantage of Industry 4.0 technologies (readiness level)? How can Industry 4.0 technologies contribute to improved integration and performance under new operating paradigms such as circular economy?

The following are some of the study's limitations. For our analysis, we looked at articles published between 2015 and 2021; however, there is a chance that we missed some published studies before 2015 or after our article was submitted (2021). We only looked at academic articles published in English, and we only used the Scopus and Web of Science databases to do so. Our study may be biased toward articles indexed in these databases while ignoring articles indexed in other databases. Topic modeling output gives the frequency of top keywords under each topic. The analysis and synthesis of topic modeling output are based on the authors' interpretation of the selected articles, which might be subjected to bias and human errors. We have not conducted co-citation or network analysis, which can help us understand how knowledge is shared between journals and how topics are linked together.

Managerial implications

DSCs have been a buzzword, and it is embedded with many technologies to optimize performance. This study helps managers identify the key technologies used in transforming traditional SCs into DSCs. Recent studies have indicated that the firm investing in digital transformation are gaining revenues as well as a reputation in the global markets [14]. DSCs offer agility, flexibility, security, and openness, which helps achieve higher performance in these highly competitive, complex global markets. With the help of digitalization and blockchain, managers can track the feedback of all stakeholders and consumers in real-time, which helps them to re-shape their business operations to achieve higher consumer satisfaction by reducing the communication and construction gap. Investment in digital technologies should be more focused on the internal integration process of the SCs once they are ready; these DSCs help reduce risks. It aids in better forecasting in terms of costs, market conditions, etc.

Scope for future research

Future studies can extend the timeframe to capture knowledge from comprehensive papers. We considered studies published in a limited timeframe (2015–2021). Researchers can also retrieve papers from other databases, such as Scopus and Web of Science, to capture important literature from other sources. This study used text mining approaches for the analysis; in future studies, researchers can compare text mining approaches to literature analysis tools such as cite space, Knime, and others to determine which tool is best for quick and efficient literature reviews. We limited our analysis to clustering, topic modeling, and keyword analysis; however, future researchers can use visual text mining and text summarization techniques to summarize research articles without reading them quickly. We strongly advise future researchers to identify a successful journey of industry or company in harnessing the benefits of digital technologies and present the findings as a roadmap that will guide industry practitioners and academic researchers through the various stages of making their organization take advantage of these emerging technologies.

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