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Current Status and Hot Spots of Blockchain and Big Data Application in Supply Chain Management——CiteSpace-Based Graphical Analysis

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Abstract. In order to investigate the research status and current hotspots of the application of blockchain and big data in supply chain management. The article visualizes and analyzes the collected literature with the help of CiteSpace software. This study finds that: (1) In terms of research strength, internal cooperation mechanisms have emerged, but the number of cooperation is low and no academic community has been established. (2) Recently, research on supply chain management has centered on the areas of data-related, technology-related, and sustainable development. These research findings provide some thoughts for scholars to further research in the field of supply chain management. Looking ahead, scholars should not only highlight research collaboration and form an author cluster model, but also conduct future research around current hotspots in supply chain management.

Keywords. Blockchain, Big Data, Supply Chain Management, Citespace

1. Introduction

With the increasing competition in the global market and the further advancement of digitalization, supply chain management has emerged as the crucial key for companies to obtain a competitive advantage. The objectives of supply chain management are typically to optimize logistics and reduce a company's purchasing costs. However, traditional supply chain management has some problems, such as slow response time, uncertain demand, and information asymmetry. To implement the application of supply chain management and solve the existing problems, enterprises need to innovate their own supply chain management mode. As emerging technologies, blockchain and big data, bring new opportunities and challenges for improving supply chain management.

In recent years, the continuous innovation of blockchain and big data technology during the digital intelligence era has prompted most enterprises to gradually combine technology and management, taking the advantages of high-precision modern

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technology into full play[1], which has also triggered the attention of many scholars. Some scholars have paid attention to the role played by these new technologies in improving output value and performance[2], and some scholars have paid attention to the role of these new technologies in enhancing supply chain intelligence and flexibilization [1]. In supply chain management, these technologies are utilized in various aspects such as logistics sustainability [3][4]. However, because the relevant research in this field has risen only with the gradual growth of blockchain and big data. Therefore, the current review research is deficient in research approach and data collection, the research is lacking in systematicity and thoroughness, and there are fewer papers summarizing and sorting out the development vein. In order to facilitate researchers to more systematically understand the research status and hotspots in the field, find research entry points and promote academic development, this paper investigates the current research status of blockchain and big data analytics in supply chain management using CiteSpace-based knowledge graph analysis. Compared with simple descriptive analysis, CiteSpace-based knowledge mapping is able to evaluate and predict the current status and development trend of a research field through various quantitative characteristics of the literature, utilizing mathematical and statistical methods. Therefore, we address the issue of how to apply blockchain and big data to the supply chain management process and provide new research hotspots by summarizing the current status of spatial and temporal distribution of related literature, the situation of issuing authors, research hotspots, and practical applications.

In this paper, we will first introduce the relevant research on blockchain and big data in recent years, and then use CiteSpace to investigate the knowledge graphics of extant literature. Finally, it will specifically analyze the current status of the application of blockchain and big data in supply chain management and call for the utilization of new technologies.

2. Relevant Works

2.1 Blockchain

Blockchain is a chained data structure, where data is divided into many blocks, connected in chronological order, and then cryptographic algorithms are used to guarantee updating data, generating data, and transmitting data, as well as guaranteeing data and access security[5]. In summary, blockchain is a technological solution that consists of backward and forward-connected blocks of data to form a channel that is jointly managed by all nodes of the system to ensure that the data is not tampered with or forged, as shown in Figure 1. In recent years, blockchain studies in supply chain management have been diverse and extensive. Researchers are interested in blockchain in food supply chain management[6], agriculture and food supply chain[7], logistics and supply chain management[8], and sustainable supply chain management [8]. These studies cover the usage of blockchain technology in improving supply chain traceability, optimizing inventory management and logistics, improving compliance and risk management, and enhancing supply chain finance and payments. Meanwhile, scholars emphasized the potential of blockchain technology in enhancing supply chain efficiency and security, promoting sustainable development, and creating value [9]. These studies provide an important theoretical foundation and practical guidance to future application of blockchain in supply chain management, as well as some worthy research questions and

new directions for further in-depth exploration of the utilization of blockchain technology in supply chain management. However, due to the slowness of information flow and knowledge conversion leading to the inability to identify the research hotspots in time, the existing research directions still have certain limitations. Therefore, it is crucial to comprehensively sort out and summarize the current literature.

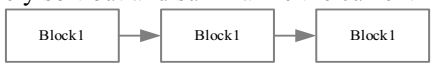

Figure 1. Blockchain diagram

2.2 Big Data

Literally, big data points to the massive gathering of data and the dynamic addition of new data. Nevertheless, Nevertheless, along with the evolution of various information technologies, big data no more refers simply to the size of data, rather, it has been given more connotations. The profound implication of "big data" means the use of specialized data and information processing tools to summarize, organize and analyse vast quantities of information, so as to derive information that is conducive to improving the management capabilities of enterprises[10]. The development course of big data was earliest mentioned by American scientist Alvin in 1980, and the growth course of big data is illustrated in TABLE I. Recently, the study of big data technology in various fields has been booming[11]. Researchers have made many important advances in the collection, processing, analysis, and use of big data. For example, Jia et al. studied the usage of big data analytics in public health[12]. In the business and management domains, big data has been widely used by scholars in marketing[2], customer relationship management[13], supply chain management[14], etc., providing companies with deeper insights and more efficient decision support. Jain et al. showed that the application of big data technologies is increasingly important in supply chain management[15]. However, it is known that the research is still in the development stage due to the immaturity of the related technology and the difficulty of supply chain management coordination. Therefore, actively researching and exploring how to effectively use big data to optimize supply chain management has become one of the focuses of attention in academia and industry.

Table 1. The Development of Big Data

Timing	Course of Development
1980	Start to enter the public view
2008	Get attention at the national level
2016	The National Big Data strategy
2017	To become a data power

3. Methods

3.1 Data Sources

This study uses the Web of Science database as the sources of data. The final search strategy was determined after several pre-searches with "Topic=Blockchain AND Big Data AND Supply Chain Management" the literature years were controlled from 2018 to 2024. Journal sources were selected as SCI and SSCI. Literature was screened by

reading the full text after excluding literature with little apparent relevance to determine inclusion. As this paper focuses on the application of blockchain and big data in supply chain management, irrelevant literature such as volume headings and book reviews were removed through screening, and a total of 247 journal documents were obtained from this search of China Knowledge Network, which was used as the data source for this study.

3.2 Specific Methods

The current study mainly analyzes the literature in two ways: one is to directly analyze the literature descriptively by simple data statistics; the other is to analyze the literature by other literature analysis tools, such as VOSviewer, Publish or Peris, etc. The above methods are unable to view the node information, and it is difficult to extract the key information. Different from the above methods, this paper uses CiteSpace to study the information contained in the documents, which is a citation visualization and analysis software developed gradually based on the background of scientometrics, and it uses spatial form to represent the interrelationships among the information, and show the knowledge development history and structural relationships. Specifically, this study mainly used the visual analysis software of CiteSpace.6.1.R6 to analyze the annual number of publications, author collaboration networks, research countries, and keywords, which reveals the current study spots and future growth trends in the domain. The discussion of the above study hotspots and cutting-edge studies is analyzed primarily based on the measure of centrality. In CiteSpace, centrality is gauged by intermediate centrality, used to measure the significance of a node in a network (other ways to measure the significance of a node such as degree centrality and neighborhood centrality are also available). The calculation formula for centrality is given below:

$$BC_i = \sum_{s \neq i \neq t} \frac{n_{st}^i}{g_{st}} \qquad (1)$$

Where g_{st} is the minimum number of paths from node s to node t, and nist is the minimum number of paths passing via node i in the minimum path from node s to node t of g_{st}. From the viewpoint of information transfer, the higher the centrality, the more important the node is, so the literature with high centrality (or country, keyword, etc.) is usually a key hub linking two diverse nodes, which can mirror the hotspots and frontiers of the study field.

4. Analysis and Results

4.1 Analysis of the Annual Volume of Communications

As seen in Figure 2, the number of documents issued on "Blockchain + Big Data + Supply Chain Management" can be divided into two stages of development, which are the continuous rise stage and the gradual decline stage. The period between 2018 and 2021 belongs to the period of stable development of this research field. However, during the subsequent period from 2021 to 2022, the number of publications in this research area continued to grow. Although the overall total number of publications and the percentage of growth between 2020 and 2021 is the smallest in the 2018 to 2021

timeframe, it still maintains a steadily increasing trend, suggesting that scholars' interest in blockchain and big data technologies in the field of supply chain management has begun to surge. However, from 2021 to 2024, the number of related literature decreased slightly during the continuous decline phase of the study on “Blockchain + Big Data + Supply Chain Management”. However, as a whole, after 2018, the number of articles on blockchain and big data technology in supply chain management has shown rapid growth and a faster growth rate, which indicates that more and more scholars have begun to pay extensive attention to this field, which is in a period of rapid development and shows a sustained growth trend.

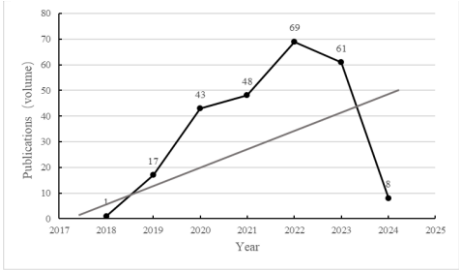

Figure 2. Literature statistics

4.2 Analysis of Authors of Publications

TABLE II lists the authors with high number of publications in the research area of "Blockchain + Big Data + Supply Chain Management". We have 2 authors who have published 6 or more papers and they are Gunasekaran and Angappa. followed by Luthra and Sunil who have published 4 papers which is slightly more than the other authors. Trailing behind are authors such as Gupta, Shivam, Rejeb, Abderahman, Michelino, and Francesca, who are ranked third overall in terms of number of articles posted, with all of them having 3 articles. It can be seen that the application of blockchain and big data technology in the field of supply chain management has been emphasized by research scholars and has achieved certain scientific results.

The cooperation between different authors can be seen in Figure 3, in which there are 190 nodes and 169 links, with an overall density of 0.0.0094, which indicates that a total of 190 organizations are involved, and there are a total of 169 links between each organization. There are many nodes in the graph but most of them are independently distributed and the density of the graph is low, which indicates that there are many research countries in this field but the cooperative relationship between them is very few and low. If we want to strengthen the related research, we should attach importance to the continuous and intensive research in this field, provide more opportunities for academic exchanges, and strengthen cooperation between various countries and scholars. In terms of cooperation, cooperation between researchers and scholars in the same country is relatively close and common, resulting in cooperation between neighboring regions, such as cooperation between scholars in Kang and Kai, cooperation between Gunasekaran and Angappa, Appolloni and Andrea, and cooperation between Luthra and Sunil. In contrast, there are fewer collaborative exchanges with other countries in terms of research around the field, which is usually independent. Most of the researchers also conduct their research independently, a situation that makes it difficult to achieve deep cross-domain research exploration. To boost the healthy and sustainable development of blockchain and big data technology in the supply chain collar management domain,

researchers should strengthen communication and establish good cooperation among themselves.

Table 2. Authors' Publication Volumes

Frequency	Vintages	Authors
6	2019	Gunasekaran, Angappa
4	2021	Luthra, Sunil
3	2023	Gupta, Shivam
3	2022	Rejeb, Abderahman
3	2023	Michelino, Francesca
3	2023	Caputo, Mauro
3	2019	Dolgui, Alexandre
3	2020	Chowdhury, Soumyadeb

Figure 3. Statistics on study authors

4.3 Research Country Analysis

Regarding the top 10 productive countries in the research field of "Blockchain +Big Data +Supply Chain Management", see TABLE III There are four countries with 40 or more articles. They are China, India, the United Kingdom, and the United States, respectively. Among them, the total number of China's literature studies in the related field reaches 63, much higher than the other three countries, they are 55, 46, and 40, respectively. Next, five countries, France (29 articles), Australia (25 articles), Italy (24 articles), Malaysia (12 articles) and Germany (12 articles) have more than ten articles.

Table 3. Top 10 Countries In Terms Of Number Of Publications

Frequency	Centrality	Vintages	Country
63	0.29	2019	China
55	0.24	2019	India
46	0.29	2019	England
40	0.36	2018	USA
29	0.14	2019	France
25	0.27	2019	Australia
24	0.08	2020	Italy
12	0.09	2020	Malaysia
12	0.28	2019	Germany
9	0.05	2019	Spain

The collaboration of the study countries is shown in Figure 4. There are 67 nodes and 182 connecting lines in the figure, with an overall density of 0.0823, indicating that a total of 67 institutions are involved and there are a total of 182 connecting lines between individual institutions. There are many nodes in the figure but most of them are independently distributed, and the density of the graph is low, which indicates that there are many research countries in this field, but there are fewer cooperative relationships among them. However, the centrality of the United States is high, 0.36, indicating that the United States is the main bridge connecting various countries for mutual research cooperation.

Figure 4. Research country statistics

4.4 Analysis of Research Hotspots

4.4.1 Keywords co-occurring hotspot presentation analysis

The keyword analysis of the retrieved literature data using CiteSpace aims to understand the hotspots of research on blockchain and big data technologies in supply chain management in recent years. Keywords can succinctly summarize the topic of an article and forecast future research trends. The 10 keywords with the highest frequency in the research field of "Blockchain +Big Data +Supply Chain Management" are shown in TABLE IV, of which "big data"(126), "management" (87), "supply chain"(67), "big data analytics"(64), and "challenge"(60) are the most frequently used. The high centrality of keywords indicates that they are more closely connected to other content in the research field. From the analysis results, there are 5 keywords with centrality ≥ 0.05, among which "big data analytics" has the highest centrality, indicating that the research on applying blockchain and big data in supply chain management mainly takes big data analysis as the pivot, which in turn leads to the efficient management of supply chain. Generally speaking, considering the frequency and centrality of the keywords and choosing the keywords which have more frequency and centrality, we can get the main hotspots of the present study on the use of big data in the field of supply chain management. Therefore, big data analytics can be regarded as a bridge connecting the research of "Blockchain +Big Data +Supply Chain Management", reflecting the hot direction of this research to some extent.

Table 4. Top 10 Keyword Frequency

Frequency	Centrality	Vintages	Keywords
126	0.09	2018	Big data
87	0.03	2019	Management
67	0.03	2018	Supply chain
64	0.11	2019	Big data analytics

60	0.03	2019	Challenge
60	0.05	2019	Supply chain management
58	0.05	2019	Blockchain technology
52	0.02	2019	Technology
51	0.05	2019	Internet
45	0.03	2019	Framework

When the research hotspots and frontiers of the keywords were sorted to produce the high-frequency keyword list, the keyword co-occurrence mapping was also obtained, as shown in Figure 5. The keyword co-occurrence mapping shows that N=269, E=816, indicating that 269 keywords appeared, and the keywords are related to each other 816 times. In general, the larger the font size of the keyword in the mapping, the more frequent the academic contribution of that keyword.

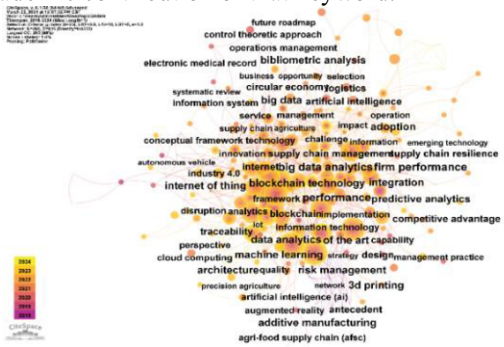

Figure 5. Keyword co-occurrence analysis

4.4.2 Keyword clustering hotspot presentation analysis

Keyword clustering analysis is a keyword reclassification based on the strength of co-occurrence between keywords, grouping closely related literature into one category, thus forming a cluster of hot and concentrated literature. It reflects the subfields of research on the topic and its composition, corresponding to the keyword clustering phrases in the clustering map. According to Figure 6, it can be seen that the clustering map has 269 nodes, and 816 connecting lines, the network density is 0.0226, and the silhouette degree (S-value) of the clustering network is 0.7925 > 0.7, which demonstrates that the clustering result has a high level of confidence. Furthermore, the module value (i.e., Q-value) of the clustered network is 0.5394 > 0.3, indicating that the internal structure of the delineated clustering module is relatively tight, and the network clustering effect is highly credible. In addition, the most compact label in the graph is “bibliometric analysis”, indicating that research on “Blockchain +Big Data +Supply Chain Management” is mostly based on the theme of “bibliometric analysis”. In addition, domestic academics are interested in “security”, “internet of things”, “machine learning”, and “digital technology”. Therefore, future research can be based on the above hot topics.

Figure 6. Keyword clustering analysis

4.5 Research frontier analysis

Using the emergence analysis function in CiteSpace, the keywords of blockchain and big data technology in the supply chain management field are highlighted, which can be used to analyze the evolution of the research development in this field in depth. By analyzing Figure 7, we find that the intensity of keyword occurrences ranges from 0.71 to 2.36, with "information system" having the highest intensity of 2.36. From Figure 7, we can see that the keywords appearing before 2020 are mainly "information system", "service", and "supply chain", which indicates that most of the keywords before 2020 are the application of information and service in supply chain theory. After 2020, research on the application of emerging technologies such as "digital supply chain" as well as "internet of things" appeared, but such research intensity lasted only two years. However, the intensity of research in this category has only been maintained for two years. From 2022 to the present, "industry 4.0 technologies", "sustainability", "perspectives", "collaboration" and "systematic literature review" have maintained a high research intensity. Changes in the emergence of hotspots can be found in blockchain and big data studies in supply chain management in China, which mainly focus on data-related, technology-related and sustainable development, which indicates the significance and long-term development of new technologies (e.g., big data and blockchain) in supply chain management. It can be seen that use of emerging technologies can effectively simplify the supply chain management process, improve management efficiency and accuracy, and thus promote the development of the supply chain.

Top 25 Keywords with the Strongest Citation Bursts

Keywords	Year	Strength	Begin	End	2018 - 2024
information system	2018	2.36	2018	2020	
service	2018	1.55	2018	2019	
supply chain	2018	1.07	2018	2019	
smart contract	2019	4	2019	2020	
information technology	2019	1.63	2019	2020	
competitive advantage	2019	0.79	2019	2020	
predictive analytics	2019	0.67	2019	2020	
data analytics	2019	0.67	2019	2020	
social media	2020	1.69	2020	2021	
simulation	2020	1.35	2020	2021	
conceptual framework	2020	1.35	2020	2021	
supply chain resilience	2020	1.31	2020	2021	
animal health	2020	0.67	2020	2021	
literature review	2021	1.86	2021	2022	
internet of things (iot)	2021	1.03	2021	2022	
operation	2021	1.01	2021	2022	
digital supply chain	2021	0.83	2021	2022	
resource based view	2021	0.83	2021	2022	
management practice	2021	0.83	2021	2022	
cloud computing	2021	0.83	2021	2022	
industry 4.0 technology	2022	0.86	2022	2024	
sustainable development	2022	0.86	2022	2024	
perspective	2022	0.71	2022	2024	
collaboration	2022	0.71	2022	2024	
systematic literature review	2022	0.71	2022	2024	

Figure 7. Keyword emergence mapping

5. Discussion

This paper is based on the visual analysis of the literature related to blockchain and big data technology in the supply chain field. It sums up the research status and hotspots in recent years, and makes a reasonable prediction of the future development trend in this field. Based on the results of the above analyses, it can be found that, firstly, the research in this field has a slowing down trend compared to the rapid growth from 2018 to 2022, but the overall trend is growing. Second, the analysis of countries and authors reveals that there is less transnational or cross-cultural scholarship surrounding research in this field. In addition, the United States is the main bridge connecting countries for mutual research collaboration. Third, the literature analysis shows that supply chain management based on blockchain and big data has accumulated certain application results in practice, in which security, IoT and machine learning have been widely used. There are also some research directions that continue to maintain a high degree of heat, such as sustainable development and collaboration.

5.1 Research contribution

As blockchain and big data are profoundly changing people's life, work and way of thinking, they are also continuously applied to supply chain management. Therefore, based on these findings, we believe that a systematic summary of the application of blockchain and big data in supply chain management helps provide research ideas and directions for researchers in this field. Firstly, the related field still has long-term development space in the future, and scholars can actively explore the unknown areas in combination with the needs of actual organizations. Second, our study actively calls for and promotes mutual exchange and cooperation among scholars from different countries. Finally, we propose many current hot areas that deserve further research by scholars.

5.2 Future research directions

By analyzing the literature, while the study in this field has gone into a speedy growth stage, some topical problems still need to be further discussed: firstly, this paper only explores the two new technologies of blockchain and big data. In the future, the research scope can be expanded to find out more new technologies that can help supply chain management to be explored. Second, the use of blockchain and big data within different supply chains should be further explored to expand the scope of supply chains where blockchain and big data are applied. Third, future research could focus on aspects such as the sustainability of related technologies in supply chain management and how to cooperate.

6. Conclusions

Overall we used CiteSpace software to analyze and visualize the literature and related data on the application of big data in supply chain management in different dimensions, and came up with the following conclusions. From the perspective of time distribution, the literature related to the application of blockchain and big data in supply chain management needs to be further developed because the related technology is not yet fully

mature. From the distribution of frontier countries and regions of supply chain management application research, there are many research countries in this field, but there is less cooperation among them. In addition, a visual analysis of the research on the utilization of blockchain and big data in supply chain management reveals that most of the research on supply chain management focuses on data-related, technology-related, and sustainable development. It can be seen that the utilization of blockchain and big data technology in supply chain management for sustainable development deserves further research by scholars.

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