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ORIGINAL PAPER

FACTORS INFLUENCING THE APPLICATION OF BLOCKCHAIN TECHNOLOGY IN AGRICULTURAL SUPPLY CHAIN MANAGEMENT: SYSTEMATIC LITERATURE REVIEW AND SOCIAL NETWORK ANALYSIS

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ABSTRACT. Background: Blockchain technology, widely recognised as a disruptive innovation, has profound potential to revolutionise agricultural supply chain management. Despite the optimistic outlook associated with its application, the existing exploration and deployment of blockchain in the agricultural sector remains at a relatively rudimentary stage, indicating that this transformative technology has yet to fully realise its inherent potential within this sphere. This study aims to identify the critical factors and explore the relationships among the factors that influence the willingness and efficacy of adoption and implementation of blockchain technology in agricultural supply chain management.

Methods: First, a systematic literature review (SLR) was conducted using VOSviewer software to visualize the status and development tendencies of research in the field of blockchain technology, and core authors in the field were identified. Second, the papers selected through SLR were further screened based on the PRISMA guidelines and discussions with experts to identify the challenges and influencing factors of adopting blockchain technology in the agricultural supply chain. Finally, social network analysis was conducted to identify the key influencing factors and explore the network relationships.

Results: Perceived cost, Establishment of consensus network, and Privacy and security are the critical factors influencing the adoption of blockchain technology in the agricultural supply chain. Policy Support is another key influencing factor. Overall, technological factors dominate the adoption willingness of users.

Conclusions: This study used social network analysis to identify the factors influencing the adoption of blockchain technology in agricultural supply chain management. The study findings will help develop targeted policy measures for blockchain application from the perspective of agriculture practitioners.

Keywords: Blockchain technology, agricultural supply chain management, disruptive technology, social network analysis

INTRODUCTION

In recent years, agricultural supply chain management has become the key factor in the development of modern agriculture. The development of the market economy and the acceleration of economic globalization has led to the formation of a global agricultural supply chain network, and the importance of agricultural supply chain management has become increasingly obvious. However, the agricultural supply chain is a long chain with numerous links and participants, which causes management problems such as poor information communication, inefficient supervision [Zhang et al. 2020], and difficulty maintaining quality and safety standards [Wang et al. 2021]. The current agricultural supply chain network in China is “scattered, disorderly, weak, and small,” and requires the integrated deployment of resources to ensure the security of trading and user information [Leng et al. 2018]. Moreover, since the COVID-19 pandemic, countries around the world have been facing food and environmental crises to varying degrees. The vulnerability of the agricultural supply chain has seriously affected people’s everyday lives, and

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an efficient agricultural supply chain management mechanism is urgently needed.

The emergence of blockchain technology has the potential to solve the problem of agricultural supply chain management. With features such as transparency, traceability, immutability, irreversibility, point-to-point encryption, and smart contracts [Hughes et al. 2019], blockchain technology has been confirmed as a disruptive innovation and has attracted extensive attention from governments, mainstream financial institutions, capital markets, technology companies, and research institutions [Kassen 2022]. Many scholars have confirmed that blockchain is conducive to the coordinated operation of agricultural supply chain networks and to improving supply chain performance. Wang et al. (2022) argue that blockchain, with its characteristics of immutability, decentralization, and traceability, can provide a reliable and effective solution for agricultural supply chain management. Prashar et al. (2020) contend that the data on the blockchain is time-stamped, transparent, and secure, and if there is any problem, the data can be traced quickly and accurately; thus, the blockchain can be used to realize the automatic traceability and management of agricultural data. Li et al. (2020) conducted a convenience analysis of sustainable e-agriculture based on blockchain technology and found that the convenience under blockchain technology increased by more than 15% compared with traditional e-agriculture. Furthermore, relevant practices have highlighted the huge application prospects of blockchain in the agricultural supply chain. For example, Walmart deployed a blockchain system to track leafy greens [Kamath 2018], and JD.com applied blockchain technology to its beef supply chain. The American company Ripo Limited introduced blockchain into the management of the tomato supply chain and used sensors to upload tomato growth environment parameters to ensure the quality of tomatoes in real time.

Despite the evidence that blockchain technology has the potential to improve supply chain performance, the research and application of blockchain technology in agricultural supply chain management is still in the nascent stage. According to the 2019 Gartner report, most of the supply-chain projects based on blockchain technology have remained at either the pilot or proof-of-concept stage. The majority of Fortune 100 companies use blockchain technology, but the investment rate in blockchain technology has dropped since 2019. Bhatt et al. argue that blockchain is still an emerging technology and its application prospects need to be analyzed by researchers and inventors [Bhatt et al. 2020].

The prospect of promoting high-quality development of agriculture and rural areas by using blockchain technology is highly valued by countries around the world, but the related application research of blockchain in the agricultural field has been relatively limited [Kshetri 2020]. When there is uncertainty or a lack of understanding about the challenges that the widespread adoption of new technology will bring to the industry, the adoption of the technology will naturally be slow. Therefore, it is necessary to explore the reasons why blockchain technology is not widely used in the agricultural supply chain. To this end, researchers need to systematically review the existing literature and identify the challenges which hinder the adoption of blockchain technology in the agricultural supply chain to better use blockchain to solve problems such as food safety, non-point source pollution and financial exclusion in the agricultural supply chain management, and to promote the formation of decentralized social governance structures based on blockchain such as targeted poverty alleviation, rural link rectification, rural asset management, and rural e-commerce integration and innovation.

This study aims to quantitatively and comprehensively review the existing fragmented literature on blockchain technology, and to use social network analysis (SNA) to identify the key obstacles to the widespread adoption of blockchain technology in agricultural supply chain management, and also to provide references and suggestions for accelerating the application of blockchain technology in agricultural supply chain management. To this end, the study proposes the following four research objectives: 1) to analyze the research hotspots and development trends of blockchain technology applied in agricultural supply chain management; 2) to summarize the factors affecting the widespread adoption of blockchain technology in the agricultural supply chain; 3) to rank these summarized influencing factors and find out the relationship between them; 4) to determine the key factors and put forward specific reference suggestions.

The rest of this paper is organized as follows. Section 2 presents a systematic analysis of the application status of blockchain technology in agricultural supply chain management by using the systematic literature review (SLR) method. Section 3 describes the research methods and steps for data collection and analysis. Section 4 presents the results and discussions, followed by the conclusions and policy recommendations in Section 5. The research prospects are proposed in Section 6.

SYSTEMATIC LITERATURE REVIEW (SLR)

SLR is a literature review method that systematically collects, collates, analyzes, and evaluates existing research results to answer specific research questions [Staples et al. 2007], which can reduce researchers' subjective bias and improve rigor and repeatability. With the development of computer technology, data visualization techniques have gradually matured, and the analysis results of SLR can be displayed through knowledge graphs.

In recent years, research into and the application of blockchain technology have seen explosive growth [Buterin 2014], and there is increasing research on blockchain technology and its application in the agricultural supply chain [Al-Jaroodi and Mohamed 2019]. However, the existing review studies were carried out during an earlier time period when there were not enough studies conducted and the analysis was also limited, which failed to explore the important research topics and research potential in the field. To overcome this limitation, the present study first adopts the SLR method to conduct a comprehensive analysis of the accumulated knowledge in this field and draws the relevant visualization map using the VOSviewer software to obtain an objective and comprehensive research hotspot and development trend.

Data sources

The data were gathered from the Web of Science (WOS) Core Collection, the retrieval type was "TS=blockchain" & "TS=agri*", the literature type was restricted to paper (not including review papers), and the language was English. A total of 480 articles published as of March 11, 2023 had been retrieved.

Author-keyword network analysis

The number of articles published by an author is one of the important indicators to measure the academic level of an author. Paying attention to the literature published by the core authors in a certain field can help us understand the field more quickly and easily [Carpenter et al. 2014]. The author collaboration network demonstrates the extent of researchers' contributions to the blockchain adoption barriers field and their collaborative relationships with each other. Keywords, known as the real index of the subject area of an article, can best represent the subject content of an article [Kevork et al. 2009]. Thus, paying attention to high-frequency keywords can indicate the research focus of the blockchain technology applied in agricultural supply chain management. In this study, author and keyword were taken as nodes to obtain the visualization diagram of the author-keyword two-mode network in Figure 1.

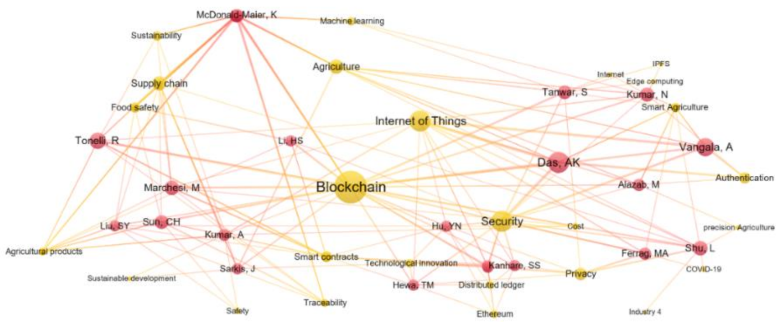


Fig. 1. Author-keyword two-mode visual map

In Figure 1, nodes in light red represent authors and nodes in yellow represent keywords. The size of the author and keyword nodes represents the number of papers published by an author and the frequency of occurrence of a keyword, respectively, and the line between the nodes represents the cooperative relationship. Das, AK; Vangala, A; and Tonelli, R are the top three core authors, and their research serves as a link between the past and the future of blockchain technology. Das mainly studied the development process of blockchain technology in intelligent agriculture. Vangala focused on security architecture, opportunities, and challenges based on the Internet of Things (IoT) and consensus mechanisms in smart agriculture. Tonelli studied the sustainability of information technology application in the food supply chain. These studies are the basis of recent research in this field and should be given high attention. By observing the node size of keywords, we can analyze that blockchain, IoT, distributed ledger, smart contract, Ethereum, cloud computing, and other information technologies are the current research hotspots in the development of agricultural informatization. Traceability is the most widely used function of blockchain technology in agricultural supply chain management. Furthermore, concerns have been raised about security, privacy, and the cost of adopting blockchain technology.

Time-keyword network analysis

To further analyze the development trend of blockchain technology in agricultural supply chain management, this study takes time and keywords as nodes to obtain the time-keyword two-mode visualization map in Figure 2.

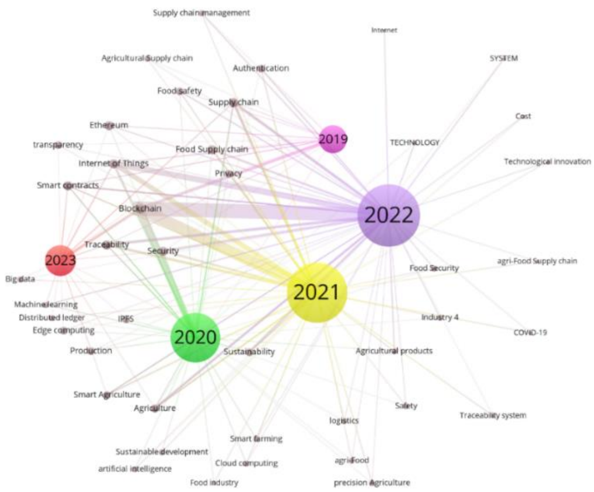


Fig. 2. Time-keyword two-mode visualization map

As can be seen from Figure 2, the nodes representing time increased in size with every passing year, indicating that this field has received increasing research attention from 2019 to 2022. To clearly see the evolution of research hotspots in this field, we used VOSviewer software to generate keyword tag views based on time and keyword dimensions in Figure 3. The color of nodes in the view represents the year of keyword occurrence, and the size of nodes represents the frequency of keyword co-occurrence.

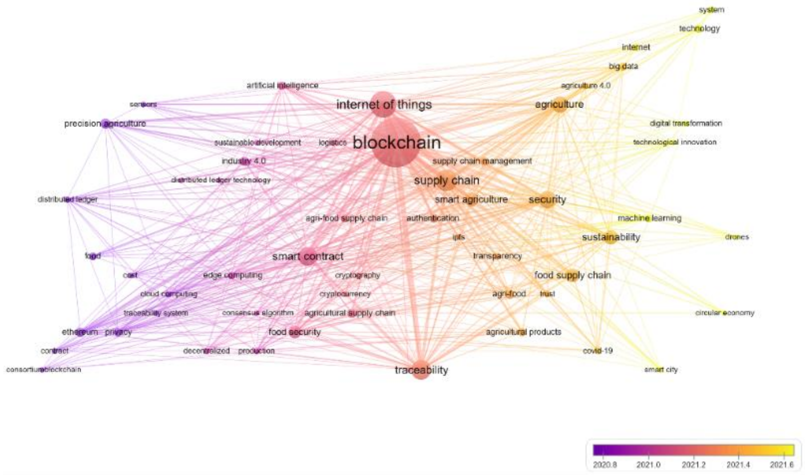


Fig. 3. Keyword tag views by year

As can be seen from Figure 3, research on the application of blockchain technology in the agricultural field only began to appear in 2020, indicating that this topic is relatively new and still worthy of in-depth discussion. With the development of the Industry4.0 era, agricultural development has also entered the Agriculture4.0 era. The traceability feature of blockchain technology has been largely used in agricultural supply chain management, whereas the consensus mechanism and smart contract features have been applied in intelligent agriculture. Since 2021, there has been increased concern about the transparency, security, sustainability, and reliability features of blockchain technology, indicating that there are still some challenges in the application of this technology in agricultural development. However, there is no doubt that digital reform and technological innovation are irreversible trends in today's world. It is important to promote the adoption and application of information technology for the development of industry, especially the relatively backward informatization development of agriculture.

RESEARCH METHODS

Content analysis

Based on the results of SLR, in-depth literature screening was conducted according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. The PRISMA checklist is mainly used to improve and enhance the quality of systematic review and meta-analysis reports. The researchers first screened and analyzed the previous studies to identify the obstacles and challenges affecting the promotion and application of blockchain technology in the agricultural supply chain. The literature selection process includes four stages: identification, preliminary screening, eligibility assessment, and comprehensive inclusion [Jüni and Egger 2009]. Considering that data is constantly updated, this study used December 2022 as the retrieval time, and related research results were collected and sorted based on the PRISMA guidelines. The literature screening process is shown in Figure 4.

For the literature search, we used "TS= Blockchain Barriers" and "TS= Agri-" or their synonyms to retrieve relevant articles from the Web of Science. The literature type was restricted to paper and the language was English. A total of 124 papers were obtained, and 5 highly cited papers of core authors identified in the SLR stage were added. After reading the titles and abstracts, we eliminated 28 articles unrelated to the adoption of blockchain technology, 29 articles only related to the necessity and benefits of blockchain application but unrelated to obstacles, and 7 articles whose full text could not be obtained. Finally, 65 articles related to blockchain technology were selected for in-depth reading.

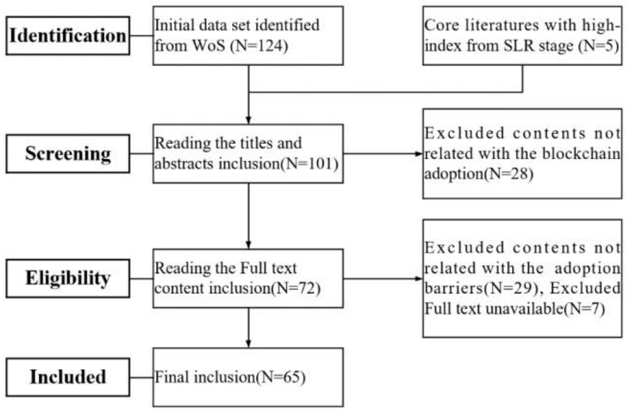


Fig. 4. Literature screening process based on PRISMA guidelines

Policy orientation is crucial for the proliferation of new technologies, and blockchain technology has attracted high attention from governments all over the world. In addition to the selected 65 papers, this study also considered key policy documents, such as the “National Strategy for Critical and Emerging Technology” released by the White House in October 2020, the “Distributed Ledger Technology: Beyond Blockchain” released by the British government in 2018, and the “German National Blockchain Strategy”, jointly published by the German Ministry of Economy, Energy and Finance in 2019. We also included a few industry research reports, such as the Global Blockchain Survey report released by Deloitte in 2020. Based on an in-depth reading of these papers and documents and through discussion with scholars in the industry, obstacles and challenges to the adoption of blockchain technology in agricultural supply chain management were extracted and summarized. For example, the effects of different rules in different regions or industries indicated institutional standard consistency, the effect of system delay indicated system efficiency, centralized control represented accessibility, modular operation and the willingness of operators to embrace new technologies indicated perceived ease of use, and the influence of cultural or technological differences indicated the compatibility of blockchain technology. Furthermore, several scholars have confirmed that the degree of infrastructure perfection affects users’ willingness to adopt technology; thus, this factor was also considered in this study. Many previous studies have found that initial investment cost also affects users’ willingness to adopt technology. However, in the analysis of relevant literature, this study found that the application and promotion of blockchain technology included the cost of initial investment and later system maintenance; therefore, this study considered sustainability and perceived cost as separate influencing factors.

Co-occurrence matrix and frequency analysis

The co-occurrence matrix presents a summary of the information association in the original data space. The value on the diagonal represents the frequency of occurrence of an item in the sample literature, while the other values represent the frequency of co-occurrence of two items in the same literature. The higher the frequency of co-occurrence, the closer the relationship between the two items, and it also represents the focus of the field [Dai et al. 2020]. The summarized influencing factors were sorted, and 38 key influencing factors were identified. To facilitate subsequent statistical analysis, the identified influencing factors were numbered A1 to A38, and the frequency statistics of influencing factors are shown in Table 1.

Table 1. Frequency statistics of influencing factors

No.	Influencing factors	Freq.	No.	Influencing factors	Freq.
A1	Perceived Cost	17	A20	Accessibility	3
A2	Policy Support	16	A21	Data Validity	2
A3	Establishment of Consensus Network	15	A22	Market Competitive Environment	1
A4	Privacy and Security	13	A23	Technological Maturity	1
A5	Stakeholder Attitude	10	A24	Technological Innovation	1
A6	Verifiability of Results	9	A25	Flexibility	1
A7	Scalability	9	A26	Market Competition Environment	1
A8	Infrastructure	8	A27	Technological Comparative Advantage	1
A9	Interoperability	7	A28	Degree of Applicability and Match	1
A10	Lack of Knowledge and Understanding	7	A29	Lower Demand for Labor	1
A11	Consistency of System Standards	6	A30	Over-publicity	1
A12	System Operation Efficiency	6	A31	Conformity of Institutional Standards	1
A13	Sustainability	6	A32	Scale	1
A14	Regulatory Uncertainty	6	A33	Decision-Maker Level	1
A15	Transparency	6	A34	Application and Matching Degree	1
A16	Energy Consumption	5	A35	Industry Boycott	1
A17	Insufficient Cognition and Understanding	3	A36	Extensible	1
A18	Complexity	3	A37	Compatibility	1
A19	Perceived Ease of Use	3	A38	Perceived Risk	1

Social network analysis (SNA)

SNA is a quantitative analysis method based on graph theory and a variety of mathematical methods. It is developed from network theory and organically combined with social theory, statistics, and computational methodology to investigate social relations and social structure [Granovetter 1988]. To analyze the importance of and the relationship between the influencing factors based on SNA, UCINET and NetDraw software were used to visualize the co-occurrence matrix of factors influencing the application of blockchain technology in agricultural supply chain management (only factors with frequency >2 were considered). The visualization diagram is presented in Figure 5, and the analysis results of network evaluation indexes are shown in Table 2.

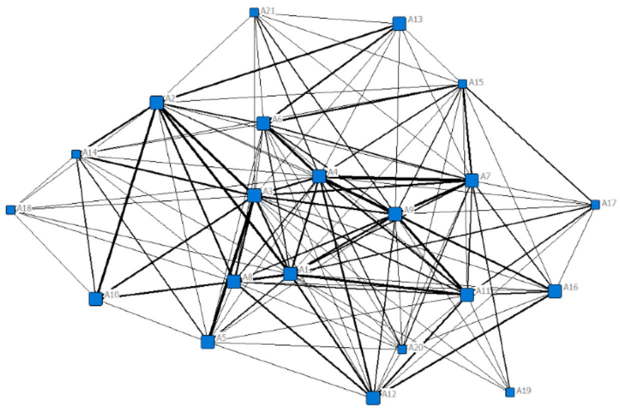
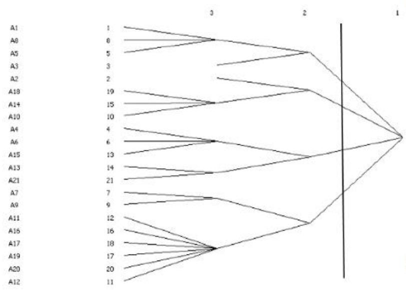


Fig. 5. Visualization diagram of influencing factors

Table 2. Network evaluation index analysis results

Lab.	Clus.	Between-ness cen.	Closeness cen.	Eigenvec-tor cen.	Cluster-ing	Degree	Degree cen.	Harmoni-c cen.	Pager-ank	Constra-int	Effective -size
A1	C0	0.07	0.91	0.29	0.63	18	0.9	19	0.08	0.20	7.33
A2	C0	0.03	0.77	0.23	0.69	14	0.7	17	0.06	0.22	5.00
A3	C0	0.07	0.91	0.28	0.59	18	0.9	19	0.08	0.19	7.89
A4	C1	0.05	0.91	0.29	0.65	18	0.9	19	0.08	0.20	7.00
A5	C0	0.01	0.71	0.21	0.80	12	0.6	16	0.04	0.22	3.17
A6	C1	0.02	0.80	0.26	0.74	15	0.75	17.5	0.05	0.21	4.60
A7	C1	0.04	0.83	0.26	0.68	16	0.8	18	0.07	0.21	5.75
A8	C0	0.03	0.80	0.25	0.72	15	0.75	17.5	0.06	0.21	4.87
A9	C1	0.04	0.87	0.28	0.67	17	0.85	18.5	0.07	0.21	6.29
A10	C0	0.00	0.61	0.12	0.95	7	0.35	13.5	0.04	0.31	1.29
A12	C1	0.01	0.71	0.22	0.88	12	0.6	16	0.05	0.24	2.33
A11	C1	0.02	0.77	0.24	0.77	14	0.7	17	0.06	0.22	4.00
A15	C1	0.02	0.74	0.22	0.68	13	0.65	16.5	0.04	0.21	4.85
A13	C1	0.00	0.63	0.15	0.96	8	0.4	14	0.03	0.28	1.25
A14	C0	0.01	0.67	0.17	0.80	10	0.5	15	0.04	0.25	2.80
A16	C1	0.00	0.69	0.20	0.89	11	0.55	15.5	0.04	0.24	2.09
A19	C1	0.00	0.57	0.10	1.00	5	0.25	12.5	0.02	0.31	1.00
A17	C1	0.00	0.63	0.15	0.96	8	0.4	14	0.03	0.27	1.25
A18	C0	0.00	0.61	0.12	0.95	7	0.35	13.5	0.02	0.30	1.29
A20	C1	0.00	0.71	0.22	0.89	12	0.6	16	0.03	0.23	2.17
A21	C1	0.00	0.63	0.15	0.96	8	0.4	14	0.02	0.28	1.25

After comparing the key influencing factors by the node size, we further explored the relationship between the influencing factors. The CONCOR method was used to conduct a cohesive subgroup analysis of the influencing factors, and the core-edge analysis function was used to conduct core-edge analysis. The cohesive subgroup analysis map and the density matrix are shown in Figure 6 and the core-edge analysis map is shown in Figure 7.



Density Matrix

	1	2	3	4	5	6	7	8
1	1.000	1.000	1.000	0.889	0.778	0.000	0.833	0.722
2	1.000		1.000	1.000	0.667	1.000	1.000	0.833
3	1.000	1.000		1.000	1.000	1.000	1.000	0.000
4	0.889	1.000	1.000	1.000	0.444	0.000	0.000	0.000
5	0.778	0.667	1.000	0.444	1.000	1.000	1.000	0.667
6	0.000	1.000	1.000	0.000	1.000	1.000	1.000	0.000
7	0.833	1.000	1.000	0.000	1.000	1.000	1.000	1.000
8	0.722	0.833	0.000	0.000	0.667	0.000	1.000	0.667

R-squared = 0.639

Fig. 6. Subgroup analysis map and density matrix

```
                 1   1 1 1 1 1 1 1 1 1 2 2
       1 2 3 4 7 6 9 8 2  5 1 0 3 4 5 6 7 8 9 0 1
       A A A A A A A A A  A A A A A A A A A A A A
      -------------------------------------------
 1  A1 |  1 1 1 1 1 1 1 1|1 1 1 1  1 1 1 1 1 1  |
 2  A2 |1  1 1 1 1 1 1  |1  1 1 1 1     1  1|
 3  A3 |1 1  1 1 1 1 1 1|1 1 1  1 1 1 1  1 1 1|
 4  A4 |1 1 1  1 1 1 1 1|1 1  1 1 1 1  1 1 1 1|
 7  A7 |1 1 1 1  1 1 1 1|  1  1 1  1 1 1  1 1|
 6  A6 |1 1 1 1 1  1 1 1|1 1  1 1 1       1 1|
 9  A9 |1 1 1 1 1 1  1 1|1 1  1 1  1 1 1  1 1|
 8  A8 |1 1 1 1 1 1 1  1|1 1 1   1 1    1 1  |
12 A11 |1  1 1 1 1 1 1  |1 1  1    1 1 1  1  |
      -------------------------------------------
 5  A5 |1 1 1 1  1 1 1 1|  1 1    1        1  |
11 A12 |1  1 1 1 1 1 1 1|1         1  1  1  |
10 A10 |1 1 1       1  |1        1      1   |
13 A15 |1 1  1 1 1 1  1|       1 1 1  1  1 1|
14 A13 |  1 1 1 1 1 1    |      1            1|
15 A14 |1 1 1 1  1  1  |1  1 1         1    |
16 A16 |1  1 1 1  1 1 1|  1  1        1  1  |
17 A19 |1  1   1   1   1|                  |
18 A17 |1    1 1  1   1|  1  1    1        |
19 A18 |1 1 1 1      1  |    1    1         |
20 A20 |1  1 1 1 1 1 1 1|1 1  1    1        |
21 A21 |  1 1 1 1 1 1    |     1 1         |
      -------------------------------------------
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Fig. 7. Core-edge analysis map

RESULTS AND DISCUSSIONS

This study used SNA to determine the rank and influence degree of the factors affecting the promotion and application of blockchain technology in agricultural supply chain management. SNA is a quantitative tool to study network relations and the network evaluation indexes include overall network density, centrality, structural hole, core-edge structure, and cohesiveness analysis [Butts 2008]. The analysis results are discussed below.

Frequency analysis of influencing factors

Statistically speaking, the greater number of times an item occurs in a list, the more important it is. In this study, 38 influencing factors related to the application of blockchain technology in the agricultural supply chain were extracted in Table 1. The top three influencing factors with the highest frequencies were Perceived Cost (A1, 17 times), Policy Support (A2, 16 times), and Establishment of Consensus Network (A3, 15 times).

Overall network density analysis

The overall network density indicates the closeness of the relationship between all nodes in the network. Generally, the higher the network density, the closer the connection between all action subjects in the network [Singh et al. 2022]. By importing the co-occurrence matrix into the UCINET software, the overall network density was found to be 0.614 (>0.500) and the number of edges was 129. The overall network density value is relatively large, indicating that the extracted influencing factors are closely related to each other.

Centrality analysis

Centrality analysis is mainly performed to measure the influence of a node in the network. The larger the measurement value, the more important the node in the network. Centrality can be expressed by degree centrality, betweenness centrality, and closeness centrality [Singh et al. 2022].

Degree centrality is an index used to measure the position of a node in the network; the node with a higher degree occupies the central position in the network. Thus, the higher the degree of an influencing factor, the more connection it has with other influencing factors. In this study, Perceived Cost (A1), Establishment of Consensus Network (A3), and Privacy and Security (A4) had the highest degree, followed by Interoperability (A9) and Scalability (A7), indicating that concerns about the cost and technological maturity of blockchain are important constraints on its adoption in the agricultural supply chain.

Betweenness centrality reflects the nodes which act as a “bridge” in the network, controlling the information flow in the network. The results of between centrality are similar to degree centrality, with Perceived Cost (A1), Establishment of Consensus Network (A3), and Privacy and Security (A4) being the top three nodes, followed by Scalability (A7) and Interoperability (A9).

Closeness centrality measures how close a node is to other nodes in the network. The lower the proximity, the stronger the independence of the node. In this study, Perceived Cost (A1), Establishment of Consensus Network (A3), and Privacy and Security (A4) are the top three nodes with the highest degree of proximity to the center, which is consistent with the analysis results of degree centrality and betweenness centrality. The top three nodes with the lowest degree of proximity to the center are Perceived Ease of Use (A19), Complexity (A18), and Lack of Knowledge and Understanding (A10), indicating that the operator’s knowledge and mastery of technology influence their decision about whether to adopt the technology.

Structural hole analysis

Structural hole refers to the phenomenon of no direct connection or discontinuous connection between nodes in the network, indicating a node’s ability to control resources in the network. There are two main measurement indicators: constraint and effective size [Brass and Behavior 2022]. The smaller the constraint value, the larger the number of resources controlled by a node; the measurement criterion of effective size is opposite to that of constraints. As shown in Table 2, the top three nodes with the lowest constraint values and the highest effective sizes are Establishment of Consensus Network (A3), Perceived Cost (A1), and Privacy and Security (A4), indicating that these three influencing factors have strong control over other factors and are less restricted by other factors.

Cohesive subgroup analysis

Cohesive subgroup analysis reveals the actual or potential relationships among nodes in the network. If there is a cohesive subgroup in a certain network, and the density of the cohesive subgroup is high, it means that the nodes within the cohesive subgroup are closely connected and frequently interact with each other for information sharing and cooperation [Gao et al. 2022]. As shown in Figure 6, the network constructed in this study has eight subgroups. Subgroup 8 includes six influencing factors (A11, A16, A17, A19, A20, and A12), followed by Subgroups 1, 4, and 5, which include three influencing factors each. Both Subgroup 2 and Subgroup 3 include only one factor each, indicating that A3 and A2 are not connected with any other factors and are relatively independent.

Core-edge analysis

Core-edge analysis distinguishes the core region and the edge region according to the closeness of the connection between nodes in the network, so as to achieve the purpose of quantitative analysis of the network location structure [Gao et al. 2022]. As shown in Figure 7, there are 9 nodes in the core region and 12 nodes in the edge region, which is consistent with the display results of the visualization map in Figure 5, indicating that the application maturity of blockchain technology and the perception of stakeholders are crucial in the adoption of blockchain technology in the agricultural supply chain.

CONCLUSION AND POLICY RECOMMENDATIONS

Pooled analysis results

To sum up, the results of centrality analysis and structural hole analysis are consistent with the frequency statistics, indicating that Perceived Cost (A1), Establishment of Consensus Network (A3), and Privacy and Security (A4) are the key factors affecting the application of blockchain in the agricultural supply chain. Although the frequency of Policy Support (A2) is high (16 times), it does not have a connection with any other factor and belongs to a single-factor subgroup. In addition, it occupies the middle position in centrality analysis. This indicates that policy support by the government directly affects the willingness to adopt blockchain technology. Furthermore, A1, A2, A3, and A4 are placed in the core region of the core-edge map, which further verifies the critical influence of these four factors. Among the nine core factors, five factors (A3, A4, A6, A7, and A9) are related to the characteristics of the technology itself, indicating that whether or not the technology is efficient is the basic factor affecting its promotion, which is consistent with the results of previous research. The other four core factors are related to cost input (A1 and A8) and policy system (A2 and A11). Thus, improving infrastructure while reducing the input cost and increasing government incentives will have a strong influence on improving the willingness to adopt blockchain technology.

Policy recommendations

This study used SNA to identify the factors influencing the adoption of blockchain technology in agricultural supply chain management. Based on the study findings, the following suggestions and policy recommendations are put forward:

Technological factors are the main factors affecting the adoption of blockchain technology. It is necessary to further improve the stability, scale, and security of the blockchain technology.

Cost factors greatly influence the adoption enthusiasm of users, especially in the agricultural industry with small-scale and dispersed individual businesses. It is suggested that the local government can bear the cost of infrastructure construction and train professionals in blockchain technology.

Policy incentives can further improve users' willingness to adopt blockchain technology in agricultural supply chain management. The government can introduce and implement relevant tax incentives to promote blockchain technology.

RESEARCH PROSPECTS

In this study, the SNA method was used to systematically analyze the factors influencing the adoption of blockchain technology in agricultural supply chain management. The study findings will help practitioners in this field more clearly understand the application challenges of blockchain technology, promote the development of agricultural informatization, and provide suggestions for local agricultural enterprises on how to effectively adopt blockchain technology, which will have positive practical significance for promoting the development of blockchain technology in agriculture.

This study also has certain limitations. First, the study was mainly based on statistical data from previous studies and the opinions of a few field experts, and did not conduct a large-scale questionnaire survey based on an empirical model. The influencing factors can be classified according to the technology-organization-environment (TOE) framework and an empirical model can be developed based on the technology acceptance model (TAM) to obtain more accurate verification results based on a large sample survey. In addition, taking into account the fact that users' adoption intentions change over time, dynamic empirical research should be conducted on the influencing factors of blockchain technology in agricultural supply chain management.

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