INTERNATIONAL JOURNAL OF ACADEMIC RESEARCH IN ECONOMICS & MANAGEMENT SCIENCES

OPEN ACCESS JOURNAL

Vol 13, Issue 2, (2024) E-ISSN: 2226-3624

A Systematic Review of the Application of Blockchain Technology in Agricultural Supply Chain

Zhu Xinyan, Siti Zaleha Bte Omain, Saleh F. A. Khatib, Jingjun Lei

Faculty of Management, University of Technology Malaysia, Johor Bahru, Malaysia
Corresponding Author Email: zhuxinyan@graduate.utm.my

To Link this Article: http://dx.doi.org/10.6007/IJAREMS/v13-i2/21730 DOI:10.6007/IJAREMS/v13-i2/21730

Published Online: 25 June 2024

Abstract

This systematic review aims to summarize the existing literature on the application of blockchain technology in agricultural supply chains, highlighting its potential benefits and identifying key research gaps. Through a systematic literature review, this study evaluated 158 articles from the Scopus database, analyzed the main research content, research methods and research tools of the 158 references, and summarized the current research trends and limitations in this field through targeted discussion and analysis of the 158 literatures. Finally, the benefits, challenges and potential future directions of blockchain integration in agricultural supply chains were identified. The key findings of this review show that blockchain technology significantly improves the traceability of agricultural products and ensures better food safety and quality by providing tamper-proof records throughout the product lifecycle. Despite these benefits, this review also highlights challenges such as high implementation costs, technical complexity and regulatory barriers that stand in the way of widespread adoption of blockchain technology. Further research is recommended on scalable blockchain solutions, integration with other digital technologies and the development of comprehensive regulatory frameworks. Future research should focus on removing existing barriers and exploring innovative applications of blockchain in various agricultural sectors.

Keywords: Blockchain, Agriculture, Supply Chain, Systematic Review, Application

Introduction

China is a large agricultural country, and the agricultural supply chain plays a crucial role in the national economy (Kaltakis et al., 2021). The agricultural supply chain affects the operating efficiency and quality of the entire national economy (Gereffi & Fernandez-Stark, 2016). In recent years, due to recurring food quality and safety problems(Zhuang et al.), For example, in the African plague pig incident in 2019, large quantities of plague-infected pork were sold all over the world. During the 2021 epidemic, Ecuadorian prawns infected with the new crown are still sold around the world. Why is there such a crazy meat supply? The root cause is the need to strictly control the quality of the supply chain. Thus,more and more consumers and agricultural supply chain regulators need fast and reliable agricultural supply chain monitoring technology to ensure the quality of agri-food (Techane Bosona & Girma Gebresenbet, 2023). Relevant research has shown that blockchain technology can improve some problems in the agricultural supply chain (Rana et al., 2021).

Blockchain technology first emerged in 2008 when Satoshi Nakamoto published a paper entitled "Bitcoin: A Peer-to-Peer Electronic Cash System" in the Bitcoin Forum(Zade et al., 2019). The Chinese government and scholars are paying close attention to it. Various countries have successively published a series of policy documents on blockchain technology to accelerate the application of blockchain and give it a leading role in leading the new generation of information technology (Hasan et al., 2021).

Back in 2016, the Chinese government published the first "White Paper on China's Blockchain Technology and Application Development" (Hou et al., 2020). The "White Paper" presents in detail the development status, application scenarios and future development direction of blockchain at home and abroad (Chen et al., 2020). In the same year, blockchain technology was clearly listed as a strategic cutting-edge technology in the National Informatization Plan "13th Five-Year Plan" issued by the State Council (Noesselt, 2020). On October 24, 2019, during the 18th Collective Study of the Politburo of the Central Committee, General Secretary Xi Jinping emphasized that " blockchain is regarded as an important breakthrough for the independent innovation of core technologies and will accelerate the development of blockchain technology and industrial innovation", further highlighting the important role of blockchain (Yuan et al., 2023). Blockchain technology has opened up new development opportunities for all walks of life, and its application has gradually expanded from the financial field to other fields, including the agricultural supply chain (Liu et al., 2021).

The agricultural supply chain is the entire process of agricultural products from origin to sale, which determines whether agricultural products can flow safely and efficiently from the source of production to the consumer, which is why it is highly valued by the government (Xiong et al., 2020). The "Guiding Opinions on Actively Promoting Supply Chain Innovation and Application" issued by the State Council in 2017, it is mentioned that the main task of supply chain application and innovation is to "establish an agricultural supply chain"; China’s "14th Five-Year Plan" also stipulates that “the agricultural supply chain should be promoted in the future”. China’s "14th Five-Year Plan" also aims to improve the supply chain of the agricultural industry, which is an important part of the comprehensive promotion of the rural revitalization strategy (Li et al., 2019). Therefore, the development of the agricultural supply chain is of great importance to the national economy and people's livelihood (Workie et al., 2020).

Due to the long chain, multiple links and complex participants in the agricultural supply chain, it faces difficulties such as poor communication of information, difficulty in ensuring quality and safety, and difficulty in monitoring (Wang et al., 2021). In recent years, the rapid development of science and technology has brought new solutions to these problems with the emergence of blockchain technology (Zhang et al., 2020). Blockchain technology is a decentralized distributed ledger, which has the characteristics of data transparency, tamper resistance, traceability and so on (Remondino & Zanin, 2022) . The introduction of blockchain technology into the agricultural supply chain can effectively improve the transparency and credibility of data and processes, greatly increase the efficiency of management, and reduce regulatory costs (Niu et al., 2021). At present, research on the combination of blockchain and agricultural supply chain is rapidly increasing, and some scholars have conducted related research in this field.

The above studies suggest that BCT can provide solutions to problems such as double spending, information asymmetry, traceability and data security in the agricultural sector. However, there is less practical research on the successful adoption of blockchain technology for agricultural supply chain management (Bhat et al., 2021). Moreover, the practical application of blockchain in the whole process of agricultural supply chain is hardly discussed. Therefore, it is very important to investigate the use of blockchain to achieve a secure and reliable agricultural supply chain. This study aims to show how blockchain technology can be used in the agricultural supply chain. The specific research questions are therefore as follows:

RQ1: What are the recent blockchain technology developments in AFSC?
RQ2: Which features of blockchain technology are widely used in agricultural product supply chains, and which features are less commonly used?
RQ3: What approaches, tools, and methodologies have been used to adopt to blockchain technology in AFSC?
RQ4: What are the significant challenges and future agenda in the concerned theme?

To address the above research problems, we draw on current literature to formulate the key elements of blockchain technology adoption in agricultural supply chains and address symptomatic problems. To achieve this goal, the present study employs a qualitative, systematic literature review approach using PRISMA to investigate the current state of blockchain technology adoption with a technical focus to be able to present the key elements to solve the related problems in process monitoring in the agricultural supply chain. The study conducted a thorough search to collect data for an in-depth analysis of the key factors of blockchain technology that can better solve some of the problems encountered during the agricultural supply chain process (Luo et al., 2022).

The main contribution of this study is to explore the key factors of blockchain technology to solve the corresponding problems of agricultural supply chain, thus realizing the sustainable development of agricultural supply chain (Zkik et al., 2022). The results of the research show that blockchain technology is mainly used in agricultural supply chain financial transactions, agricultural product traceability, agricultural product circulation transparency and agricultural product quality assurance. In addition, the application of blockchain technology in the agricultural supply chain has brought other benefits, mainly reflected in (a) improved stakeholder collaboration, (b) increased mutual accountability of partners, (c) increased customer trust, improved service quality, (d) ensuring data security and availability, (e) improved efficiency of the agricultural supply chain, and (f) strengthening the agricultural and rural economy (El Mane et al., 2022). This study provides meaningful insights for researchers and practitioners to better understand issues related to the adoption of blockchain technology and offers technical guidance for sustainable agricultural supply chain development.

This article is divided into the following sections. Section 2 discusses blockchain and agricultural supply chains. Section 3 discusses the research methodology of the study. Section 4 discusses the results of the review process. Section 5 contains the discussion and finally section 6 contains the conclusions of the study.

Method

The Systematic Literature Review (SLR) method is a research method that collects, screens, evaluates and analyzes existing research literature in a systematic and structured way. Unlike traditional literature reviews, SLR emphasizes the transparency, reproducibility, and comprehensiveness of methods and aim to provide a comprehensive, objective, and credible summary of a specific research field (Sharma et al., 2022). SLR comprehensively collects, screens, and analyzes existing research literature in a systematic and structured manner to provide researchers with a panoramic perspective. (Song et al., 2022). Through SLR, a wide range of research results can be covered to avoid missing important research and ensure a comprehensive and in-depth understanding of the research topic (Xia et al., 2023). The SLR method emphasizes the use of predefined search and screening criteria, reducing the impact of personal bias and ensuring the objectivity and reliability of the review. Generally, SLR can help researchers identify research gaps and deficiencies in the existing literature, thereby providing direction and inspiration for future research. By analyzing and summarizing existing research, it is discovered which issues have not been fully studied, such as the application effect of specific technologies in specific fields that has not yet been verified (Bosona & Gebresenbet, 2023). In addition, A systematic literature review can propose potential directions and key issues for future research, guiding researchers to focus on the next step of research. The systematic literature review method is rigorous and emphasizes transparency and reproducibility, which makes the research more academically valuable and credible (Dey et al., 2022). Ensure transparency of the research process by describing in detail the steps for literature search, screening, and analysis, so that other researchers can repeat the process and verify the results. The systematic literature review integrates a large number of high-quality research results to enhance the authority and persuasiveness of the paper.

Furthermore, SLR can not only summarize and integrate the theoretical framework of existing research, but also provide specific guidance and suggestions for practice. Through systematic literature review, researchers can sort out and integrate the theoretical contributions of different studies and build a solid theoretical foundation to provide support for subsequent research (Ehsan et al., 2022). In addition, Systematic literature reviews often combine the findings of existing research to provide valuable suggestions for practical applications, such as what key factors need to be paid attention to in the application of a certain technology, how to optimize the operating process, etc (Vyas et al., 2022).

Therefore, the SLR method was chosen for this study because of its Systematic and comprehensive. SLR research can explore research topics that have not yet been thoroughly researched or understood. For in-depth SLR research, a thorough review of existing literature helps the researcher to identify questions about the research topic.

Search Strategy

This systematic literature review includes peer-reviewed articles published in scientific journals. It is important to make informed strategic decisions that are consistent with your research questions. All insights, findings and discoveries are documented in detail in the interest of transparency and credibility (Khan et al., 2022). For this systematic review, the inclusion and exclusion criteria for the literature were clearly defined and applied to all sources collected and presented in this review. A systematic assessment of study quality was also included in the review. In this process, the source of the exclusion is identified and justified. By using a clear and systematic approach to reviewing articles and gathering evidence, bias can be minimized, resulting in reliable results that can be used as a basis for decision-making (Yu et al., 2021). Results were qualitatively synthesized and meta-analyzed to provide findings suitable for drawing conclusions (Griffin et al., 2021).

This study is based on a literature search in the Scopus database for its high-quality publications from Elsevier and thousands of other international publishers. The last literature search was conducted on August 1, 2023. Without considering the length of publication, each publication could be searched by the article title, the abstract and the combinations of keywords. For example, a certain publication could be searched by suitable keywords such as "supply chain" and "agriculture" and "blockchain" and Boolean operators.

Data Collection

The data collection for this systematic review was carried out using the Scopus database. First, by entering "supply chain" and "agriculture*", a total of 1426 publications in the field of agriculture from 2016 to 2023 were retrieved. From this perspective, there are relatively many studies on agricultural supply chains. However, this study targets the agricultural supply chain using blockchain technology. So if you create a search string with the combined terms "supply chain" and "agriculture" and "blockchain", the time period is still from January 1, 2016 to August 1, 2023, but only 986 documents are eligible. No publications prior to 2016 were found over the years, suggesting that the application of blockchain-based technology in agricultural supply chains is relatively new but growing rapidly. In the literature search, of the 986 papers, about 921were screened based on causality, non-blockchain and non-agricultural supply chain criteria, and the 158 most relevant peer-reviewed papers were finally selected for the final review. This identification is done by reading the title, abstract and conclusion of the article. The final panel of judges selected articles that are written in English and focus on the application of blockchain-based technology in agricultural supply chains. After reviewing the relevant articles, conduct a comprehensive analysis of the content. Figure 1.1 illustrates the data selection process, inclusion and exclusion of articles according to the preferred eligibility criteria.

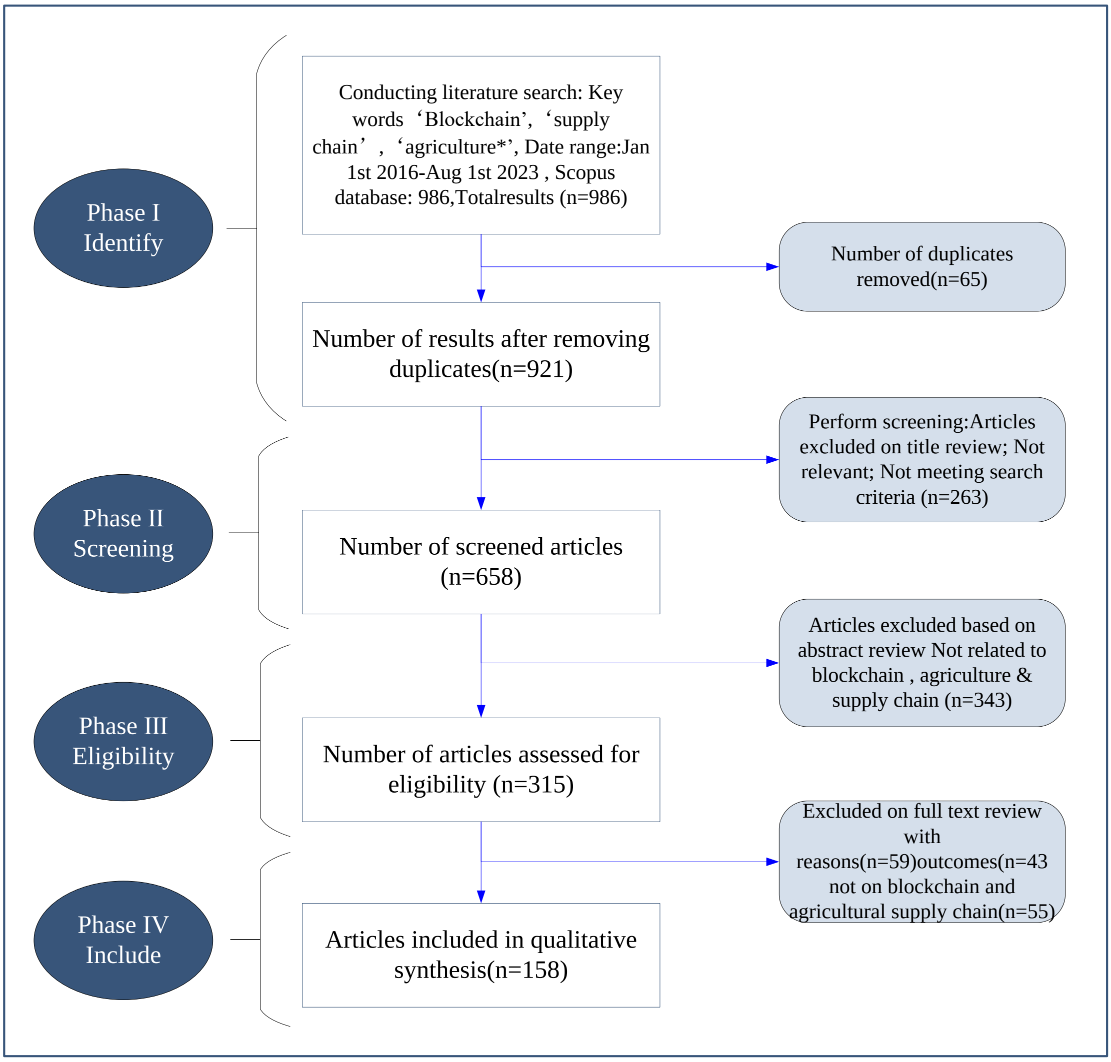

Figure 1.1 PRISMA flow diagram for systematic review

The analysis of the existing literature has revealed that the existing applications based on blockchain technology are more related to agricultural supply chain traceability system, financial services, etc. However, most papers discuss the use of blockchain technology in the field of agricultural products in general without any specific focus, and there are even few studies on how blockchain technology is used in agricultural supply chains. In layman's terms, most studies are conversations on paper that have not been implemented. Of course, there are limitations to this study, as there may be papers that are not included in this review.

Data Cleaning and Extraction

The first task of this systematic review was to collect literature with characteristics that would fulfill the purpose of the study. Thorough inclusion/exclusion criteria set the boundaries for review and formed the basis for achieving the study objectives. Well-defined criteria increase the likelihood of reliable and reproducible results, minimize bias, and prevent spurious conclusions. For the purposes of this study, the criteria were defined based on several factors. Table 1 summarizes the criteria for selecting articles based on various characteristics such as time frame, research topic, language, and reported results.

Table 1
Inclusion / Exclusion criteria

Parameters	Inclusion	Exclusion
Date range (Jan 2016-Jul 2023)	Articles within this date range	All articles not in the date range
Study topic	Application of blockchain technology in agricultural supply chain	Non-blockchain and non-agricultural supply chain
article title, abstract, and keywords	"Supply chain" AND "agriculture" AND "blockchain"	Generic search words lead to biased results and confusion
Duplicate results	Store articles in a repository to inspect and manage unique papers	Scrutinize for redundant articles based on authors and title
Eligibility	Relevance to blockchain and agricultural supply chain	Review the abstract and exclude
Language	English only	Identify language and exclude
Selection	Conduct thorough full -text review based on keywords and outcomes matching with purpose and seem meaningful	Full-text review of papers with keywords, only on blockchain, agriculture, and supply chain

Result

This section presents the results of this systematic literature review. The specific results are analyzed in detail below.

Yearly Distribution of the Sample

The trend graph of the number of selected works in recent years is shown in Figure 2. As can be seen from this figure, interest in blockchain technology in agricultural supply chains has increased significantly in recent years. Figure 2.1 shows the number of articles published in the Scopus database in different years. In this study, the years from January 1, 2016 to August 1, 2023 were selected as the research subject. According to the sample data, the number of relevant publications only appeared in 2018, which means that there was no research in related fields between 2016 and 2017. The analysis of the annual distribution of the sample shows that the number of publications gradually increased during the study period. From the correlation analysis of the content of the articles, the number of systematic literature reviews published each year is also continuously increasing, indicating that the interest in blockchain and agricultural supply chain is increasing. Notably, 2022 has the highest number of articles, suggesting that research activity peaked in this year. This trend underscores the continued attention and relevance of blockchain to agricultural supply chains over time.

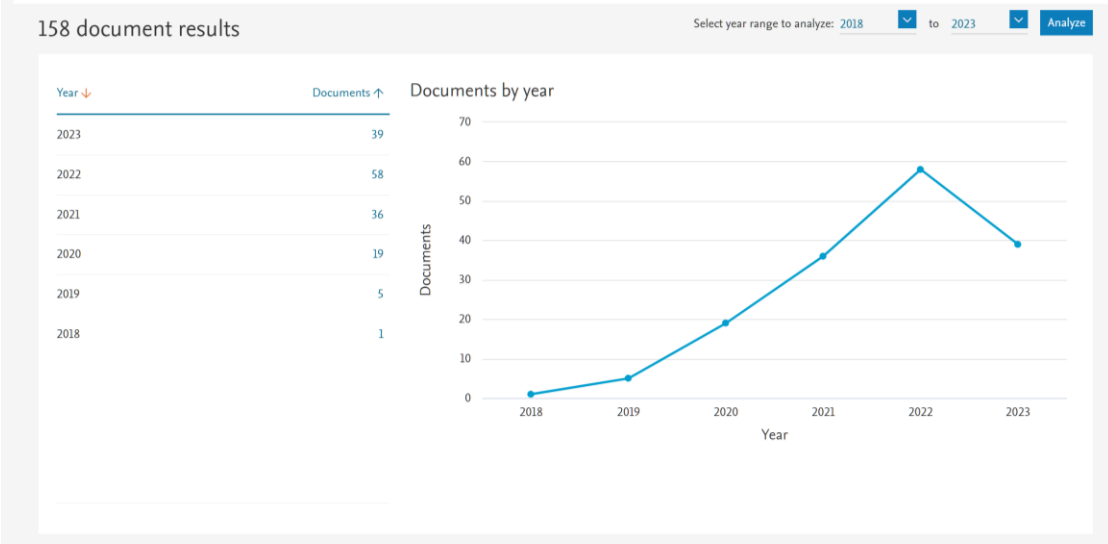

Figure 2.1 Number of papers per year

The Geographical Distribution

Figure 2.2 shows that the geographical distribution in this study spans several regions, reflecting the global interest in the topic of blockchain technology in agricultural supply chains. These studies come from different regions such as Asia, Europe, North America, etc. Although North America and Europe have contributed much of the literature, the research in Asia, especially China and India, is conspicuous. China and India are developing countries that rely mainly on agricultural production, so research in this area is the strongest, which also reflects the national conditions of the two countries. This global representation of the subject of this study, 'Blockchain and agricultural supply chains', shows that there is widespread awareness of the potential benefits and challenges of integrating blockchain into agricultural supply chains in different international contexts. The geographical distribution of the research literature in each country is shown in Figure 2.2. It should be noted that the literature data of the countries shown in the table are countries with at least two literatures, while countries with less than two research literatures were not included. Furthermore, among the 158 literatures researched, the country source corresponding to the journal was only found in 148 articles. For the 10 journals where the country was not found, the search revealed that these were journals that had not been blindly reviewed and the quality was relatively low, so these articles were excluded.

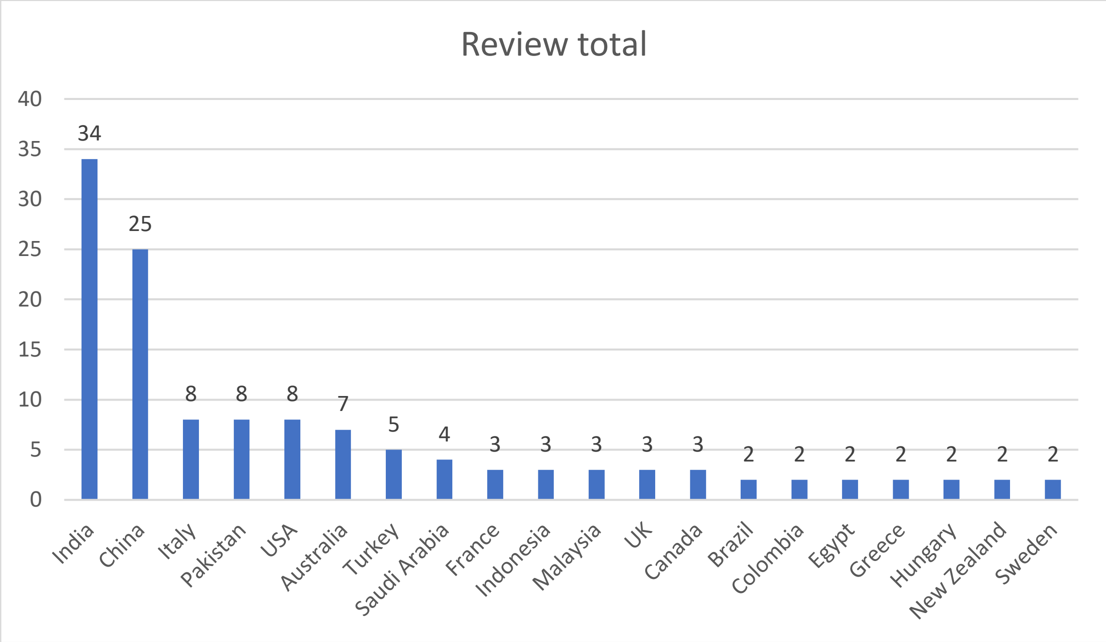

Figure 2.2 Statistical chart of the number of papers published by different countries

A breakdown of the published articles shows that most of the literature has been produced in Asian countries, with India leading the way, followed by China. AFSC research on blockchain adoption and implementation is more prevalent in China, while research in India is more concerned with the design of the conceptual framework and the combination of blockchain and IoT. Italy's research focus is on the traceability system of blockchain technology, the United States mainly combines blockchain technology with 5G research and artificial intelligence research in AFSC, and Pakistan's research focus is on the reliability and traceability of blockchain technology. Australia is more concerned with the privacy and financial transactions of blockchain technology. Turkey's research focuses on IoT, CC and CPS, while blockchain and IoT-based research is more prominent in Saudi Arabia. However, some literature reviews are only a suggestion without mentioning their specific implementation.

Judging from the overall publication, the problem of food safety in developing countries is more prominent. For example, in India, where food safety incidents are frequent, blockchain technology can be used to track the entire process of food from production to consumption to ensure food quality and safety (Anjum et al., 2017; Kamilaris et al., 2019). In China, through blockchain technology, farmers can directly connect with consumers or retailers, reducing middlemen and increasing income. Smallholder farmers play an important role in agricultural supply chains in developing countries, but they are often at a disadvantage (Guo & Yu, 2022). Blockchain technology can provide a fair and transparent trading environment and enhance market participation and bargaining power of smallholder farmers. In Nigeria, blockchain technology can be used to ensure that smallholder farmers have access to fair transaction prices and transparent market information, improving their economic status (RAMBIM & AWUOR, 2020). In Brazil, blockchain technology makes it possible to track every step of the coffee production process, ensuring that the production process meets environmental and sustainable standards (Gashema, 2021). Therefore, on the whole, developing countries, especially those with large Chinese populations, need to completely solve food safety problems. Therefore, China is far ahead in the number of exploratory research publications in this area, and more are exploring how blockchain technology can record and track the production process of agricultural products, ensure compliance with sustainable development standards, and promote green agriculture and environmental protection.

Conduct Systematic Literature Review Studies

AFSC has undergone several transformations over the years, the most recent being the embedding of complex technologies. Technology has changed the structure of traditional AFSC and given its players more influence. The emergence of blockchain technology is revolutionizing AFSC and will be the future of AFSC (Das et al., 2023).

Recent Blockchain Technology Development and Application In AFSC

Blockchain is a cryptographically secure, distributed ledger technology used to record the history of transactions. Each node in a blockchain system keeps a copy of all previous transactions/records made in that system. Here, no single node is the owner, making it a decentralized system. In this study, the relevant literature in the Scopus database is searched out from January 1, 2016 to August 1, 2023. It is explained here that because the research is only focused on blockchain technology and the supply chain of agricultural products, blockchain may limit the scope of application of chain-related technologies, so in order to obtain more technical characteristics of blockchain, there is a study on the application of blockchain technology in agriculture, not only the supply chain of agricultural products. The relevant characteristics of the application of blockchain in the field of agriculture are:

(i) ***Decentralized marketplaces (decentralization)***

Blockchain-based platforms have emerged to create decentralized marketplaces where farmers can engage directly with buyers without the need for intermediaries. These platforms allow farmers to obtain fair prices for their produce and ensure that their products reach end consumers more efficiently.

(ii) ***Digital identities for farmer***

Blockchain offers a secure and tamper-proof way to establish digital identities for farmers, giving them easier access to financial services, loans and subsidies. Including farmers who were previously unbanked or underserved can contribute to an overall improvement of the agricultural sector.

(iii) ***Data management and sharing***

Data is critical in agriculture and blockchain can provide a secure and controlled way to manage, share and monetize agricultural data. Farmers, researchers and other stakeholders can share data while retaining ownership and control of their information.

(iv) **Sustainability and certification**

Blockchain technology is being researched to verify and certify sustainable practices in agriculture, such as organic farming or fair trade. This makes the certification tamper-proof and easily accessible, which increases the credibility of the certification.

(v) **Reduce food waste**

By tracking products and conditions in real time, blockchain can help reduce food waste by identifying inefficiencies or delays in the supply chain that lead to spoilage.

(vi) **Collaborative Network**

Blockchain consortia and networks are being formed in which several organizations work together on a common platform. These collaborations simplify information sharing, data management and decision-making throughout the supply chain.

(vii) **Integration with the Internet of Things**

Internet of Things (Kaltakis et al., 2021) devices can provide real-time data from the field. The combination of IoT and blockchain ensures the integrity and authenticity of this data, which is crucial for making informed decisions about crop management and distribution.

Of course, some of these functions have more pre-development applications for AFSC, such as traceability, certification and information systems management. Therefore, blockchain can realize traceability in AFSC, and the smart contract mechanism is conducive to the smooth operation of agribusiness. A blockchain-based AFSC system brings transparency and builds trust among fraudsters (Yadav et al., 2020).

As we all know, Japan will "dump nuclear pollution into the sea" on August 24, 2023. Many countries around the world have responded by implementing strict quality checks and controls on Japanese products in some areas and even canceling import transactions. Blockchain technology can not only create traceability information, but also verify production time, local temperature, water source and soil parameters, food safety certification, organic cultivation and other transparent information. Tian (2016) was the first to propose an integrated blockchain and RFID-based framework for traceability in AFSC. Taking breeding insurance as an example, it can be seen that the biggest "pain point" faced by the traditional insurance industry is "uniqueness" management". Due to information asymmetry, insurance companies have no way of recording the specific information of the insured cattle and sheep. The insurance company simply cannot identify which cow is insured and which is not.

But the development of blockchain solves this problem. The blockchain project for cattle insurance implemented by PICC uses biometric technology to extract the unique identification data of each animal and store it with farmers, insurance companies and credit institutions through encryption technology (Hu et al., 2021). Banks, quarantine authorities, etc. are building a smart traceability system for farmers with blockchain technology as the core. Besides, blockchain can serve as a banking and financial platform to provide better support to farmers. The results of their pilot projects show that this mechanism will increase profits for all stakeholders. However, it is worth noting that the adoption of blockchain in agriculture is an ongoing process. To get a more accurate picture of the impact of blockchain technology on AFSC, you also need to read industry reports, news articles and research papers on the topic of blockchain technology in agricultural supply chains.

Thematic Analysis of the Sample Literature

Based on a systematic literature review, this study finds 8 articles that discuss the application of blockchain technology for traceability in agricultural supply chains. 4 articles focus on blockchain technology to promote the sustainable development of agricultural product supply chain. 6 articles mainly focus on the model and research framework of blockchain in agricultural product supply chain. Three articles focus on the promotion factors of blockchain technology in the agricultural product supply chain, and three articles explain that blockchain technology can improve the efficiency of agricultural product supply chain management. 2 articles discuss applicability disruptions. 3 articles discuss the reliability and convenience offered by blockchain technology smart contracts in the delivery of agricultural products. Two articles directly address the benefits that blockchain technology can bring to the supply chain of agricultural products.

During the literature search, each paper is thoroughly checked for selection using search criteria containing suitable terms. Relevant research topics are then systematically categorized and tagged to enable in-depth analysis and conclusions to be drawn. See Table 3.1 for further details.

Table 3.1
Classification of research themes

Authors	**Research Themes**							
	Traceability	**Sustainability**	**Barriers**	**Enablers**	**benefits**	**efficiency**	**smart contract**	**Frame/ model**
(T. Bosona & G. Gebresenbet, 2023)	√							
(Song et al., 2022)		√						
(Ronaghi, 2021)								√
(Bhat et al., 2021)						√		
(Khan et al., 2022)					√			
(El Mane et al., 2022)							√	√
(R. L. Rana et al., 2021)		√						
(Ehsan et al., 2022)								√
(Saranya & Maheswari, 2023)	√							
(Zkik et al., 2022)		√	√					
(Marchese & Tomarchio, 2022)	√							
(Peng et al., 2022)							√	
(Wang & You, 2022)								√

(Suroso A.I et al.,2021)	√							
(Raza et al., 2023)								√
(Eluubek kyzy et al., 2021)								√
(Zheng et al., 2023)	√							
(Bai et al., 2022)				√				
(Nayal et al., 2021)	√							
(Niknejad et al., 2021)				√				
(Dos Santos et al., 2021)							√	
(Katsikouli et al., 2021)					√			
Hu S et al.(2021)				√				
Saurabh S et al.(2021)		√						
(Chen et al., 2021)						√		
(Yadav et al., 2020)			√					
(Kamble et al., 2020)	√							
(Hassoun et al., 2022)						√		
(Salah et al., 2019)	√							
Total	**8**	**4**	**2**	**3**	**2**	**3**	**3**	**6**

Table 3.1 shows that research into blockchain technology in the supply chain for agricultural products is still in its early stages. There are only a few relevant case studies on chains. This is also the direction of future efforts, and more theoretical research should be applied to practice instead of remaining in conceptual models.

Approaches, Tools, Methodologies of Reviewed Articles

The literature is also categorized according to the methods used in the reviewed articles into different titles of conceptual proposals, implementation scenarios, simulation modeling, interviews, and statistical (survey-based) methods of blockchain technology in agricultural supply chains. Most of the articles are related to the theory of technical features of blockchain, followed by a conceptual framework proposal for some ideas or implementations. In addition, important articles were found that simulate the inclusion of simulations in various modeling framework decisions. Fewer articles were also found in the statistical (survey-based) category and fewer articles in quantitative analysis and empirical research. The research focuses mainly on the application of verified techniques and quantitative analysis and surveys. Most of the literature is qualitative analysis, and only a few papers use qualitative and quantitative mixed methods. This shows that the adoption of embedded blockchain technology is less mentioned, as well as research that belongs to the simulation category. These articles are counted under the following headings. See Table 3.2 for more details on method-based classification.

Table 3.2
Approaches, tools, methodologies of reviewed articles

Authors	**theory**	**method**	**approach**
(Song et al., 2022)	Evolutionary game	Qualitative	Evolutionary game model
(Ronaghi, 2021)	Maturity model; SWARA	Qualitative	Questionnaire, SWARA method, Case study
(Van Nguyen et al., 2023)	fuzzy theory	Qualitative	Scalable data-driven reviewing
(Ehsan et al., 2022)	System Flow Analysis	Qualitative	Literature review
(Raza et al., 2023)	Architecture for Modeling	Qualitative	Business Process Modeling (BPM).
(Eluubek kyzy et al., 2021)	Ant colony optimization algorithm	Qualitative	Description
(Sharma et al., 2022)	the Interpretive Structural Modeling	Qualitative	Interview
(Zheng et al., 2023)	Mathematical modeling	Quantitative	Simulation analysis
(Valencia-Payan et al., 2023)	System Architecture	Qualitative	Experiment
(Awan et al., 2021)	Simulation	Qualitative	Description
(Katsikouli et al., 2021)	Case studies	Qualitative	Description
(Alkahtani et al., 2021)	Variable demand analysis	Qualitative	Interviews
(Patel et al., 2021)	System architecture	Qualitative	Description

(Chen et al., 2021)	A two-stage Stackelberg game-theoretic	Qualitative	A Stackelberg game approach
(Kamble et al., 2020)	Interpretive Structural Modelling	Quantitative	ISM and DEMATEL
(Shahid et al., 2020)	system model	Qualitative	Description
(Hassoun et al., 2022)	System Architecture	Qualitative	Description
(Salah et al., 2019)	Smart contracts;traceability	Qualitative	A consortium blockchain approach
(Leng et al., 2018)	Design of consensus algorithm	Qualitative	Description

Journal Source of Reviewed Articles

The literature is also categorized according to the methods used in the reviewed articles into different titles of conceptual proposals, implementation scenarios, simulation modeling, interviews, and statistical (survey-based) methods of blockchain technology in agricultural supply chains. Most of the articles are related to the theory of technical features of blockchain, followed by a conceptual framework proposal for some ideas or implementations. In addition, important articles were found that simulate the inclusion of simulations in various modeling framework decisions. Fewer articles were also found in the statistical (survey-based) category and fewer articles in quantitative analysis and empirical research. The research focuses mainly on the application of verified techniques and quantitative analysis and surveys. Most of the literature is qualitative analysis, and only a few papers use qualitative and quantitative mixed methods. This shows that the adoption of embedded blockchain technology is less mentioned, as well as research that belongs to the simulation category. These articles are counted under the following headings. See Table 3.2 for more details on method-based classification.

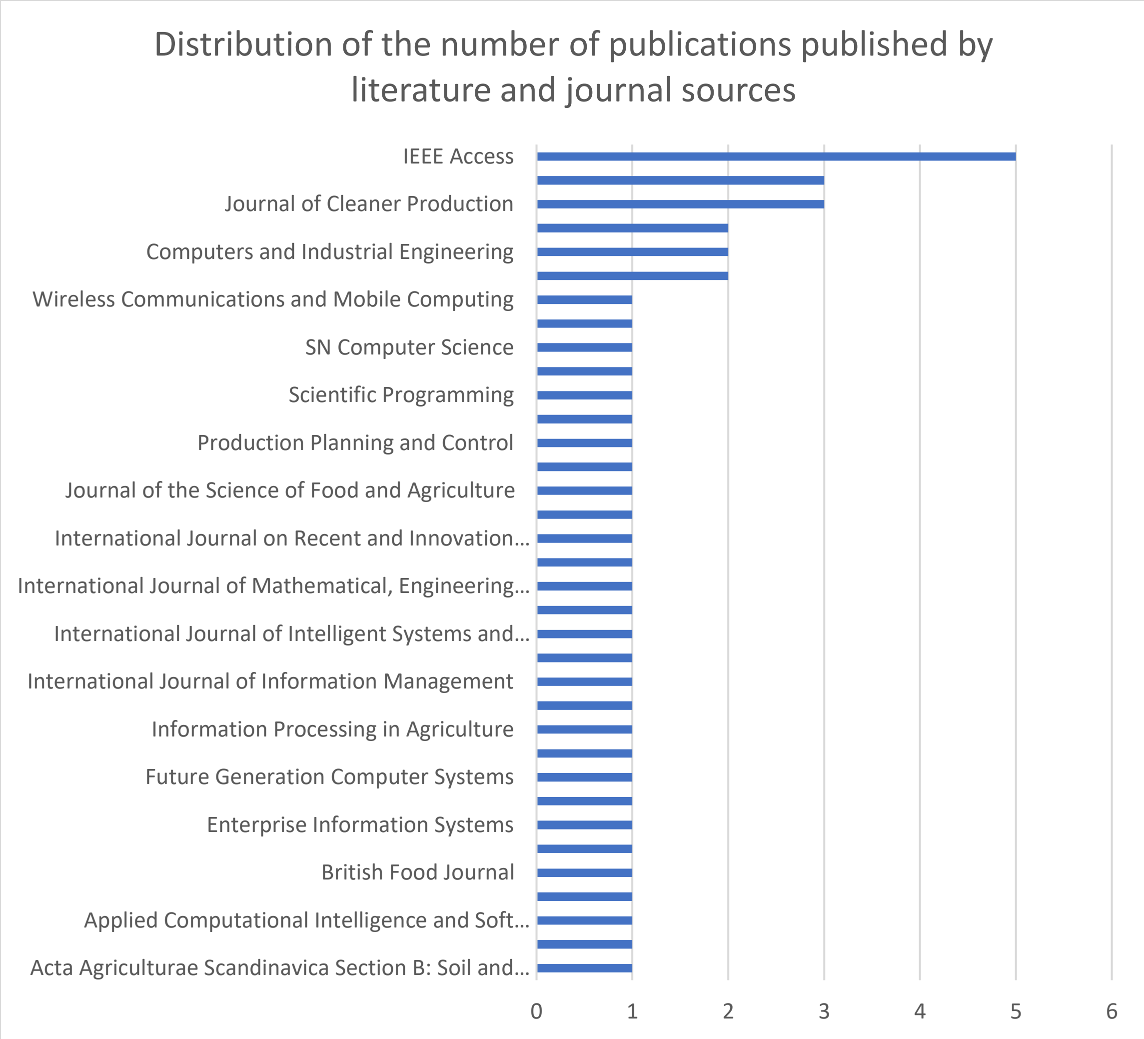

Figure 3.2 Distribution of the number of publications published by literature and journal sources

Challenges in The Application of Blockchain Technology In the Agricultural Supply Chain

Analysis of the literature shows that blockchain technology is attracting a great deal of interest and has the potential to improve transparency, traceability and efficiency in agricultural supply chains. However, in practical application, blockchain still faces some major challenges in the agricultural supply chain. According to the literature review, the current challenges of blockchain technology in the agricultural supply chain can be summarized in the following categories (see table 4.1).

Tabel 4.1
Challenges of blockchain technology in agricultural supply chains

NO.	Challenge	Reason Analysis	Reference
1	Data quality and Reliability	In agricultural supply chains, data accuracy is critical. Literature shows that untrusted data sources or incorrect data input can lead to inaccuracies in blockchain records. Therefore, how to ensure data quality and credibility remains an important challenge.	(El Mane et al., 2022); (Vangipuram et al., 2022); (Griffin et al., 2021); (Erol et al., 2020)
2	Standardization and Interoperability	Agricultural product supply chains involve multiple parties, each of which may use different systems and data formats. Ensuring interoperability and data standardization between blockchain systems remains a complex issue. Future research could focus on developing common standards and protocols.	(Quayson et al., 2021); (Lezoche et al., 2020)
3	Privacy and Compliance	Agricultural product supply chains contain large amounts of sensitive information, such as farmers' identities and transaction data. How to balance information sharing and privacy protection is an ongoing challenge. Future research could focus on developing privacy-preserving technologies and compliance frameworks.	(Chen et al., 2022); (Conti, 2022); (Shinkar & Thankachan, 2022); (Yu et al., 2021); (Leng et al., 2018)
4	Technical Infrastructure	Implementing blockchain solutions requires appropriate technical infrastructure and network connectivity. This may not be readily available in some rural areas. Future research could focus on how to address the problem of insufficient infrastructure.	(Bhat et al., 2021); (Luo et al., 2022); (Kaltakis et al., 2021); (Adow et al., 2022); (Patel et al., 2021)
5	Cost and Complexity	Implementing and maintaining blockchain systems often requires significant funding and resources. For small-scale agricultural supply chains, this can lead to cost and complexity issues. Future research	(Mishra et al., 2023); (Alobid et al., 2022); (Antonucci et al., 2019); (Rijanto, 2020); (Chen et al., 2021)

		could look for ways to reduce costs and simplify implementation.	

Discussion and Future Research Directions

Discussion

Blockchain technology has become a transformative force in the agricultural supply chain, revolutionizing the way we produce, distribute and consume agricultural products. This section looks at the key applications and benefits of blockchain technology in this context.

RQ1: What are the recent blockchain technology developments in AFSC?

Recent developments in blockchain technology for agricultural supply chains are significantly changing the way agricultural products are tracked, traded and verified (Kamble et al., 2020). These advancements not only increase transparency and efficiency, but also promote sustainability and ethical practices throughout the supply chain. As technology continues to evolve, further integration of blockchain with other emerging technologies such as the Internet of Things and artificial intelligence is expected to bring more innovative solutions to the agricultural sector (Song et al., 2022). However, most of China's agriculture is operated by small farmers, so if you want to implement blockchain technology, you must not only have certain capabilities in technology, management, cost reduction and efficiency, but also have a strong understanding of the development of Internet of Things technology. The key is to better promote the application of blockchain technology in the agricultural product supply chain.

RQ2: Which features of blockchain technology are widely used in agricultural product supply chains, and which features are less commonly used?

Blockchain technology offers a range of features that can be leveraged in agricultural product supply chains. Some features are widely used due to their immediate benefits in improving transparency, traceability, and efficiency, while others are less commonly adopted either due to complexity, cost, or current limitations in the technology's implementation.

Blockchain technology in agricultural supply chains prominently utilizes features like traceability, transparency, smart contracts, and real-time tracking due to their direct impact on improving efficiency, safety, and trust. However, more complex applications like decentralized finance, tokenization, decentralized marketplaces, and sustainability tracking are less commonly adopted. These features, while promising, face barriers in terms of regulatory acceptance, market readiness, and technological integration. As these barriers are addressed, it is likely that the adoption of these advanced blockchain features will increase, further transforming the agricultural supply chain landscape.

RQ3: What approaches, tools, and methodologies have been used to adopt to blockchain technology in AFSC?

To understand the adoption of blockchain technology in agricultural and food supply chains (AFSC), it is mainly based on literature analysis. Through detailed analysis of the literature, in this field, more researchers use qualitative analysis, through cases, Interviews, experiments, and observations are described to analyze the application of blockchain technology in agricultural product supply chains.

Ehsan et al. argue that the adoption of blockchain technology in agri-food supply chains involves a combination of collaborative approaches, specialized tools and powerful methodologies. By leveraging blockchain platforms such as IBM Food Trust and VeChain, leveraging intelligence on Ethereum and Hyperledger Fabric Contracts and integrated IoT devices, organizations can significantly improve transparency, traceability, and efficiency (Ehsan et al., 2022) Awan et al. and others believe that methods such as agile development, design thinking, and system integration ensure that these solutions are user-friendly. Centered, scalable and compliant with regulatory standards (Awan et al., 2021). Of course, with the continuous development of technology, researchers believe that the application of blockchain technology methods and tools will give full play to the role of blockchain in the agricultural field. potential to play a key role.

RQ4: What are the significant challenges and future agenda in the concerned theme?

While blockchain technology holds significant promise in improving the efficiency, transparency and sustainability of agri-food supply chains, there are still challenges that need to be addressed (Lee et al., 2022). Technical, economic, regulatory, social and environmental barriers must be overcome to realize the full potential of this technology. A future agenda focused on research and development, a clear regulatory framework, economic incentives, education, collaboration and sustainability could pave the way for wider and more effective adoption of blockchain in agriculture (El Mane et al., 2022). Through these efforts, blockchain technology can fundamentally transform agricultural supply chains, making them more resilient, transparent, and sustainable.

Future Research Directions

Through the analysis of this study, the current implementation of blockchain technology requires highly complex technical configuration and integration, which may lack the required technical knowledge and resources for many farmers and small enterprises. This poses an obstacle to the adoption of technology (Kouhizadeh et al., 2021). Some scholars also mentioned that blockchain systems are expensive to implement and maintain, including hardware, software, training, and operating expenses. For resource-constrained farmers and SMEs, these costs can be unaffordable (Rejeb et al., 2022). Some scholars mentioned that blockchains, especially public blockchains, face scalability issues, with slow transaction speeds and limited processing power. In high-volume agricultural supply chains, this can lead to reduced efficiencies and delays (Vyas et al., 2019). Another challenge is that blockchain technology, especially the use of proof-of-work blockchains, consumes a lot of energy, burdens the environment and resources, and is not conducive to sustainable development (Tayebi & Amini, 2024).

At present, the legal and regulatory frameworks in many countries are not yet perfect, and there is uncertainty about the application of blockchain technology, which may hinder the enthusiasm and investment of enterprises (Toufaily et al., 2021). Agricultural supply chains tend to be global, with different countries having different legal and regulatory requirements, bringing complexity to the cross-border application of blockchain technology (Kamilaris et al., 2019). In addition, Garcia et al. mentioned that the transparent and immutable nature of blockchain can lead to the leakage of sensitive information, such as trade secrets and personal data, and how to ensure transparency while protecting privacy is a challenge (Bernabe et al., 2019). Although blockchain technology itself has a high level of security, there may be vulnerabilities in related application systems, resulting in data tampering or leakage (Guo & Yu, 2022).

However, while facing many challenges and difficulties, some scholars have also found some new opportunities, Balamurugan et al, pointed out that blockchain technology can record information at every link in the supply chain, from farm to consumer, and achieve full traceability. This can help improve food safety and reduce the risk of counterfeit products (Balamurugan et al., 2022). By providing immutable records, blockchain technology can enhance trust among all parties involved in the supply chain, reduce fraud, and increase supply chain transparency (Raja Santhi & Muthuswamy, 2022). Kamilaris et al. proposed that blockchain technology can enable peer-to-peer direct transactions, reducing middlemen and unnecessary links, thereby reducing transaction costs and improving efficiency (Esmat et al., 2021).

In addition, smart contracts can automate the execution of trading conditions, reduce human error and delays, and improve the automation and efficiency of the supply chain (Law, 2017). Through blockchain technology, the production, transportation and sales of agricultural products can be monitored and recorded in real time, and problems can be found and solved in a timely manner to ensure food safety and quality (Bhutta & Ahmad, 2021). In the event of a food safety incident, blockchain technology can quickly trace the source of the problem, clarify responsibilities, and take quick and effective measures (Toufaily et al., 2021). Most importantly, blockchain technology can provide smallholder farmers with direct access to markets, reduce middlemen, ensure that they receive fair transaction prices, and increase their incomes (Bhutta & Ahmad, 2021). Through transparent records and certifications, blockchain technology can promote eco-friendly and sustainable agricultural practices, enhancing consumer trust and choice in green products (Law, 2017).

In this SLR study, the above research challenges need to be solved in the future, data quality and credibility need to be improved, and technologies and methods need to be developed to ensure the accuracy and credibility of supply chain data.

(1) Standardization and interoperability studies: Develop common blockchain standards and protocols to facilitate interoperability between different systems.

(2) Privacy and compliance research: Research privacy protection technologies to ensure the security of sensitive data and develop compliance frameworks.

(3) Infrastructure improvements: Explore ways to improve technology infrastructure in rural areas to support blockchain applications

(4) Reducing cost and complexity: Explore ways to reduce the cost and complexity of blockchain applications to make them more suitable for agricultural supply chains of different sizes.

These challenges and research directions will help solve the problem of practical application of blockchain in the agricultural supply chain and drive the improvement of the agricultural supply chain.

Of course, future research directions, in addition to those mentioned in the above literature, may also explore and develop some new areas of research. First of all, given the specificity of supply chains for agricultural products, we can consider combining them with blockchain research in cross-border trade. Blockchain has the potential to streamline cross-border trade processes, reduce delays and reduce the need for intermediaries. Investigate how blockchain can solve customs and regulatory challenges in international agricultural trade. Second, integrating Internet of Things (Kaltakis et al.) devices with blockchain can enable real-time data collection in the field. Future research could focus on developing secure and efficient methods to connect physical sensors with blockchain networks. Third, design an effective incentive mechanism that allows participants to join and actively participate in the blockchain-based supply chain. Research could explore token-based incentives, data sharing rewards, or other mechanisms to encourage participation. Fourth, assess the socio-economic impact of blockchain adoption in agricultural supply chains. Research could examine how the technology affects farmers' income, market access and overall livelihoods. In addition, collaborative governance models between supply chain participants on blockchain platforms can also be explored. This can include decision-making processes, dispute resolution mechanisms and maintaining a balance between transparency and confidentiality.

Overall, advancing blockchain technology, overcoming these challenges and pursuing these future research directions will help realize the full potential of blockchain in revolutionizing agricultural supply chains to improve efficiency, transparency and sustainability.

Conclusion

This study involves four RQs, of which RQ1 discusses the latest development of blockchain technology in the agricultural supply chain in detail in section 3.3.1, focusing on the current status of the application of blockchain technology in the agricultural product supply chain. RQ2 is mainly embodied in Section 3.3.1, which discusses the characteristics of blockchain technology that are currently being studied by scholars in the field of agriculture. RQ3 is mainly embodied in Section 3.3.3, which details the methods and tools used in the research of blockchain technology in agricultural supply chains. RQ4 is mainly embodied in chapter 3.4, which analyzes in detail the challenges and future research directions of blockchain technology in the application of blockchain technology in the agricultural product supply chain based on the research literature.

To summarize, an SLR was conducted in this thesis, which found that the application of blockchain technology in agricultural product supply chains is mainly based on qualitative analysis and theoretical technology research, and few scholars use quantitative analysis for empirical research. Of course, this is also a direction that can be explored in the future. At the same time, this study discussed and analyzed the technical characteristics of blockchain and its application in AFSC in detail. It has been found that the blockchain technology in AFSC is more reflected in the theoretical framework, and the conception of the model and traceability have been explored the most. And it has gained much attention due to its powerful application in traceability. The next promising technology is the encryption technology and financial applications of blockchain, which can not only address farmers' concerns about transactions, but also protect consumers. There is currently almost no research on these aspects. The financial applications of blockchain technology have so far focused mainly on financial companies and have hardly appeared in the supply chains for agricultural products. In the future, blockchain and the Internet of Things will be combined to jointly solve the problem of agricultural and agricultural product supply chains. In particular, the incident in Japan on August 4, 2023, in which nuclear wastewater was discharged into the sea", will have an impact on global agricultural production and the supply of agricultural products and cause damage. In order to protect the interests of more consumers, the security and transparency of blockchain technology can only be strengthened, which is also the focus of the AFSC in the future. In the literature review, it was found that the financial, encryption, security and transparency technologies of blockchain have been little discussed in the literature reviewed. Therefore, extensive research is needed to utilize its benefits.

Moreover, it is worth mentioning that although blockchain technology has made some progress in the supply chain for agricultural products, there are still some missing aspects that need to be developed and improved in the future. The focus should be on building a complete blockchain ecosystem that includes all links and various participants in the agricultural product supply chain and requires continuous collaboration and development. Future research can focus on how to foster collaboration and attract more participants to participate, which is not the case in the current literature.

In addition, the literature reviewed was classified and categories relating to different countries and publication years were examined according to the main research content of the journal and the theories and methods used in order to investigate the development trend of literary research. The development of the annual publication volume of journals shows that publications have increased exponentially after 2018, which is mainly due to the use of blockchain technology for traceability and the construction of theoretical structural models in agricultural product supply chains. Traceability is mainly reflected in the urgent demands of consumers for food safety, which is why blockchain technology has risen in people's favor in recent years. In addition, a more extensive bibliometric analysis of this topic was possible using bibliometric software packages. Use relevant document analysis software, such as Citespace for author analysis, keyword analysis, and inter-document cluster analysis to better examine current development trends. In addition, we hope to inspire relevant actors in the food supply chain to proactively address existing challenges and further developments in this area.

References

Adow, A. H., Shrivas, M. K., Mahdi, H. F., Zahra, M. M. A., Verma, D., Doohan, N. V., & Jalali, A. (2022). Analysis of Agriculture and Food Supply Chain through Blockchain and IoT with Light Weight Cluster Head. Comput Intell Neurosci, 2022, 1296993. https://doi.org/10.1155/2022/1296993

Alkahtani, M., Khalid, Q. S., Jalees, M., Omair, M., Hussain, G., & Pruncu, C. I. (2021). E-Agricultural Supply Chain Management Coupled with Blockchain Effect and Cooperative Strategies. Sustainability, 13(2). https://doi.org/10.3390/su13020816

Alobid, M., Abujudeh, S., & Szűcs, I. (2022). The Role of Blockchain in Revolutionizing the Agricultural Sector. Sustainability, 14(7). https://doi.org/10.3390/su14074313

Anjum, A., Sporny, M., & Sill, A. (2017). Blockchain Standards for Compliance and Trust. Ieee Cloud Computing, 4(4), 84-90. https://doi.org/10.1109/mcc.2017.3791019

Antonucci, F., Figorilli, S., Costa, C., Pallottino, F., Raso, L., & Menesatti, P. (2019, Nov). A review on blockchain applications in the agri-food sector. J Sci Food Agric, 99(14), 6129-6138. https://doi.org/10.1002/jsfa.9912

Awan, S., Ahmed, S., Ullah, F., Nawaz, A., Khan, A., Uddin, M. I., Alharbi, A., Alosaimi, W., Alyami, H., & Khan, S. (2021). IoT with BlockChain: A Futuristic Approach in Agriculture and Food Supply Chain. Wireless Communications and Mobile Computing, 2021, 1-14. https://doi.org/10.1155/2021/5580179

Bai, C., Quayson, M., & Sarkis, J. (2022). Analysis of Blockchain's enablers for improving sustainable supply chain transparency in Africa cocoa industry. Journal of cleaner production, 358. https://doi.org/10.1016/j.jclepro.2022.131896

Balamurugan, S., Ayyasamy, A., & Joseph, K. S. (2022). IoT-Blockchain driven traceability techniques for improved safety measures in food supply chain. International Journal of Information Technology, 14(2), 1087-1098.

Bernabe, J. B., Canovas, J. L., Hernandez-Ramos, J. L., Moreno, R. T., & Skarmeta, A. (2019). Privacy-preserving solutions for blockchain: Review and challenges. IEEE Access, 7, 164908-164940.

Bhat, S. A., Huang, N.-F., Sofi, I. B., & Sultan, M. (2021). Agriculture-Food Supply Chain Management Based on Blockchain and IoT: A Narrative on Enterprise Blockchain Interoperability. Agriculture, 12(1). https://doi.org/10.3390/agriculture12010040

Bhutta, M. N. M., & Ahmad, M. (2021). Secure identification, traceability and real-time tracking of agricultural food supply during transportation using internet of things. IEEE Access, 9, 65660-65675.

Bosona, T., & Gebresenbet, G. (2023, Jun 5). The Role of Blockchain Technology in Promoting Traceability Systems in Agri-Food Production and Supply Chains. Sensors (Basel), 23(11). https://doi.org/10.3390/s23115342

Bosona, T., & Gebresenbet, G. (2023). The role of blockchain technology in promoting traceability systems in agri-food production and supply chains. Sensors, 23(11), 5342.

Chen, H., Chen, Z., Lin, F., & Zhuang, P. (2021). Effective Management for Blockchain-Based Agri-Food Supply Chains Using Deep Reinforcement Learning. IEEE Access, 9, 36008-36018. https://doi.org/10.1109/access.2021.3062410

Chen, W., Zhou, K., Fang, W., Wang, K., Bi, F., & Assefa, B. (2020). Review on blockchain technology and its application to the simple analysis of intellectual property protection. International Journal of Computational Science and Engineering, 22(4), 437-444.

Chen, Y., Lu, Y., Bulysheva, L., & Kataev, M. Y. (2022). Applications of Blockchain in Industry 4.0: a Review. Information Systems Frontiers. https://doi.org/10.1007/s10796-022-10248-7

Conti, M. (2022). EVO-NFC: Extra Virgin Olive Oil Traceability Using NFC Suitable for Small-Medium Farms. IEEE Access, 10, 20345-20356. https://doi.org/10.1109/access.2022.3151795

Das, P., Singh, M., Karras, D. A., & Roy, D. G. (2023). Block-A-City: An Agricultural Application Framework Using Blockchain for Next-Generation Smart Cities. IETE Journal of Research, 69(9), 5773-5783. https://doi.org/10.1080/03772063.2022.2162982

Dey, S., Saha, S., Singh, A. K., & McDonald-Maier, K. (2022). SmartNoshWaste: Using Blockchain, Machine Learning, Cloud Computing and QR Code to Reduce Food Waste in Decentralized Web 3.0 Enabled Smart Cities. Smart Cities, 5(1), 162-176. https://doi.org/10.3390/smartcities5010011

Dos Santos, R. B., Torrisi, N. M., & Pantoni, R. P. (2021, Aug 6). Third Party Certification of Agri-Food Supply Chain Using Smart Contracts and Blockchain Tokens. Sensors (Basel), 21(16). https://doi.org/10.3390/s21165307

Ehsan, I., Irfan Khalid, M., Ricci, L., Iqbal, J., Alabrah, A., Sajid Ullah, S., Alfakih, T. M., & Gupta, P. (2022). A Conceptual Model for Blockchain-Based Agriculture Food Supply Chain System. Scientific Programming, 2022, 1-15. https://doi.org/10.1155/2022/7358354

El Mane, A., Chihab, Y., Tatane, K., Korchiyne, R., & Ashraf, I. (2022). Agriculture Supply Chain Management Based on Blockchain Architecture and Smart Contracts. Applied Computational Intelligence and Soft Computing, 2022, 1-23. https://doi.org/10.1155/2022/8011525

Eluubek kyzy, I., Song, H., Vajdi, A., Wang, Y., & Zhou, J. (2021). Blockchain for consortium: A practical paradigm in agricultural supply chain system. Expert Systems with Applications, 184. https://doi.org/10.1016/j.eswa.2021.115425

Erol, I., Ar, I. M., Ozdemir, A. I., Peker, I., Asgary, A., Medeni, I. T., & Medeni, T. (2020). Assessing the feasibility of blockchain technology in industries: evidence from Turkey. Journal of Enterprise Information Management, 34(3), 746-769. https://doi.org/10.1108/jeim-09-2019-0309

Esmat, A., de Vos, M., Ghiassi-Farrokhfal, Y., Palensky, P., & Epema, D. (2021). A novel decentralized platform for peer-to-peer energy trading market with blockchain technology. Applied Energy, 282, 116123.

Gashema, C. (2021). Blockchain and certification for more sustainable coffee production.

Gereffi, G., & Fernandez-Stark, K. (2016). Global value chain analysis: a primer.

Griffin, T. W., Harris, K. D., Ward, J. K., Goeringer, P., & Richard, J. A. (2021). Three Digital Agriculture Problems in Cotton Solved by Distributed Ledger Technology. Applied Economic Perspectives and Policy, 44(1), 237-252. https://doi.org/10.1002/aepp.13142

Guo, H., & Yu, X. (2022). A survey on blockchain technology and its security. Blockchain: research and applications, 3(2), 100067.

Hasan, M. R., Deng, S., Sultana, N., & Hossain, M. Z. (2021). The applicability of blockchain technology in healthcare contexts to contain COVID-19 challenges. Library Hi Tech, 39(3), 814-833.

Hassoun, A., Boukid, F., Pasqualone, A., Bryant, C. J., Garcia, G. G., Parra-Lopez, C., Jagtap, S., Trollman, H., Cropotova, J., & Barba, F. J. (2022). Emerging trends in the agri-food sector: Digitalisation and shift to plant-based diets. Curr Res Food Sci, 5, 2261-2269. https://doi.org/10.1016/j.crfs.2022.11.010

Hou, J., Wang, C., & Luo, S. (2020). How to improve the competiveness of distributed energy resources in China with blockchain technology. Technological Forecasting and Social Change, 151, 119744.

Hu, S., Huang, S., Huang, J., & Su, J. (2021). Blockchain and edge computing technology enabling organic agricultural supply chain: A framework solution to trust crisis. Computers & Industrial Engineering, 153. https://doi.org/10.1016/j.cie.2020.107079

Kaltakis, K., Polyzi, P., Drosatos, G., & Rantos, K. (2021). Privacy-Preserving Solutions in Blockchain-Enabled Internet of Vehicles. Applied Sciences, 11(21). https://doi.org/10.3390/app11219792

Kamble, S. S., Gunasekaran, A., & Sharma, R. (2020). Modeling the blockchain enabled traceability in agriculture supply chain. International Journal of Information Management, 52. https://doi.org/10.1016/j.ijinfomgt.2019.05.023

Kamilaris, A., Fonts, A., & Prenafeta-Boldύ, F. X. (2019). The rise of blockchain technology in agriculture and food supply chains. Trends in Food Science & Technology, 91, 640-652.

Katsikouli, P., Wilde, A. S., Dragoni, N., & Hogh-Jensen, H. (2021, Apr). On the benefits and challenges of blockchains for managing food supply chains. J Sci Food Agric, 101(6), 2175-2181. https://doi.org/10.1002/jsfa.10883

Khan, H. H., Malik, M. N., Konecna, Z., Chofreh, A. G., Goni, F. A., & Klemes, J. J. (2022, May 1). Blockchain technology for agricultural supply chains during the COVID-19 pandemic: Benefits and cleaner solutions. J Clean Prod, 347, 131268. https://doi.org/10.1016/j.jclepro.2022.131268

Kouhizadeh, M., Saberi, S., & Sarkis, J. (2021). Blockchain technology and the sustainable supply chain: Theoretically exploring adoption barriers. International journal of production economics, 231, 107831.

Law, A. (2017). Smart contracts and their application in supply chain management Massachusetts Institute of Technology].

Lee, N. M., Varshney, L. R., Michelson, H. C., Goldsmith, P., & Davis, A. (2022). Digital trust substitution technologies to support smallholder livelihoods in Sub-Saharan Africa. Global Food Security, 32. https://doi.org/10.1016/j.gfs.2021.100604

Leng, K., Bi, Y., Jing, L., Fu, H.-C., & Van Nieuwenhuyse, I. (2018). RETRACTED: Research on agricultural supply chain system with double chain architecture based on blockchain technology. Future Generation Computer Systems, 86, 641-649. https://doi.org/10.1016/j.future.2018.04.061

Lezoche, M., Hernandez, J. E., Alemany Díaz, M. d. M. E., Panetto, H., & Kacprzyk, J. (2020). Agri-food 4.0: A survey of the supply chains and technologies for the future agriculture. Computers in Industry, 117. https://doi.org/10.1016/j.compind.2020.103187

Li, J.-F., Gu, A.-L., Ma, Z.-Y., Zhang, C.-L., & Sun, Z.-Q. (2019). Economic development, energy demand, and carbon emission prospects of China's provinces during the 14th Five-Year Plan period: Application of CMRCGE model. Advances in Climate Change Research, 10(3), 165-173.

Liu, Y., Zhang, S., Chen, M., Wu, Y., & Chen, Z. (2021). The sustainable development of financial topic detection and trend prediction by data mining. Sustainability, 13(14), 7585.

Luo, Z., Zhu, J., Sun, T., Liu, Y., Ren, S., Tong, H., Yu, L., Fei, X., & Yin, K. (2022, Aug 2). Application of the IoT in the Food Supply Chain horizontal line From the Perspective of Carbon Mitigation. Environ Sci Technol, 56(15), 10567-10576. https://doi.org/10.1021/acs.est.2c02117

Marchese, A., & Tomarchio, O. (2022). A Blockchain-Based System for Agri-Food Supply Chain Traceability Management. SN Computer Science, 3(4). https://doi.org/10.1007/s42979-022-01148-3

Mishra, R. A., Kalla, A., Braeken, A., & Liyanage, M. (2023). Blockchain Regulated Verifiable and Automatic Key Refreshment Mechanism for IoT. IEEE Access, 11, 21758-21770. https://doi.org/10.1109/access.2023.3251651

Nayal, K., Raut, R. D., Narkhede, B. E., Priyadarshinee, P., Panchal, G. B., & Gedam, V. V. (2021, Dec 6). Antecedents for blockchain technology-enabled sustainable agriculture supply chain. Ann Oper Res, 1-45. https://doi.org/10.1007/s10479-021-04423-3

Niknejad, N., Ismail, W., Bahari, M., Hendradi, R., & Salleh, A. Z. (2021). Mapping the research trends on blockchain technology in food and agriculture industry: A bibliometric analysis. Environmental Technology & Innovation, 21. https://doi.org/10.1016/j.eti.2020.101272

Niu, B., Shen, Z., & Xie, F. (2021). The value of blockchain and agricultural supply chain parties' participation confronting random bacteria pollution [Article]. Journal of cleaner production, 319, Article 128579. https://doi.org/10.1016/j.jclepro.2021.128579

Noesselt, N. (2020). A presidential signature initiative: Xiong'an and governance modernization under Xi Jinping. Journal of Contemporary China, 29(126), 838-852.

Patel, N., Shukla, A., Tanwar, S., & Singh, D. (2021). KRanTi: Blockchain-based farmer's credit scheme for agriculture-food supply chain. Transactions on Emerging Telecommunications Technologies. https://doi.org/10.1002/ett.4286

Peng, X., Zhang, X., Wang, X., Li, H., Xu, J., & Zhao, Z. (2022, Dec 5). Construction of rice supply chain supervision model driven by blockchain smart contract. Sci Rep, 12(1), 20984. https://doi.org/10.1038/s41598-022-25559-7

Quayson, M., Bai, C., & Sarkis, J. (2021). Technology for Social Good Foundations: A Perspective From the Smallholder Farmer in Sustainable Supply Chains. IEEE Transactions on Engineering Management, 68(3), 894-898. https://doi.org/10.1109/tem.2020.2996003

Santhi, R. A., & Muthuswamy, P. (2022). Influence of blockchain technology in manufacturing supply chain and logistics. Logistics, 6(1), 15.

RAMBIM, D., & AWUOR, F. M. (2020). Blockchain based milk delivery platform for stallholder dairy farmers in Kenya: enforcing transparency and fair payment. 2020 IST-Africa Conference (IST-Africa),

Rana, R. L., Tricase, C., & De Cesare, L. (2021). Blockchain technology for a sustainable agri-food supply chain. British Food Journal, 123(11), 3471-3485. https://doi.org/10.1108/bfj-09-2020-0832

Rana, S. K., Kim, H.-C., Pani, S. K., Rana, S. K., Joo, M.-I., Rana, A. K., & Aich, S. (2021). Blockchain-based model to improve the performance of the next-generation digital supply chain. Sustainability, 13(18), 10008.

Raza, Z., Haq, I. U., & Muneeb, M. (2023). Agri-4-All: A Framework for Blockchain Based Agricultural Food Supply Chains in the Era of Fourth Industrial Revolution. IEEE Access, 11, 29851-29867. https://doi.org/10.1109/access.2023.3259962

Rejeb, A., Keogh, J. G., & Rejeb, K. (2022). Big data in the food supply chain: a literature review. Journal of Data, Information and Management, 4(1), 33-47.

Remondino, M., & Zanin, A. (2022). Logistics and Agri-Food: Digitization to Increase Competitive Advantage and Sustainability. Literature Review and the Case of Italy [Article]. Sustainability (Switzerland), 14(2), Article 787. https://doi.org/10.3390/su14020787

Rijanto, A. (2020). Business financing and blockchain technology adoption in agroindustry. Journal of Science and Technology Policy Management, 12(2), 215-235. https://doi.org/10.1108/jstpm-03-2020-0065

Ronaghi, M. H. (2021). A blockchain maturity model in agricultural supply chain. Information Processing in Agriculture, 8(3), 398-408. https://doi.org/10.1016/j.inpa.2020.10.004

Salah, K., Nizamuddin, N., Jayaraman, R., & Omar, M. (2019). Blockchain-Based Soybean Traceability in Agricultural Supply Chain. IEEE Access, 7, 73295-73305. https://doi.org/10.1109/access.2019.2918000

Saranya, P., & Maheswari, R. (2023). Proof of Transaction (PoTx) Based Traceability System for an Agriculture Supply Chain. IEEE Access, 11, 10623-10638. https://doi.org/10.1109/access.2023.3240772

Shahid, A., Almogren, A., Javaid, N., Al-Zahrani, F. A., Zuair, M., & Alam, M. (2020). Blockchain-Based Agri-Food Supply Chain: A Complete Solution. IEEE Access, 8, 69230-69243. https://doi.org/10.1109/access.2020.2986257

Sharma, M., Khalil, A. A., & Daim, T. (2022). Blockchain Technology Adoption: Multinational Analysis of the Agriculture Supply Chain. IEEE Transactions on Engineering Management, 1-18. https://doi.org/10.1109/tem.2022.3193688

Shinkar, S. V., & Thankachan, D. (2022). SCMBQA: Design of a Customised SCM-Aware Sidechaining Model for QoS Enhancement under Attack Scenarios. International Journal on Recent and Innovation Trends in Computing and Communication, 10(1s), 200-212. https://doi.org/10.17762/ijritcc.v10i1s.5824

Song, L., Luo, Y., Chang, Z., Jin, C., & Nicolas, M. (2022). Blockchain Adoption in Agricultural Supply Chain for Better Sustainability: A Game Theory Perspective. Sustainability, 14(3). https://doi.org/10.3390/su14031470

Tayebi, S., & Amini, H. (2024). The flip side of the coin: Exploring the environmental and health impacts of proof-of-work cryptocurrency mining. Environmental Research, 118798.

Toufaily, E., Zalan, T., & Dhaou, S. B. (2021). A framework of blockchain technology adoption: An investigation of challenges and expected value. Information & Management, 58(3), 103444.

Valencia-Payan, C., Grass-Ram譁ez, J. F., Ramirez-Gonzalez, G., & Carlos Corrales, J. (2023). Smart Contract to Traceability of Food Social Selling. Computers, Materials & Continua, 74(3), 4703-4728. https://doi.org/10.32604/cmc.2023.031554

Van Nguyen, T., Cong Pham, H., Nhat Nguyen, M., Zhou, L., & Akbari, M. (2023). Data-driven review of blockchain applications in supply chain management: key research themes and future directions. International journal of production research, 61(23), 8213-8235. https://doi.org/10.1080/00207543.2023.2165190

Vangipuram, S. L. T., Mohanty, S. P., Kougianos, E., & Ray, C. (2022, Oct 27). agroString: Visibility and Provenance through a Private Blockchain Platform for Agricultural Dispense towards Consumers. Sensors (Basel), 22(21). https://doi.org/10.3390/s22218227

Vyas, N., Beije, A., & Krishnamachari, B. (2019). Blockchain and the supply chain: concepts, strategies and practical applications. Kogan Page Publishers.

Vyas, S., Shabaz, M., Pandit, P., Parvathy, L. R., Ofori, I., & Al-Farga, A. (2022). Integration of Artificial Intelligence and Blockchain Technology in Healthcare and Agriculture. Journal of Food Quality, 2022, 1-11. https://doi.org/10.1155/2022/4228448

Wang, L., Xu, L., Zheng, Z., Liu, S., Li, X., Cao, L., Li, J., & Sun, C. (2021). Smart contract-based agricultural food supply chain traceability. IEEE Access, 9, 9296-9307.

Wang, Y., & You, J. (2022). The Operation Mode of Agricultural Supply Chain Finance Using Blockchain. Comput Intell Neurosci, 2022, 3338030. https://doi.org/10.1155/2022/3338030

Workie, E., Mackolil, J., Nyika, J., & Ramadas, S. (2020). Deciphering the impact of COVID-19 pandemic on food security, agriculture, and livelihoods: A review of the evidence from developing countries. Current Research in Environmental Sustainability, 2, 100014.

Xia, J., Li, H., & He, Z. (2023). The Effect of Blckchain Technology on Supply Chain Collaboration: A Case Study of Lenovo. Systems, 11(6). https://doi.org/10.3390/systems11060299

Xiong, H., Dalhaus, T., Wang, P., & Huang, J. (2020). Blockchain technology for agriculture: applications and rationale. Frontiers in Blockchain, 3, 7.

Yadav, V. S., Singh, A. R., Raut, R. D., & Govindarajan, U. H. (2020). Blockchain technology adoption barriers in the Indian agricultural supply chain: an integrated approach. Resources, conservation and recycling, 161. https://doi.org/10.1016/j.resconrec.2020.104877

Yu, Z., Song, L., Jiang, L., & Khold Sharafi, O. (2021). Systematic literature review on the security challenges of blockchain in IoT-based smart cities. Kybernetes, 51(1), 323-347. https://doi.org/10.1108/k-07-2020-0449

Yuan, Y., Li, Y., Wu, C., & Li, J. (2023). A Comparative Regional Study of Key Core Technology Innovation Policies——a Textual Analysis of 48 Blockchain Policies from China (2516-2314).

Zade, M., Myklebost, J., Tzscheutschler, P., & Wagner, U. (2019). Is bitcoin the only problem? a scenario model for the power demand of blockchains. Frontiers in Energy Research, 7, 21.

Zhang, J., Zhong, S., Wang, T., Chao, H.-C., & Wang, J. (2020). Blockchain-based systems and applications: a survey. Journal of Internet Technology, 21(1), 1-14.

Zheng, Y., Xu, Y., & Qiu, Z. (2023). Blockchain Traceability Adoption in Agricultural Supply Chain Coordination: An Evolutionary Game Analysis. Agriculture, 13(1). https://doi.org/10.3390/agriculture13010184

Zhuang, D., Abbas, J., Al-Sulaiti, K., Fahlevi, M., Aljuaid, M., & Saniuk, S. (2022). Land-use and food security in energy transition: Role of food supply [Article]. Frontiers in Sustainable Food Systems, 6, Article 1053031. https://doi.org/10.3389/fsufs.2022.1053031

Zkik, K., Belhadi, A., Rehman Khan, S. A., Kamble, S. S., Oudani, M., & Touriki, F. E. (2022). Exploration of barriers and enablers of blockchain adoption for sustainable performance: implications for e-enabled agriculture supply chains. International Journal of Logistics Research and Applications, 26(11), 1498-1535. https://doi.org/10.1080/13675567.2022.2088707