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An analysis of Blockchain in Supply Chain Management: System Perspective in Current and Future Research

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Abstract

Purpose: *This study aims to review the current academic research on blockchain, especially in the fields of business and economics. Based on a systematic review of literature retrieved from the Web of Science service, the researchers explore the top-cited articles, the most productive countries, and the most common keywords.*

Methodology: *This research conducts a clustering analysis and identifies the following five research themes: "economic benefit," "blockchain technology," "initial coin offerings," "fine tech revolution," and "sharing economy."*

Findings: *It showed that the most common subject area is Computer Science, following research by Engineering, Telecommunications, and Business and Economics. With regard to Business and Economics, several key nodes have been identified in the literature, such as the top-cited articles, most productive countries.*

Keywords: *Blockchain, Cite Space, Systematic Literature Review, Supply Chain.*

Introduction

The concepts of blockchain were first proposed by research in 2008 by someone using the pseudonym Satoshi Nakamoto, who described how cryptology and an open distributed ledger could be combined into a digital currency application (Nakamoto, 2008). Initially, the extremely high volatility of bit coin and the attitudes of many countries towards its complexity somewhat restrained its development. Nevertheless, the advantages of the blockchain, which is an underlying technology of bit coins, have attracted increasing attention. Some of the advantages of blockchain include its distributed ledger, decentralization, information transparency, tamper-proof construction, and openness. The evolution of the blockchain has been a progressive process. Blockchain is currently delimited to Blockchains 1.0, 2.0, and 3.0, based on their implementations. The current research provides more details about the three generations of blockchain in the Appendix. The application of blockchain technology has extended from digital currency to finance, and it has even gradually extended to healthcare, supply chain management, market monitoring, smart energy, and copyright protection (Engelhardt, 2017; Hyvärinen, et al., 2017; O'Dair & Beaven, 2017; Kim & Laskowski,

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2018; Radanović & Likić, 2018; Savelyev, 2018). Blockchain technology has been studied in a wide variety of academic disciplines. For example, some researchers have studied the underlying technology of blockchain, such as distributed storage, peer-to-peer networking, cryptography, smart contracts, and consensus algorithms (Christidis & Devetsikiotis, 2016; Kraft, 2016; Cruz, et al., 2018). Meanwhile, legal researchers are concerned with regulations and laws.

As the old saying goes: "scholars in different disciplines have many different analytical perspectives and speak many different languages." This paper focuses on analyzing and combining papers in the fields of business and economics. The research aims to identify the key nodes (e.g., the most influential articles and journals) in the related research and to find the main research themes of blockchain in our discipline. In addition, the research attempts to offer some recommendations for future research and provide some suggestions for businesses that aim to implement blockchain in practice.

This study conducts a systematic and objective review based on data statistics and analysis. The research first describes the overall number and discipline distribution of blockchain-related papers. A total of 756 journal articles were retrieved. Subsequently, the research refined the subject area to business and economics, and managed to add 119 articles to our additional analysis. The research then explored the influential countries, journals, articles, and most common keywords. On the basis of a scientific literature analysis tool, the research was able to identify five research themes on blockchain. The researchers believe that this data-based literature review will be able to present the status of this research more objectively.

The remainder of this paper is organized as follows. In the next section, the research provides an overview of the existing articles in all disciplines. The research comprehensively describes the number of papers related to blockchain and discipline distribution of the literature. The research then conducts a further analysis in the subject field of business and economics, where the research analyzes the countries, publications, and highly cited papers, etc. The research also demonstrates the main research themes of this paper, based on Cite Space. These are the recommendations for promising research directions and practical applications. In the last section, the research discusses the conclusions and limitations.

Overview of the Current Research

This paper first conducts a study of the research of Science Core Collection (WOS), including four online databases: Science Citation Index Expanded (SCI-EXPANDED), Social Sciences Citation Index (SSCI), Arts & Humanities Citation Index (A&HCI), and Emerging Sources Citation Index (ESCI). This research choses the WOS because the papers in these databases can typically reflect scholarly attention towards blockchain. When searching the term "blockchain" as a topic, the research found a total of 925 records in these databases.

After filtering out the less representative record types, the research reduced these papers to 756 articles that the research then used for further analysis. The research extracted the complete bibliographic record of the articles identified by the search from WOS, including information on the title, author, keywords, abstract, journal, year, and other publication information. This research was then exported to CiteSpace for subsequent analysis. CiteSpace is a scientific literature analysis tool that enables us to visualize trends and patterns in the scientific literature (Chen, 2004). In this paper, CiteSpace was used to visually represent complex structures for statistical analysis and for conducting cluster analysis. Table 1 displays the number of academic papers published per year.

The research listed the number of all the publications in WOS, the number of articles in all the disciplines, and the number of articles in business and economics topics. It should be noted that the research retrieved the literature on March 25, 2019. Therefore, the number of articles in 2019 relatively small. The number of papers has continued to grow in recent years, which indicates that there is a growing interest in blockchain.
All of the extracted papers were published in WOS

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after 2015, seven years after blockchain and bitcoin were first described by Nakamoto. In these first seven years, many research papers were published online or indexed by other databases, however, they were not discussed here. The research selected only WOS, which are representative of high-level literature databases. This is the most common way to conduct a literature review (İpek, 2019).

Table I: Number of Academic Papers on Blockchain

	WOS-All	WOS-Articles	WOS- Business & Economics
Before 2015	0	0	**0**
2015	4	1	**0**
2016	40	28	**5**
2017	200	158	**45**
2018	553	453	**61**
#2019	138	116	**8**
Total	**925**	**756**	**119**

In the 756 articles that the research managed to retrieve, the three most common keywords besides blockchain are bitcoin, smart contract, and cryptocurrency, with the frequency of 113 times, 72 times, and 61 times, respectively. This shows that the majority of the literature mentions the core technology of blockchain and its most widely known application bitcoin,

In WOS, each article is assigned to one or more subject categories. Therefore, the research utilized CiteSpace to visualize what research areas are included in current research on blockchain. Figure 1 shows a network of these subject categories. The most common category is Computer Science, which includes the largest circle, following research by Engineering and Telecommunications. Business and Economics is also a common subject area for blockchain. Consequently, the research will conduct further analysis in this field.

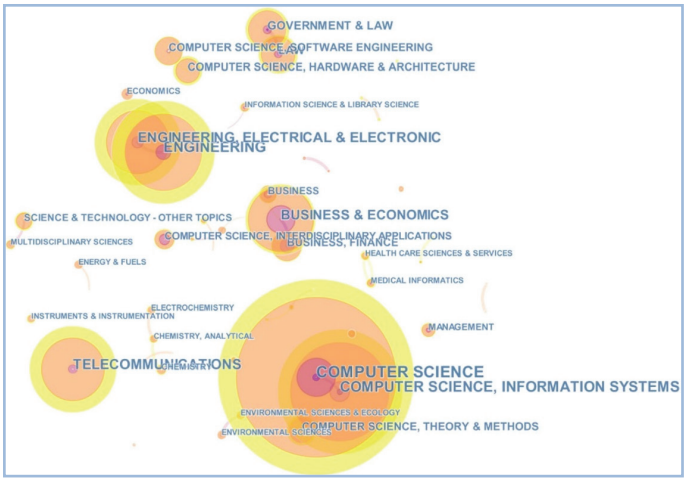

Fig. 1: Disciplines in blockchain

Articles in Business and Economics

Given that the main objective of our research was to investigate the research of blockchain in the areas of economics and management, the research conducted an in-depth analysis on the papers in this field. The study refined the research area to Business and Economics. Finally, the research retrieved 119 articles from WOS. In this section, the research analyzed their published journals, research topics, and citations, etc., to depict more comprehensively the research status of block-chain in the fields of business and economics.

There are several review papers on the blockchain. Each of these papers contains a summary of multiple research topics, rather than a single topic. The research did not include either these literature reviews or articles; nonetheless, it also played an important role in the study of blockchain. For instance, Wang, et al. (2019) investigated the influence of blockchain on supply chain practices and policies. Zhao, et al. (2016) suggested that blockchain would be widely adopted in finance and would lead to many business innovations and research opportunities.

Countries

The United States, the United Kingdom, and Germany are the top three countries by the number of papers published on blockchain; specific data were shown

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in Table II. The United States has issued more papers than the other countries and it has produced more than one-third of the total articles. As for data collection, China contributed 11 papers, ranking fourth. A total of 119 papers came from 17 countries and regions. In contrast, the paper searched "big data" and "financial technology" in the same way, and found 286 papers on big data came from 24 countries, while 779 papers on fintech came from 43 countries. This shows that blockchain is still an emerging area of research, and it needs more countries and scholars to contribute to this research discipline.

Table II: Main Research Countries

Country	No. of Papers	%/119
USA	41	34.454%
ENGLAND	14	11.765%
GERMANY	12	10.084%
PEOPLES R CHINA	11	9.244%
CANADA	8	6.723%
FRANCE	8	6.723%

Journals

The research counted the journals published in these papers, and found that 44 journals published related papers. Table III lists the top 11 journals to have published blockchain research. The first is "Strategic Change: Briefings in Entrepreneurial Finance," followed by "Financial Innovation" and "Asia Pacific Journal of Innovation and Entrepreneurship." The research included/covered the majority of papers published in the journal "Strategic Change" in 2017, with the exception of one published in 2018 and another one in 2019.

Table III: Top 11 Journals Publishing Blockchain Research

Source Title	No. of Papers
Strategic Change- Briefings in Entrepreneurial Finance	12
Financial Innovation	6
Asia Pacific Journal of Innovation and Entrepreneurship	5
Journal of Risk and Financial Management	4
Mit Sloan Management Review	4
Quality- Access to Success	4
Technological Forecasting and Social Change	4
Technology Innovation Management Review	4
Business Horizons	3
Intelligent Systems in Accounting Finance & Management	3
Journal of Risk Finance	3

Cited References

Table IV presents the top six cited publications, which were cited by the research no less than five times. The list consists of three papers and three journal articles. Some of these publications introduce blockchain from a technical perspective, while others present it from an application perspective. A paper by Swan (2015) illustrated the application scenarios of blockchain technology. In this paper, the author demonstrates that blockchain is essentially a public ledger with the potential of being a decentralized digital repository of all assets—not only tangible assets, but also intangible assets such as votes, software, health data, and ideas.

The paper of Tapscott and Tapscott (2016) explained why blockchain technology would fundamentally change the world. Yermack (2017) demonstrated that blockchain would have a substantial impact and would present many challenges to corporate governance. Böhme et al. (2015) introduced bitcoin, the first and most famous application of blockchain. Narayanan et al. (2016) also focused on bitcoin and explained how bitcoin worked on a technical level. Iansiti and Lakhani (2017) argued that it would take years to truly

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transform the blockchain since it was a fundamental rather than disruptive technology, which would not drive implementation, and thus companies would need other incentives to adopt blockchain.

Table IV: Cited References

Title	Author & Year	Type	Citations
Blockchain: Blueprint for a New Economy	(Swan, 2015)	paper	**21**
Blockchain revolution: how the technology behind Bitcoin is changing money, business, and the world	(Tapscott and Tapscott, 2016)	paper	**17**
Bitcoin: Economics, Technology, and Governance	(Böhme *et al.*, 2015)	article	**7**
Corporate Governance and Blockchains	(Yermack, 2017)	article	**5**
Bitcoin and Cryptocurrency Technologies: A	(Narayanan *et al.*, 2016)	paper	**5**
Comprehensive Introduction			
The Truth about Blockchain	(Iansiti and Lakhani, 2017)	article	**5**

Most Influential Articles

The research cited these 119 papers 314 times in total, and 270 times without self-citations. The number of articles cited was 221, of which 197 were non-self-citations. The most influential articles with more than 10 citations were listed in Table V. The most popular article in our dataset was Iansiti & Lakhani (2017), with 49 citations in WOS. This suggests that this article has had a strong influence on blockchain research. This paper postulated that there is still some distance to the real application of blockchain. The other articles described how blockchain affects and works in various areas, such as financial services, organizational management, and health care. Since blockchain is an emerging technology, it is particularly necessary to investigate how to combine blockchains with various industries and fields.

By comparing the journals in Tables IV and V, the research found out that some journals appeared in both of the lists, such as Financial Innovation. In other words, the research papers on blockchain are the papers that come up the most in these journals, and the journal papers are highly recognized by other scholars.

Table V: Most Cited Articles

Title	Author & Year	Journal	Citations in WOS(a)
The Truth about Blockchain	(Iansiti and Lakhani, 2017)	Harvard Business Review	**49**
Blockchain-based sharing services: What blockchain technology can contribute to smart cities	(Sun, Yan and Zhang, 2016)	Financial Innovation	**19**
Citizen utilities: The emerging pothe research paradigm	(Green and Newman, 2017)	Energy Policy	**18**
Blockchain and Its Coming Impact on Financial Services	(Fanning and Centers, 2016)	Journal of Corporate Accounting and Finance	**15**
Toward Blockchain-Based Accounting and Assurance	(Dai and Vasarhelyi, 2017)	Journal of Information Systems	**12**
How Blockchain Will Change Organizations	(Tapscott and Tapscott, 2017)	Mit Sloan Management Review	**11**
Hitching Healthcare to the Chain: An Introduction to Blockchain Technology in the Healthcare Sector	(Engelhardt, 2017)	Technology Innovation Management Review	**10**
a Data last updated on 2019-04-08			

Meanwhile, although journals such as Harvard Business Review have only published a few papers related to blockchain, they were highly cited. Consequently, the journals in both of these lists were found to be of great importance.

Research Themes

Addressing research themes is crucial to understanding a research field and exploring future research directions. This paper investigated the research topic based on keywords. The keywords are representative and provide a brief description of the article's content. First, the research analyzed the most common keywords used by the papers. The research found that the top five most frequently used keywords are "blockchain," "bitcoin," "cryptocurrency," "fintech," and "smart contract." Although the potential of blockchain applications goes beyond digital currencies, bitcoin and other cryptocurrencies are widely discussed in these articles as important blockchain application scenarios in the finance industry. Smart contracts were found to allow firms to set up automated transactions in blockchains,

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thus playing a fundamentally supporting role in blockchain applications. Similar to the literature across all subject areas, studies in business and economics also frequently used bitcoin, cryptocurrency, and smart contract as their keywords. The difference found was that many researchers have combined blockchain with finance, considering it as an important financial technology.

After analyzing the frequency of keywords, the research conducted an analysis of the keyword clustering in order to identify the research themes. As shown in Figure 2, the research identified five clusters through the log-likelihood ratio (LLR) algorithm in Citespace, namely; cluster #0 "economic benefit," cluster #1 "blockchain technology, "cluster #2 "initial coin offerings," cluster #3 "fintech revolution," and cluster #4 "sharing economy."

Several researchers have studied the economic benefits of blockchain. They suggested the application of blockchain technology to streamline transactions and settlement processes can effectively reduce the costs associated with manual operations. For instance, in the health care sector, blockchain can play an important role in centralizing research data, avoiding prescription drug fraud, and reducing administrative overheads (Engelhardt, 2017). In the music industry, blockchain could improve the accuracy and availability of copyright data and significantly improve the transparency of the value chain (O'Dair and Beaven, 2017). Swan (2017) demonstrated the economic value of blockchain through four typical applications, including digital asset registries, leapfrog technology, long-tail personalized economic services, payment channels, and peer banking services.

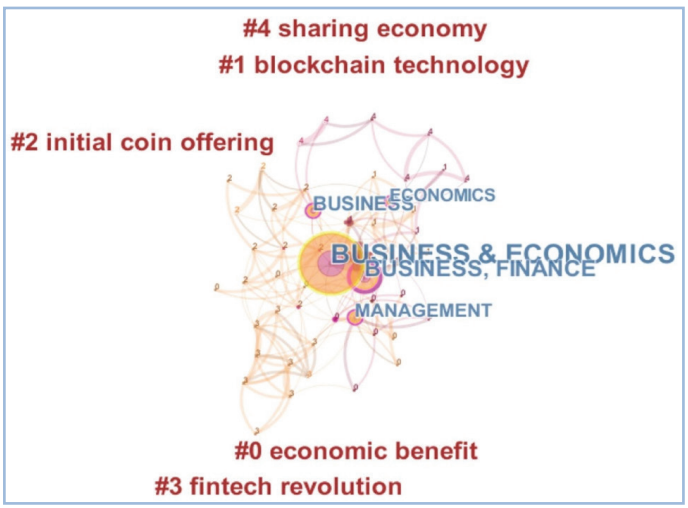

Fig. 2: Disciplines and topics

The representative paper on the "blockchain technology" cluster was published by Iansiti and Lakhani (2017), who analyzed the inherent features of blockchain and pointed out that further research was needed in order to extensively apply blockchain. Other researchers have investigated the characteristics of blockchain technology from multiple perspectives. For example, Xu (2016) explored the types of fraud and malicious activities that blockchain technology can prevent and identified attacks to which blockchain remains vulnerable. Meanwhile, Aune et al. (2017) proposed a crypto-graphic approach to solve information leakage problems on the blockchain.

Initial coin offering (ICO) is also a research topic of great concern to scholars. Many researchers have analyzed the determinants of the success of initial coin offerings (Adhami, et al., 2018; Ante, et al., 2018). For example, Fisch (2019) assessed the determinants of the amount raised in ICOs and discussed the role of the technological capabilities of signaling ventures in ICOs. Deng, et al. (2018) argued that the outright ban on ICOs may hinder revolutionary technological development and provide some regulatory reform suggestions regarding the current ICO ban in China.

Many researchers have explored blockchain support for various industries. The fintech revolution brought by the blockchain has received extensive attention Yang and Li (2018). Researchers agreed that this nascent technology may transform traditional trading methods and practice in financial industry (Chen et al., 2017; Ashta and Biot-Paquerot, 2018; Kim and Sarin, 2018). For instance, Gomber et al. (2018) discussed transformations in four areas of financial services: operations management, payments, lending, and deposit services. Dierksmeier and Seele (2018) addressed the impact of blockchain technology on the nature of financial transactions from a business ethics perspective.

Another cluster corresponds to the sharing economy. Few researchers have focused on this field and they have discussed the supporting role that blockchain plays in the sharing economy. Pazaitis, et al. (2017) described a conceptual economic model of blockchain-based decentralized cooperation that may better support the

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dynamics of social sharing. Sun, et al. (2016) discussed the contribution of emerging blockchain technologies to the three major factors of the sharing economy (i.e., human, technology, and organization). They also analyzed how blockchain-based sharing services contribute to smart cities.

Discussion

In this section, the research discusses the following issues: (1) What are the future re- search directions for blockchain? (2) How can businesses benefit from blockchain? The researchers hope that the research discussions will be able to provide guidance for future academic development and social practice.

What Will be the Future Research Directions for Blockchain?

In view of the five themes mentioned in this paper, the research provides some recommendations for future research in this section.

The economic benefits of blockchain have been extensively studied in previous research. For individual businesses, it is important to understand the effects of blockchain applications on the organizational structure, mode of operation, and management model of the business. For the market as a whole, it is important to determine whether blockchain can resolve the market failures caused by information asymmetry, and whether it can increase market efficiency.

For researchers in blockchain technology, this paper suggested that the research should pay more attention to privacy protection and security issues. Despite the fact that all of the blockchain transactions are anonymous and encrypted, there is still a risk of the data being hacked. In the security sector, there is a view that absolute security can never be guaranteed wherever there is a physical contact. Consequently, the question of how to share transaction data while also protecting personal data privacy are particularly vital issues for both academic and social practice.

Initial coin offering and cryptocurrency markets have grown rapidly, which raises many interesting questions, such as how to manage digital currencies. Although the majority of the previous research has focused on the determinants of the success of initial coin offerings, the research believed that future research will discuss how to regulate cryptocurrency and the ICO market. The success of blockchain technology in digital currency applications prior to 2015 attracted the attention of many traditional financial institutions. As blockchain has continued to reinvent itself, it is now more than capable of fulfilling the needs of the finance industry. The research believed that blockchain is able to achieve large-scale applications in many areas of finance, such as banking, capital markets, internet finance, and related fields. The deep integration of blockchain technology and fintech will continue to be a promising research direction.

The sharing economy is often defined as a peer-to-peer activity of sharing goods and services among individuals. In the future, sharing among enterprises may become an important part of the new sharing economy. Therefore, building the interconnection of blockchain may become a distinct trend. These interconnections will facilitate the linkages supply chain management, and payments in commercial operations. It will also allow for instantaneous information exchange and data coordination among enterprises and industries.

How Can Businesses Benefit from Blockchain?

Businesses can benefit from blockchain in a variety of ways to gain an advantage over their competitors. They can streamline their core business, reduce transaction costs, and make intellectual property ownership and payments more transparent and auto-mated (Felin & Lakhani, 2018). Many researchers have discussed the application of blockchain in business.

Accounting Settlement and Crowdfunding

Bitcoin or another virtual currency supported by blockchain technology can help businesses solve funding-related problems. For instance, cryptocurrencies support companies who want to implement non-cash payments and accounting settlement. The automation of electronic transaction management accounting improves the level of control of monetary business execution, both

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internally and externally (Zadorozhnyi, et al., 2018). In addition, blockchain technology represents an emerging source of venture capital crowdfunding (O'Dair & Owen, 2019). Investors or founders of enterprises can obtain alternative entrepreneurial finance through sales tokens or initial coin offerings. Companies can handle financial-related issues more flexibly by holding, transferring, and issuing digital currencies that are based on blockchain technology.

Data Storage and Sharing

As the most valuable resource, data plays a vital role in every enterprise. Blockchain provides a reliable storage and efficient use of data (Novikov et al., 2018). As a decentralized and secure ledger, blockchain can be used to manage digital asset for many types of business (Dutra, et al., 2018). Decentralized data storage means the data is not given to a centralized agency, but it is given to people around the world because no one can manipulate with the data on the blockchain. Businesses can use blockchain to store data, improve the transparency and security of the data, and prevent the data from being tampered with. At the same time, blockchain also supports data sharing. For instance, all the key parties in the accounting profession leverage an accountancy blockchain to aggregate and share instances of practitioner misconduct across the country on a nearly real-time basis (Sheldon, 2018).

Supply Chain Management

Blockchain technology has the potential to significantly change supply chain management (SCM) (Treiblmaier, 2018). Recent adoptions of the Internet of Things and block- chain technologies support better supply-chain provenance (Kim & Laskowski, 2018). When the product goes from the manufacturer to the customer, important data are recorded in the blockchain. Companies can trace products and raw materials to effectively monitor product quality.

Smart Trading

Businesses can build smart contracts on blockchain, which are widely used to implement business collaborations in general and inter-organizational business processes in particular. Enterprises can automate transactions based on smart contracts on blockchains without manual confirmation. For instance, businesses can file taxes automatically under smart contracts (Vishnevsky and Chekina, 2018).

Findings and Conclusion

This paper reviewed 756 articles related to blockchain on the research of Science Core Collection. It showed that the most common subject area is Computer Science, following research by Engineering, Telecommunications, and Business and Economics. With regard to Business and Economics, several key nodes have been identified in the literature, such as the top-cited articles, most productive countries, and most common keywords. After a cluster analysis of the keywords, the research identified the five most popular research themes: "economic benefit," "blockchain technology," "initial coin offerings," "fintech revolution," and "sharing economy."

As an important emerging technology, blockchain will play a role in many fields. Therefore, the research postulated that the issues related to commercial applications of blockchain are critical for both academic and social practice. The research proposed several promising research directions. The first important research direction is understanding the mechanisms through which blockchain influences corporate and market efficiency. The second potential research direction is privacy protection and security issues. The third relates to how to manage digital currencies and how to regulate the cryptocurrency market.

The fourth potential research direction is how to deeply integrate blockchain technology and fintech. The final topic is cross-chain technology—if each industry has its own blockchain system, then researchers as well as developers must discover new methods for data exchange. This is the key to achieving the Internet of Value. Therefore, cross-chain technology will become an increasingly significant topic with the passage of time.

Businesses can substantially benefit from blockchain

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technology. Therefore, the research suggested that the application of blockchain be considered when businesses have the following requirements: accounting settlement and crowdfunding, data storage and sharing, supply chain management, and smart trading.

The study has some limitations. First, this paper only analyzed the literature in the research of Science Core Collection databases (WOS), which may lead to the incompleteness of the relevant literature. Second, the research literature was filtered based on the subject category in WOS. In this process, the research may have omitted some relevant researches. Third, our recommendations have subjective limitations. The researchers hope to initiate more research and discussions to address these points in the future.

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