

Study on blockchain technology from an information system perspective^①

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Abstract

Blockchain, as a decentralized platform and distributed ledger technology, will complement and promote the existing centralized system to form a relatively comprehensive ecosystem. A systematic review of blockchain research on information system (IS) disciplines during the five years from 2016 to 2020 selected dozens of papers from 16 leading IS journals. The technological characteristics and implementation models of blockchain are introduced, highlighting and discussing its research status and development in context. Moreover, the future research directions for blockchain in IS are illustrated. It aims to discuss the decentralized and emerging technology of blockchain in its early development stage and to depict the relevant IS issues that are worthy of further investigation.

Key words: information system (IS), business value, blockchain, cryptocurrency, Bitcoin, supply chain management

0 Introduction

As an emerging technology, blockchain plays an important role in cryptographic technologies and applications, e. g. storage, calculation, interaction, and transaction. Ref. [1] believed that blockchain has the potential to generate not only the creation but also the revolution of business activities. Since 2008, when Bitcoin was introduced and implemented in the financial market, the sharp rise in the value of Bitcoin has surprised the entire world, more and more attention was paid to its foundation, blockchain technology. Refs[2-4] found a distributed ledger technology (DLT), blockchain has been applied to many disciplines and industries. For example, partnering with International Business Machine (IBM), Walmart deployed blockchain technology to track its food-producing process and to enhance its logistics system.

Blockchain refers to a series of decentralized tamper-proof ledgers combined as a network rather than as a centralized platform; anonymity function, cryptographic data, consensus protocol, smart contract, and reputation mechanism are integrated into a distributed system that can process disintermediated, precise, consistent, traceable, and secure services to end-users at lower transaction costs and without unnecessary intervention. Because of its uniqueness, blockchain has

offered many benefits to business and management, such as decentralization, intractability and strategic applications, security and behavior, and operations and strategic decision-making, among others. But how blockchain technology can be effectively implemented, managed and applied, has become a very important theoretical and practical issue in information system (IS)^[5-6].

The rapid development of blockchain technology in practice has attracted attention in the academic community. Scholars have begun to devote themselves to the research of blockchain. Some studied the technological perspective of blockchain's operation mode, technical features, and potential challenges. However, the research on blockchain technology in the field of information systems is still very limited. As blockchain has been in development, scholars have begun to explore more specific blockchain insights based on purely descriptive research. Of the many research issues discovered, blockchain-based service provision and technology application has been the focus of most of the research. This reflects the consistent characteristics of technological innovation and information systems research, and it shows a clear upward trend toward research on blockchain adoption, absorption, and business values. Refs[2,6] found that many blockchain studies have researched in the fields of economics, management, or psychology, as well as from the more

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expected perspective of information system.

The goals of this paper are to recognize the main themes of blockchain in information systems research, to identify the disciplines of blockchain in information systems research, and to prospect potential trends of blockchain in information systems research.

The paper is organized as follows. Section 1 provides an overview of the technological feature and the service model of blockchain, as well as its transaction procedure. Section 2 presents a literature review results and explanations. Section 3 illustrates the developing contexts of blockchain in IS. Section 4 discusses future research about blockchain in IS. Section 5 provides a conclusion.

1 Technological feature and service model of blockchain technology

1.1 Technological feature

Blockchain is a decentralized database of a ledger-proofed transaction system. Without caring about security and privacy, the involved entity presents a request to the blockchain system. Refs[1,7] proved the information can be recorded and processed on the chain if more than half of the participants accept and admit the transaction.

Due to a lack of understanding about blockchain technology, scholars, in its early years, have committed themselves to study its technical characteristics and application models. In summary, The core technical characteristics of blockchain technology are mainly reflected in the following ten aspects: decentralization, disintermediation, immutability, anonymity, smart contract, traceability and provenance, cost reduction, transparency, security and privacy, and audibility^[1,7-8].

1.2 Service model

In general, blockchain is divided into four categories; this division includes all of the platforms related to blockchain technology, such as public, private, consortium, and hybrid blockchain^[1,7]. The main differences among these four categories are the scope of the participants and the level of adoption. For instance, the public blockchain is available to everyone; Bitcoin has become a popular public blockchain infrastructure. A private blockchain platform is used for an organization or an enterprise; only authorized entities can join the system. A consortium blockchain is an integration of semi-public and semi-private systems that has specific purposes for organizations and participants. A hybrid blockchain platform consists of at least two different types of blockchain systems^[2].

2 Result and explanation

Blockchain-related research has become an interdisciplinary study that is not limited to the scopes of computing, engineering, or encryption. Our study focuses on blockchain and its relevant issues in information systems. The papers selected are from 16 IS-related top journals, including ACM Transactions on Management Information Systems (TMIS), Decision Sciences (DS), Decision Support Systems (DSS), Journal of Information Technology (JIT), Journal of Management Information Systems (JMIS), Journal of Strategic Information Systems (JSIS), Journal of the Association for Information Science and Technology (JAIST), Journal of the Association for Information Systems (JAIS), Management Science, Management Information Systems Quarterly (MISQ). The keywords “blockchain”, “cryptocurrency”, “DLT (distributed ledger technology)”, and “Bitcoin” were used to search for papers from the journals published between 2016 and 2020.

In total, 46 papers were selected. Fig.1 shows a holistic picture of the papers published in these 16 journals.

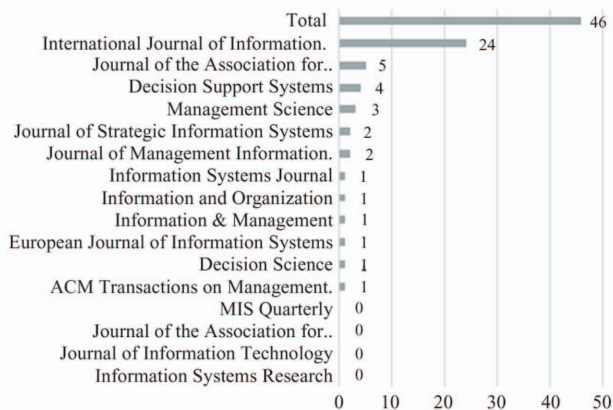


Fig.1 Publication distribution

Judging from paper publication and distribution, the study of blockchain is only in its early stage. This can explain why only 46 papers on blockchain have been published in the 16 IS journals. Besides, from 2016 to 2020, the number of blockchain-related papers published has increased (Fig.2). No papers appeared in 2016; one paper was published in one journal in 2017; 7 papers were published from 6 journals in 2018; 15 papers were published from 8 journals in 2019; and, for the year to date, up to July of 2020, 23 papers have been published from 5 journals.

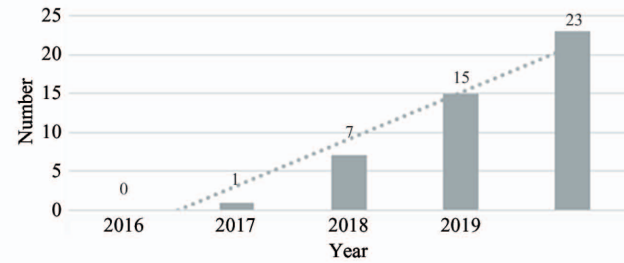


Fig. 2 Publication trend

Blockchain is a multi-disciplinary technology that researchers have investigated across a variety of different fields. Fig.3 lists all of the possible disciplines of blockchain research in IS from the 46 papers. Blockchain and its relevant technologies will spread to more fields soon, and undoubtedly, more papers on a variety of blockchain-related topics will be published.

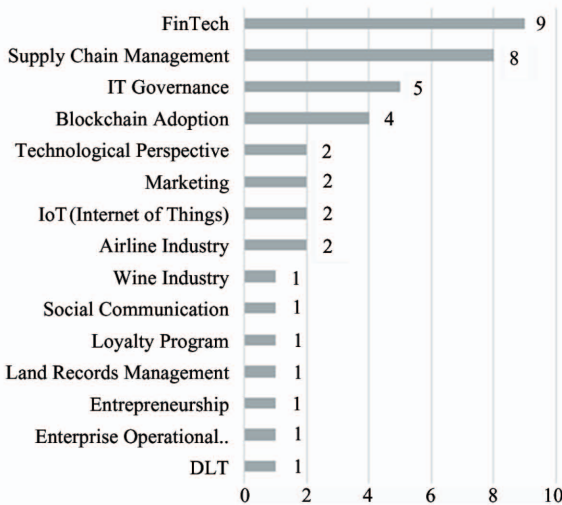


Fig. 3 Discipline and blockchain research in IS

Researchers have employed a variety of theories in their study of blockchain, such as the technology acceptance model (TAM), the unified theory of acceptance and use of technology (UTAUT), the regret theory,

the self-determination theory, and the network theory. Also, researchers have used different qualitative and quantitative methodologies and techniques to validate blockchain-related issues. Methodologies (Fig.4) include case study (10 papers), literature review (10 papers), mathematical models (5 papers), and design science research framework (3 papers). Specifically, case study, review, and conceptual framework have been the most popular methodologies that scholars have used to conduct blockchain-related research, currently.

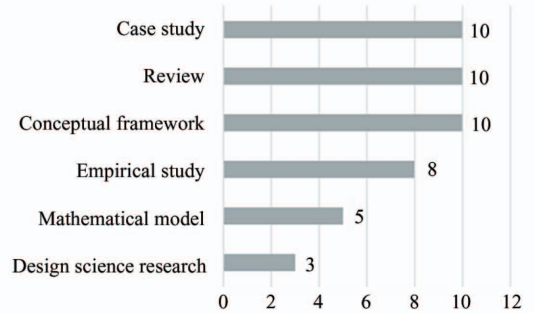


Fig. 4 Methodology in blockchain research

3 Developing context of blockchain

In the IS discipline, research into emerging technology has a similarly developing context, which was shown in papers on the topics of enterprise resource planning (ERP), decision support systems (DSS), electronic data interchange (EDI), Internet, etc. The developing context of emerging technology (Fig.5) consists of four stages: technology improvement, research and development, adoption and absorption, and business values. The consideration of the 46 papers indicates that blockchain has the same developing contexts.

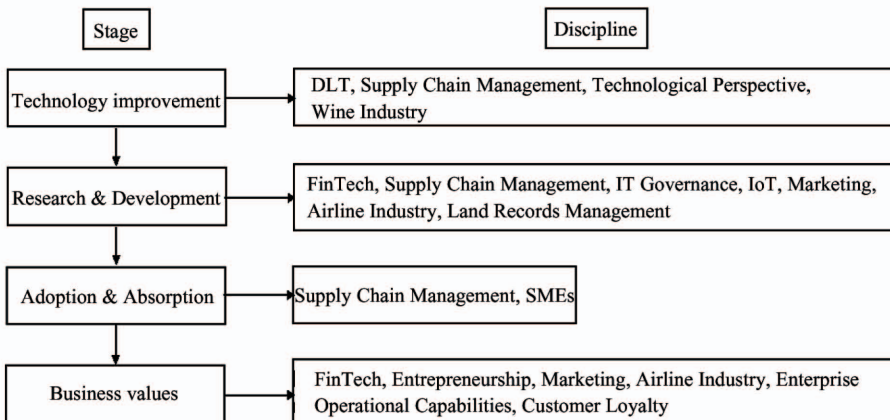


Fig. 5 A developing context of emerging technology

The extant blockchain research in IS (Fig. 6) mainly focuses on the second stage of the blockchain research and development context (25 papers), while only a few studies are related to Stage 3 blockchain adoption and absorption (4 papers) and Stage 4 blockchain business values (6 papers). The first stage of blockchain technology development is discussed in 5 research papers. Six out of the 46 are review papers that comprehensively describe the status of blockchain development, discuss real cases and challenges, and point out potential research directions.

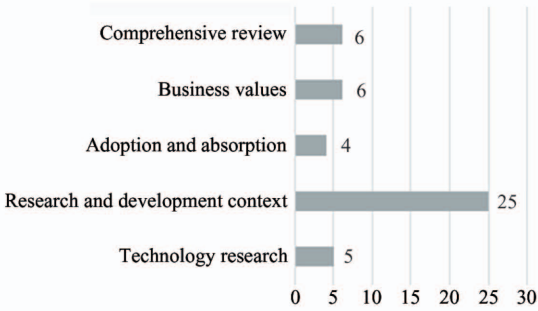


Fig. 6 Article distribution among contexts

3.1 Technology improvement of blockchain

The first blockchain development context is technology improvement that is directly related to the various features of blockchain. In the selected articles, the scholars paid attention to the different types of blockchain, the popular blockchain platform, technical improvement in blockchain mining, and DLT.

Ref. [9] distinguished two types of blockchain, permissionless, by a case study of the wine industry, and they note that, although both drivers and barriers exist for each of the two types of blockchain, enterprises could implement both types of blockchain under certain conditions. Ref. [10] investigated one popular permissible blockchain Hyperledger Fabric used in food distribution to estimate the challenges of the mechanisms and the infrastructures of the blockchain. Technically, blockchain still has issues regarding transaction and mining that can be resolved by classical theory and mechanisms, i. e. game theory and a reward mechanism. A text mining technique was employed to investigate DLT development, and Ref. [11] found that the developing pattern is similar to that of Gartner’s Phases of the Hyper Cycle. The benefits and challenges of application and adoption with DLT were discussed in this paper, as well.

3.2 Research and development of blockchain

The second development context of blockchain is research and development, which is the targeted re-

search stage, right now. Refs[12-13] were seeking to integrate blockchain into different disciplines with other technologies to solve problems that cannot be dealt with.

A blockchain-based money payment framework was modeled to analyze users’ recognition in the transaction process. Based on an analysis of potential blockchain investment in Enterprise 8-K filing, the study illustrated the relation between investor reaction, cryptocurrency value, and blockchain technology emphasized the drivers of investing in Bitcoin. Compared with a more centralized clearing procedure, the decentralized clearing process can also solve the issues of bankruptcy and liability. Ref. [14] posited that blockchain could be used to resolve financial exclusion and to facilitate financial inclusion in less-developed areas.

Many features of blockchain are key factors that affect food supply chain systems. Among blockchain features, traceability, audibility, immutability, and provenance were found to be the most important factors that impact the agricultural supply chain. One case study evaluated the relation among blockchain technology, stakeholders, and business models. One study looked at a blockchain-based e-commerce supply chain framework that was constructed to improve security and traceability. Ref. [15] attempted to build a blockchain-based immunization management infrastructure to achieve a strong vaccine supply chain system.

Based on a case study of decentralized autonomous organizations (DAO), a blockchain-based framework of information technology (IT) governance was built. Ref. [16] conducted a supervised machine learning approach to decode some unidentified Bitcoin transactions, to estimate illegal activities. If this proposed method can be validated, it will be good for organizational regulation and compliance. In another study, Blockchain was embedded into the crowd work platform to enhance governance performance and to consolidate organizational value. Blockchain technology has the potential to improve governance regulation, especially regarding security and accessibility.

Through a time-series empirical study, the exchange rate of Bitcoin was investigated to check how technical and economic factors impact rate changes under different market conditions. Ref. [17] conducted to investigate the influence of participants in social media on the value of Bitcoin. Interestingly, the silent majority was found to play a more important role in value fluctuation.

Blockchain technology can be integrated with another emerging technology, Internet of Things (IoT), to secure sensor data. The integration of these two advanced systems will promote the performance of data

processing to a higher level. Based on the features and the advantages of blockchain, Bitcoin has the potential to form self-organizing communities and to implement interactions between members. Ref. [18] believed in marketing, the Logarithmic Market Scoring Rule (LMSR) has issues of availability, security, and privacy; blockchain technology can resolve these problems. Ref. [19] implemented a blockchain-based system design to build a system for land management. The performance of a blockchain-based Airport Collaborative Decision Making Platform (A-CDM) was observed to evaluate sustainability in airport operational management.

3.3 Adoption and absorption of blockchain

The third research is adoption and absorption. An enterprise's capability of adopting or absorbing blockchain technology is critical to the enterprise generation of business values related to blockchain. At the current stage of blockchain, the supply chain is a system to which practitioners apply blockchain technology, aiming to achieve high levels of traceability, security, and transparency.

A framework was published to explain how blockchain adoption worked among institutional, market, and technical factors. An empirical study focused on a comparison of individual-level blockchain adoption behavior between India and the USA, providing strong research into behavioral theory-based blockchain adoption. Ref. [20] investigated how the enterprise can apply blockchain adoption to supply chain management. A small supply chain components were highlighted; among them were 'relationship, information quality, service quality, supply uncertainty, mass customization, and delivery reliability'. Ref. [21] discussed the blockchain adoption for small and medium enterprises (SMEs) which focused on competitive advantage, complexity, and cost reduction.

3.4 Business value of blockchain

After Bitcoin has shown huge profits and influence in the financial markets, more and more people no longer regard blockchain as merely a financial speculation instrument; cryptocurrency's foundation in blockchain may become a general and valuable tool in practice. Blockchain has great potential to be transformed into business values. Researchers should focus on the differences between various blockchain applications and analyze the value creation mechanism of blockchain with the support of relevant theories. Refs [22-23] carried out the potential questions including how to integrate blockchain into enterprise business process, how to use

blockchain to enhance enterprise core competitiveness, and how to employ blockchain to strengthen enterprise strategy and decision making.

By comparing five blockchain-related enterprises, the study created business models to illustrate how markets can be differentiated for enterprise and how the enterprise can transform blockchain to business values. Ref. [24] considered how blockchain technology transforms itself to business values with a case study in the airport industry, such as employee benefits, information security, and organizational enablement. Ref. [16] represented the enterprise operational capability by the total assets that influence the implementation of the blockchain. Blockchain technology enhances the perceived value of customer loyalty by stimulating both extrinsic and intrinsic factors.

4 Future research direction of blockchain in information system

With the support of physical virtualization and self-service, blockchain can continue to provide diverse functions for enterprises. Enterprises can use blockchain to quickly expand the business scale while maintaining the standardization and high quality of products or services. Also, the strong service capabilities of blockchain can provide a good environment for enterprises to conduct business and service innovation. Through continuous improvement, enterprises will have more creativity and agility. The future research direction and enterprise management issues of blockchain are blockchain integration and low-carbon economy, strategic planning and implementation, emerging companies and market structure, B2B, B2C and C2C communications and cross-organizational governance and collaborative cooperation.

4.1 Blockchain integration and low-carbon economy

Due to geographical, cultural, and market limitations, enterprises have huge differences in accessing and adapting information resources, leading to unbalanced opportunities and unfair competition. The distributed network and the agile interoperability of blockchain will greatly improve the ability of enterprises to obtain information resources and to fulfill IT-relevant challenges. Hence, future research can be conducted based on the theory of technology diffusion, technological innovation, and resource endowment and informatization, to study blockchain related information issues and service modes of the blockchain economy.

Both the low-carbon economy and ecological civi-

lization require the support of emerging technologies with low pollution and high efficiency. Blockchain is this type of emerging technology. Blockchain can provide economies of scale, a green IT environment, and a low-carbon economy. Based on general growth theory, economic externality theory, and economies of scale theory, future research can be targeted at the efficiency and greenness of blockchain in the development of a low-carbon economy and the efficiency of that economy.

4.2 Enterprise strategic planning and implementation

Strategic planning and implementation are the key issues that influence the development and success of an enterprise. Business strategies require the blockchain to coordinate with IT and other technical strategies. Faced with a variety of different strategies, the question of how an enterprise will choose its blockchain model (to match its business and other technical strategies) will offer a new challenge. In the future, relevant research should be conducted based on strategic choices, strategic matching, and dual capability theory. For example, questions might include how to choose an appropriate blockchain usage model, how to use blockchain to support business and other technical strategies, and how to use blockchain to enhance strategic flexibility, among others.

4.3 Emerging companies and market structure

The development of emerging companies and the burgeoning of multinational companies are related to blockchain technology. Because blockchain can improve the cooperation and innovation of an enterprise by integrating a variety of resources through a decentralized platform, it has an impact on both enterprise profits and management models. Based on the theories related to international trade, service science, production and operation, and industrial organization, future research should be focused on global blockchain operations systems, blockchain tertiary industry service models, and blockchain-related businesses or industries.

Market structure is an important issue. Faced with competition and cooperation in the banking, telecommunications, mining, and energy industries, research on oligopoly or monopoly competition provides logical explanations and reliable solutions. As blockchain develops, the traditional market structure may undergo major changes. Under the blockchain system, Ref. [25] believed it is unclear whether the future competitive landscape will be one in which small enterprises will cooperate through a blockchain network to

compete with large enterprises or one in which large enterprises will build networks, through blockchain, to attract partners. Future research can use the business ecosystem theory, game theory, cross-organizational governance theory, and incomplete competition theory to study the blockchain business ecosystem, blockchain business cooperation models, and the competition of monopoly or oligopoly through the blockchain platform.

4.4 B2B, B2C, and C2C communications and cross-organizational governance and collaborative cooperation

Blockchain will bring us a richer way of completing both communication and transactions. It will have an impact on B2B, B2C, and C2C transactions, and even on new e-commerce models. The existing research on e-commerce is still focused on transactions among physical products. Blockchain will greatly increase virtual service products and services. Based on e-commerce theory, marketing theory, and consumer behavior, and psychology theory, research can be conducted on issues such as e-commerce models, marketing model innovation, consumer purchasing behavior, and IT service usage habits.

As competition between enterprises gradually evolves into a competition between supply chains, cross-organizational governance, and collaborative cooperation are becoming important issues. Blockchain may contribute to new IT application rules and IT investment structures. How to use blockchain to form a governance model that conforms to supply chain structure while it offers competitive advantages is an important research direction. Specifically, based on the theories of information processing, inter-organizational relationship governance, strategic alliances, and resource dependence, future research may study issues such as blockchain and cross-organizational cooperation models, cross-organizational governance models, and strategic partnerships, among others.

5 Conclusion

For the study of blockchain application and adoption and blockchain-centric management issues, we need to understand the technological characteristics, the potential advantages, the implementation risks and governance, adoption and absorption, and the business value of blockchain. Also, the integration and the collaboration of blockchain with other emerging technologies, like IoT, cloud computing, and 6 G, determine that the relevant research objects are not just one or two enterprises, but the entire blockchain network-and

even the business ecosystem.

Blockchain is one of the most revolutionary technologies in the development of ICT. The benefits of capability, interoperability, scalability, and agility of blockchain provide a potential foundation for research in the IS disciplines. The future research of blockchain in IS will move forward to its adoption and absorption; furthermore, both blockchain-related traditional and emerging enterprises will seek approaches to transform blockchain to their business values.

Reference

- [1] Lu Y. Blockchain and the related issues: a review of current research topics[J]. *Journal of Management Analytics*, 2018, 5(4): 231-255
- [2] Rossi M, Mueller-Bloch C, Thatcher J B, et al. Blockchain research in information systems: current trends and an inclusive future research agenda[J]. *Journal of the Association for Information Systems*, 2019, 20(9): 1388-1403
- [3] Wamba S F, Queiroz M M. Blockchain in the operations and supply chain management: benefits, challenges and future research opportunities[J]. *International Journal of Information Management*, 2020, 52: 102064
- [4] Lu Y, Zheng X, Li L, et al. Pricing the cloud: a QoS-based auction approach [J]. *Enterprise Information Systems*, 2020, 14(3): 334-351
- [5] Li J, Yuan Y, Wang F Y. A novel GSP auction mechanism for ranking Bitcoin transactions in blockchain mining [J]. *Decision Support Systems*, 2019, 124: 113094
- [6] Upadhyay N. Demystifying blockchain: a critical analysis of challenges, applications and opportunities[J]. *International Journal of Information Management*, 2020, 54: 102120
- [7] Zhang C, Chen Y. A review of research relevant to the emerging industry trends: Industry4.0, IoT, Blockchain, and business analytics[J]. *Journal of Industrial Integration and Management*, 2020, 5(1): 165-180
- [8] Yi H. A secure logistics model based on blockchain[J]. *Enterprise Information Systems*, 2019, doi:10.1080/17517575.2019.1696988
- [9] Helliard C V, Crawford L, Rocca L, et al. Permissionless and permissioned blockchain diffusion [J]. *International Journal of Information Management*, 2020, 54: 102136
- [10] Kumar A, Liu R, Shan Z. Is blockchain a silver bullet for supply chain management? technical challenges and research opportunities [J]. *Decision Sciences*, 2020, 51(1): 8-37
- [11] Perdana A, Robb A, Balachandran V, et al. Distributed ledger technology: its evolutionary path and the road ahead[J]. *Information and Management*, 2020, 58(3): 103316
- [12] Chod J, Trichakis N, Tsoukalas G, et al. On the financing benefits of supply chain transparency and blockchain adoption[J]. *Management Science*, 2020, 14(5): 3434-1-19
- [13] Ali O, Ally M, Dwivedi Y. The state of play of blockchain technology in the financial services sector: a systematic literature review [J]. *International Journal of Information Management*, 2020, 54: 102199
- [14] Schuetz S, Venkatesh V. Blockchain, adoption, and financial inclusion in India: research opportunities[J]. *International Journal of Information Management*, 2020, 52: 101936
- [15] Yong B, Shen J, Liu X, et al. An intelligent blockchain-based system for safe vaccine supply and supervision[J]. *International Journal of Information Management*, 2020, 52: 102024
- [16] Pan X, Pan X, Song M, et al. Blockchain technology and enterprise operational capabilities: an empirical test [J]. *International Journal of Information Management*, 2020, 52: 101946
- [17] Mai F, Shan Z, Bai Q, et al. How does social media impact Bitcoin value? A test of the silent majority hypothesis [J]. *Journal of Management Information Systems*, 2018, 35(1): 19-52
- [18] Carvalho A. A permissioned blockchain-based implementation of LMSR prediction markets [J]. *Decision Support Systems*, 2020, 130: 113228
- [19] Thakur V, Doja M N, Dwivedi Y K, et al. Land records on blockchain for implementation of land titling in India [J]. *International Journal of Information Management*, 2020, 52: 101940
- [20] Karamchandani A, Srivastava S K, Srivastava R K. Perception-based model for analyzing the impact of enterprise blockchain adoption on SCM in the Indian service industry [J]. *International Journal of Information Management*, 2020, 52: 102019
- [21] Kamble S S, Gunasekaran A, Sharma R. Modeling the blockchain enabled traceability in agriculture supply chain [J]. *International Journal of Information Management*, 2020, 52: 101967
- [22] Bogusz I C, Morisse M. How infrastructures anchor open entrepreneurship: the case of Bitcoin and stigma[J]. *Information Systems Journal*, 2018, 2(6): 1176-1212
- [23] Ying W, Jia S, Du W. Digital enablement of blockchain: evidence from HNA group [J]. *International Journal of Information Management*, 2018, 39: 1-4
- [24] Andersen J V, Bogusz C I. Self-organizing in blockchain infrastructures: generativity through shifting objectives and forking[J]. *Journal of the Association for Information Systems*, 2019, 20(9): 11
- [25] Janssen M, Weerakkody V, Ismagilova E, et al. A framework for analysing blockchain technology adoption: integrating institutional, market and technical factors[J]. *International Journal of Information Management*, 2020, 50: 302-309

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