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ORIGINAL PAPER

Emerging advances of blockchain technology in finance: a content analysis

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Abstract
Blockchain has become a widely used information system technology recently because of its effectiveness as an intermediary-free platform. While the use of blockchain in various fields, such as finance, supply chains, healthcare, education, and energy consumption, is increasingly enabling the development of Internet-enabled "distributed databases," there are not many exploratory studies available to provide an understanding of how the field is progressing. Therefore, it is imperative to explore the status quo of blockchain technology in the finance sector, particularly highlighting how blockchain architectures can aid the finance sector to gain competitive advantage. This systematic literature review analyzes the content of the 50 most relevant articles and professional industry reports through peer-reviewed relevant academic literature in the finance sector from 2008 to 2022 to identify several possible features of blockchain research in the financial sector. This study highlighted the dimensions of blockchain technology, blockchain in finance, its competitive advantages, the current status of finance, and various challenges that keep the implementation of blockchain-based financial information systems at the initial stage. We identified three main areas that require research attention in order for blockchain technology to become the "next-generation networks" that will revolutionize the financial sector.

Keywords Blockchain · Finance · Banking · FinTech · Financial big data

1 Introduction

As a revolutionary technology invention after the Internet [1, 2], blockchain enables new online businesses to acquire and gain the trust of stakeholders for data transactions. It has become a common technology that has transformed the status quo of many business functions, such as finance, healthcare, supply chains, education, and energy consumption. This technology guarantees secure, immutable, decentralized, and transparent data services, enabling quick transactions at low cost for various business network stakeholders [3]. Central banks, financial institutions, and technological firms are all interested in blockchain technology as the financial sector has understood its huge potential [4]. This implies that this innovation would create a significant push to transform the structure of financial services, how the entire financial industry operates, and reinvents the banking industry [5, 6] and address dynamic changes while providing effective data solutions that meet the demands of modern distributed industries. For instance, by implementing blockchain technology, traditional banking systems can gain competitive advantages in securing transactions at a lower cost [7, 8]. Existing studies have shown that banks are continuously exploring options for implementing blockchain [9–11]. The Interbank Information Network, which is the largest blockchain payment network (Global partners: J. P. Morgan, Australia-New Zealand Banking Group Ltd., and Royal Bank of Canada), has already started its journey with blockchain technology applications [10, 11]. A frequently used application is the American Express instant blockchain-based payment system, which was developed on the Ripple platform.[1] Because of the rapidly

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[1] The Ripple platform is unknown as a distributed ledger that incorporates a network of validating servers and crypto tokens called XRP, and under the Ripple network, users may develop robust and secure

growing use of the Ripple network, remittance companies such as MoneyGram have also joined Ripple to overcome the barriers of cross-border transactions and concerns with legal compliance.

The use of the Internet, the latest mobile applications, and other smart mobile devices reinforced the demand [12] for features and services that the finance sector may offer for effective electronic transaction processes and provisions in financial information systems. FinTech, the combination of technology and financial services [13, p.3; 14], has become a well-discussed area of study in the new era of the business industry. FinTech companies offer many services, such as digital cash, cognitive systems, and distributed ledger technology. Traditional financial organizations and start-up companies are increasingly partnering with FinTech [15] to provide user-friendly and cost-effective financial electronic services. Blockchain is a common FinTech that transforms how financial businesses operate, collaborate, and transact with their stakeholders [16]. This suggests that the decentralized financial network is bringing about a major financial sector revolution with the enhancement of digital wallets as a crucial component of financial inclusion. The decentralized electronic ledger system will transform the way transactions are carried out, changing the shape and size of the financial sector. Studies [1, 17] have demonstrated that research on blockchain applications can save business money and open up new commercial and export opportunities, both of which will expand in the near future. According to the Australian Blockchain Roadmap [18], Gartner predicts that "blockchain will generate an annual business value of over US$175 billion by 2025 and over US$3 trillion by 2030. By 2023, blockchain will support the global movement and tracking of US$2 trillion worth of goods and services annually." This shows the rapid growth of blockchain implementation in the commercial and financial service sectors.

Blockchain technology has emerged as a revolutionary and disruptive [19–22] innovation in both technology and economics in the finance industry and requires a critical level of data integrity. The main objectives are to replace the existing process by eliminating the need for the "trusted third parties." Undoubtedly, in the finance sector, the global money remittance and automated banking industry will be disrupted by blockchain transformation. PricewaterhouseCoopers (PwC) in its 2019 Global FinTech Report stated that "FinTech is a major disruptor in the financial services industry" and it affects "the way financial services market players do business." To secure the integrity of financial systems and prevent money laundering, it is vital for financial big data[2] to be validated and verified to offer credibility. The use of blockchain with security encryption and smart contracts in the finance sector enhances identity management, transparency, trust, and privacy [16]. Research supports the evidence that blockchain technology can provide efficient, fast, and low-cost transaction platforms.

Although blockchain transforms the current forms of FinTech to gain a competitive advantage, it still has vulnerabilities, drawbacks, and enormous challenges to overcome. Gan et al. [21] investigated the aspects of designing FinTech: technological, organizational, usability, social, and regulatory. In an IEEE editorial note, Choo et al. [23] summarized the technological and management opportunities and challenges in a blockchain ecosystem. The involvement of several stakeholders increases the complexity of blockchain usage in the finance sector. The complexities vary in different aspects, such as technical, capability, knowledge, experience niche, regulatory, and cybersecurity. Blockchain and its applications require regulatory frameworks suitable for their intended purpose similar to any other disruptive new technology. This is the time to expand the awareness of the disruption and long-term benefits and enhance the knowledge to assist with this transformation. Researchers [9–11] have investigated the challenges that the financial sector faces when implementing blockchain technology. They have identified many challenges, such as maintaining trust, ensuring the security of blockchain systems, ensuring the integrity of data, identifying participants in blockchain systems, balancing privacy with transparency, tech-neutrality, secure interpretability, and the legal status of smart contracts. It is difficult to guarantee trust and anonymity in platform-mediated networks.

The major disadvantage of blockchain is scalability, which relies on throughput [2, 3]. It requires a high throughput while dealing with a large volume of transactions. For example, blockchain has a very low throughput compared to Visa and PayPal (Fig. 1). In some cases, the immutability of the blockchain itself becomes an issue in ensuring effective transactions. There are gaps in the state-of-the-art literature relevant to the theoretical, technological, practical, and social aspects of blockchain technology.

This literature review was prompted by an investigation of how blockchain technology revolutionized the finance sector to become its future, given that relevant financial sector research is still in its initial stages compared to blockchain

Footnote 1 (continued)

decentralized payment applications to send and receive funds globally over the given blockchain capacity.

[2] Big data simply refers to the huge volume, velocity, and variety of data sets. The financial big data can be defined as huge transactional or other forms of data sets that are large, rapidly accumulating, and complex in nature, therefore require a collection of technologies and methods used to collect, sort, process, and analyze the data sets.

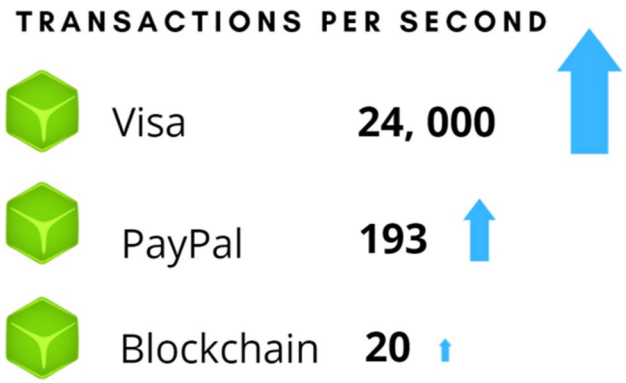


Fig. 1 Transaction speed

technology research in other disciplines. Blockchain-based information systems are significant for financial institutions, particularly remittance companies and banks, where identity management and transparency are crucial to their financial transactions. Ensuring the security and reliability of big financial data is also crucial. Blockchain-based financial applications will be advantageous to banks, remittance companies, audit firms, financial trading companies, digital asset management companies, and any type of financial and e-finance institution.

This study aims to highlight how blockchain architecture can help the finance sector achieve a competitive advantage. We describe the features of blockchain technology and how they help resolve issues in the financial sector. We highlight the recent growth in research interest in blockchain technology in the financial sector and categorize its study fields. Exploring this topic, the focus of this study aims to recognize the potential of blockchain in the finance sector and develop the knowledge of its core components, major challenges, and current research gaps.

The rest of this paper is structured as follows. In Section 2, we describe the fundamentals of blockchain technology, the blockchain revolution, and blockchain applications in the financial sector. In Section 3, we explain the systematic literature review methodology of this study and develop the research questions. In Section 4, we provide an overview of the existing work, present the findings, and discuss the problems to be solved. In Section 5, we outline the conclusions and possible future research opportunities.

2 Study background

2.1 Basics of blockchain technologies

The first and most fundamental blockchain technology was introduced in November 2008 as an electronic cash system, the distributed ledger behind Bitcoin transactions, by Satoshi Nakamoto (an unknown programmer or group of programmers) [24]. This system was viewed as a paradigm shift, given that it comprises four core components as shown in Fig. 2: hash, digital signature, peer-to-peer network, and consensus mechanisms. The technology used in distributed digital ledger record transactions as an immutable list of blocks that are shared in a peer-to-peer network. It does not require a single server, thus eliminating a single point of failure. Each piece of information in the block is encrypted, and each block is linked to the previous block using a unique identifier created using the hashing algorithm [25]. A new block of data can be appended to the ledger only if majority of the nodes agree that it is valid. The entire process of transaction verification and addition to the blockchain is called mining, which requires a highly configured hardware computational power. The agreement between multiple nodes (participants) about the validity of a block is derived via a consensus algorithm, such as proof-of-stake (PoS), proof-of-work (PoW), proof-of-elapsed time (PoET), delegated proof-of-stake (DPoS), and practical byzantine fault tolerance (PBFT). Each block in the blockchain encrypts the transaction using a cryptographic hashing function (Hash256), which provides security in blockchain technology. All these components enhance the attributes of the blockchain: security, trust, privacy, and anonymity [25].

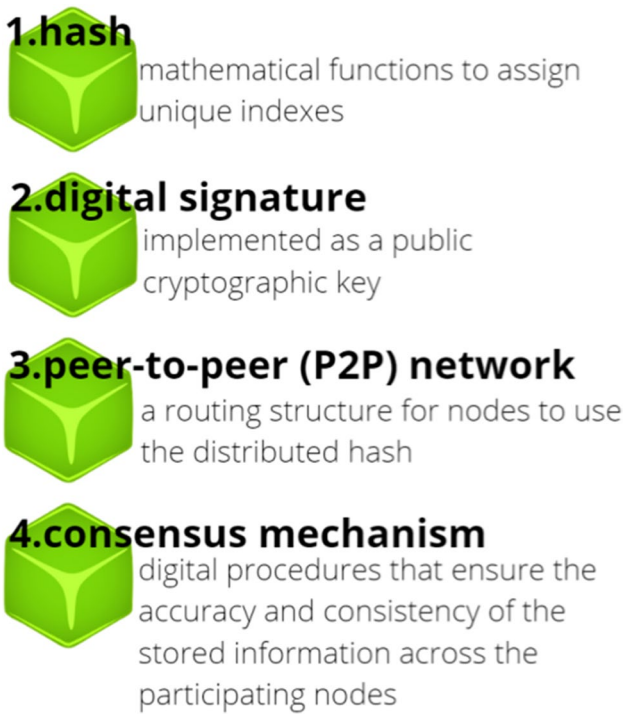


Fig. 2 Four core components of the blockchain technology

2.2 Revolution of blockchain technology

Blockchain has been revolutionized in four stages since 2008 (Fig. 3); the first of which is cryptocurrencies, particularly Bitcoin. The popularity of blockchain has increased because of the introduction of Bitcoin. The second era introduced monetary transactions and smart contracts in mortgages, loans, and other monitory bonds, an automated computer program that executes automatically. In the third era, it has increased in digital society by enhancing the features of smart contracts. The fourth era concerns industrial decentralized ledger systems in different industries such as government, healthcare, supply management, education, energy, and finance [12]. Blockchain technology has advanced from being a platform for digital currencies to smart contracts to decentralized applications (DApp) with high-speed and expandable decentralized storage and decentralized communication to the infrastructure available for Industry 4.0.

2.3 Blockchain in the financial sector

In the financial sector, interest in blockchain has grown. The use of blockchain technology in finance to conduct money transfers, cross-border payments, identity confirmation, contractual agreements, trade finance, insurance, smart contracts, auctions, and currency trading has led to its exponential growth. Western countries (for example, the USA, Australia, Canada, South Korea, Russia, and Israel) have been encouraged to invest in blockchain-oriented application development [26]. The three main blockchain applications (Fig. 4) in finance that have been identified include cryptocurrencies and their trading platforms, digital asset registers and management, and cross-border payments. According to Deloitte [27], blockchain applications can be used to transform finance processes: "intercompany transactions, procure-to-pay, order-to-cash, rebates, warranties, and trade financing."

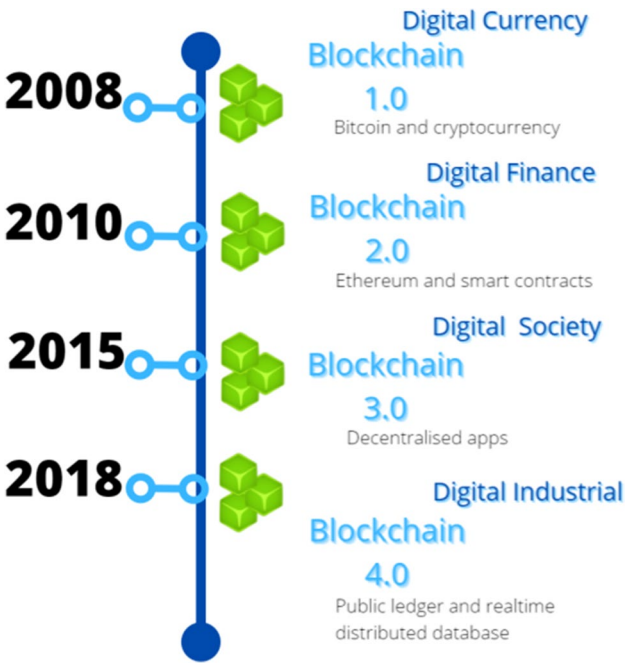


Fig. 3 Blockchain evolution

The primary factor in financial transactions that contributes to the success of a financial institution and the effective use of an application is trust [27]. Blockchain establishes trust, instructs the Internet on how to transfer money or other assets via secured smart networks using a cryptographic algorithm, and guarantees that the money is spent only once. The current legal channels used in remittances are banking services, automated teller machine (ATM) withdrawals abroad, money transfer operators (MTOs), cash transfers (through informal couriers), and carrying cash when returning home (Kasiyanto, 2016). The current challenges of cross-border remittances are data collection and verification as well as transaction costs. Lowering the transaction costs of remittances is not an easy task. Blockchain technology plays a major role in finance [28].

The traditional and labor-intensive identification method used by FinTech institutions to go through the know your customer (KYC) process [25] increased the overhead of the business. Blockchain-oriented systems can overcome business overheads in financial institutions by providing efficient KYC processes [8]. Evidence is also reported in the government sector. For example, in March 2015, the UK government set out its approach to digital cryptocurrencies by adopting a friendlier regulatory stance. Furthermore, the UK government plans to invest money in the potential future of leveraging blockchain technology to fundamentally change the financial world [4]. Although there is a high demand for blockchain technology in the finance sector, it is still in its infancy.

3 Systematic literature review methodology

A systematic literature review was conducted in three phases (Fig. 5 illustrates the details of the phases) using the existing peer-reviewed literature in the finance sector from 2008 to 2022. Our scope includes finance research and covers blockchain technology studies. In the initial phase, we identified the scope of the research area, focusing on blockchain technology in the finance sector. The timeframe for the study was obtained from the first reference to the blockchain published by Satoshi Nakamoto in 2008. To ensure credibility, only peer-reviewed articles were selected from the eight different databases. Phase two was conducted using two main strategies.

Fig. 4 Blockchain applications

Fig. 5 Phases of the literature review

First, the review concentrated on the "Abstract" section of articles found relevant to the sector. We then moved the review to a deeper content analysis, where we needed to gain extant knowledge and understand the intellectual structure of blockchain in the finance sector. The final phase began with an evaluation of the gathered information to determine the contributions to the topic and then we synthesized the results into a summary of known and

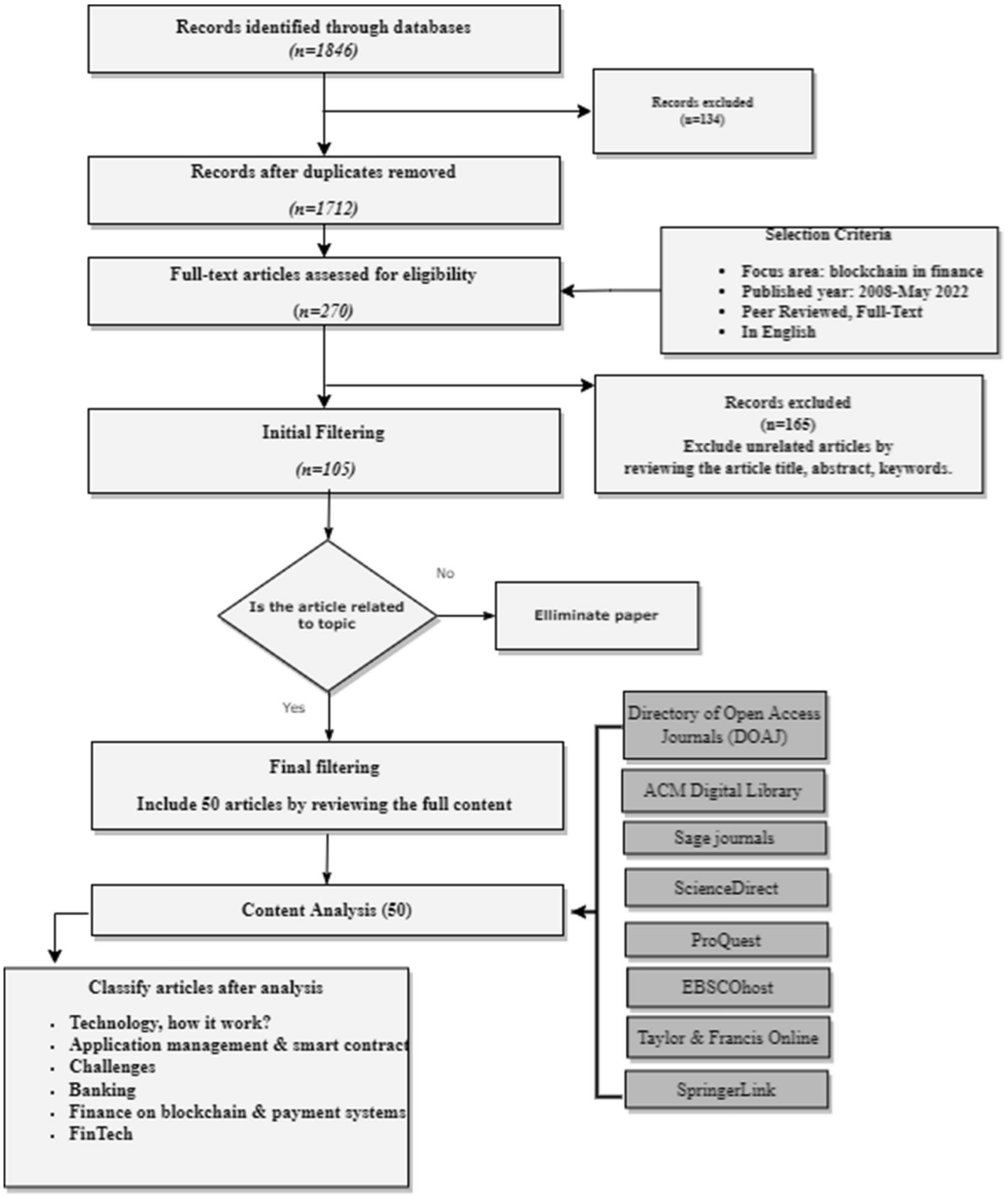


Fig. 6 Sample collection and analysis process

unknown findings and controversy. Finally, the research questions were formulated, and further research areas were identified.

Our primary objective is to gain insights into blockchain technology in the finance sector, particularly highlighting how the blockchain architecture can help the finance sector

achieve a competitive advantage. As illustrated in Fig. 6, we referred to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to systematically locate, select, and evaluate article samples. The 50 articles reviewed in this study were sourced from 26 journals in eight different databases related to business, finance, and information systems (*ACM Digital Library*, *Directory of Open Access Journals* (DOAJ), *SAGE journals*, *ScienceDirect*, *ProQuest*, *EBSCOhost*, *Taylor & Francis Online*, and *SpringerLink*). Sample articles were identified to understand the topic and its influence. The thematic content analysis methodology has been used to systematically identify significant research topics, potential business benefits, and potential challenges of applying blockchain technology to the finance sector.

By analyzing other similar literature review articles, we adopted a stepwise approach [29, 30] to develop our research questions. Research questions can be developed using different formats depending on the aspect to be developed, such as existence, description and classification, composition, relationship, and descriptive [29]. The literature reviewed in this study framed the research questions based on the existence of a particular theory revealing an explanation, description, and classification where the questions show uniqueness and relationships that evaluate the relationship between variables.

In the development process of research questions, as many researchers have done, we began identifying the broader subject of interest in blockchain in the finance sector. We framed the questions based on the composition, where the research was broken down into components. In our preliminary research, we identified the existing information that clarifies information gaps in the blockchain in the finance sector. We then discuss what we should still know. Every research question in our study leads to a more specific question: "Is blockchain technology the future of the finance sector?" Therefore, the following questions were developed to narrow the scope and focus of this study.

This study intends to answer the following research questions to identify blockchain as the future of the financial sector.

RQ1

How has blockchain technology been used in the finance sector since its emergence?

RQ2

Can blockchain technology streamline different financial services, including payments, interbank processes, international remittances, and financial accounting [4, 26, 31, 32]?

RQ3

Has blockchain technology disrupted the financial sector? Blockchain technology can disrupt asset management payments, compliance, and insurance processes in the financial sector [1, 15].

RQ4

Why is it still in its initial stages? The research trend is widespread in terms of business opportunities, challenges, and regulatory requirements [2, 6, 32–35].

4 Findings and discussions

This review investigated the blockchain literature to provide useful research insights in the financial sector to assess its technical value by adding and addressing issues relevant to application design aspects. Our study identified major obstacles to realizing ubiquitous smart applications as well as an important aspect for generating new conceptual knowledge in the problem domain. Previous studies have attempted to investigate blockchain technology, its challenges, and its applications in finance rather than focusing on blockchain in the banking, finance, and FinTech categories in depth.

To the best of our knowledge, no reviews have either explored the adequate theoretical grounding and empirical rigor or identified the areas that need to be addressed in a single research review. This is despite earlier studies on blockchain in finance showing room for improvement in various ways. In contrast to previous work, our investigation addresses a broader view of blockchain in finance to justify the statement "The future of finance is blockchain" by revealing the current status of the financial sector and how blockchain can revolutionize it. We recognized the technology evolution, its disruptions, and blockchain implementation challenges. Our analysis identified three major foci of blockchain implementation in the finance sector: business, technology, and social aspects. We argue that successful implementation of blockchain in finance is possible if these areas are addressed appropriately. The contribution of this study is that it assists researchers and practitioners in making a strategic view of implementing blockchain in the finance sector.

The following sections include details that summarize our findings.

4.1 Blockchain disruption and the future of finance

Blockchain is an innovative technology that disrupts the financial sector and transforms the financial sector, and its use in FinTech is surging in popularity. FinTech can be

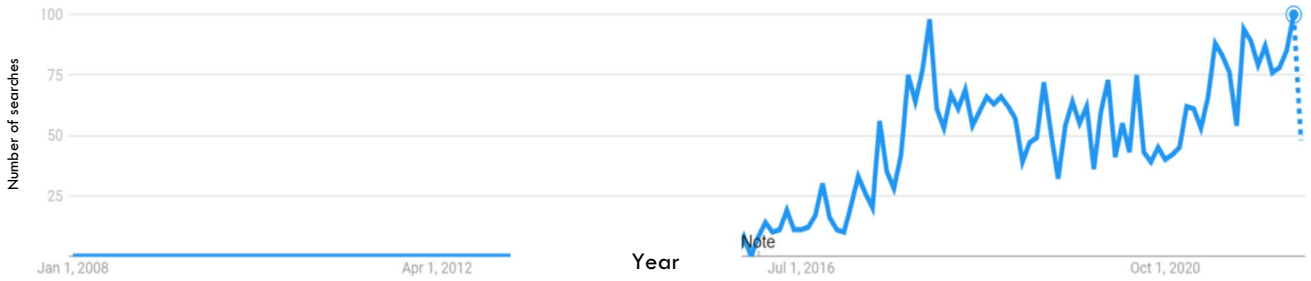
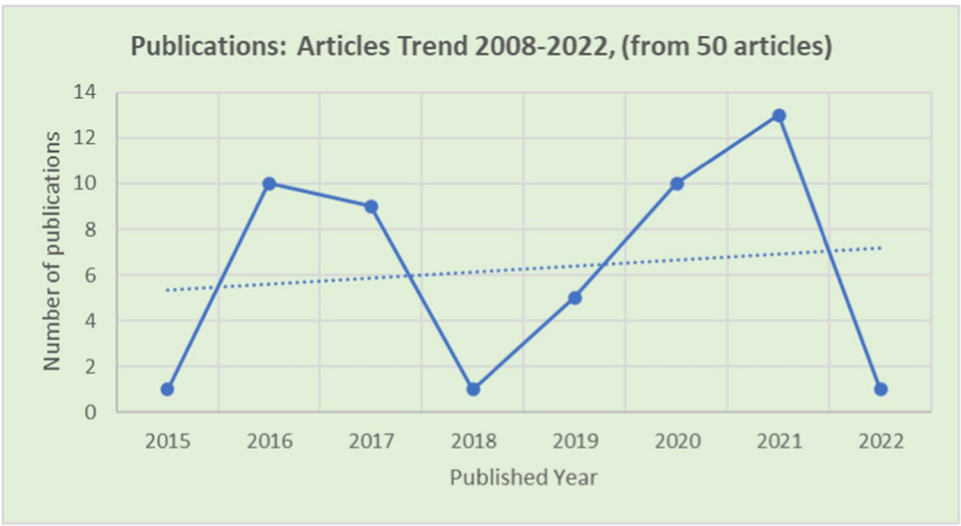


Fig. 7 Google trend search volume—blockchain in finance January 2008–2022

Fig. 8 Publication article trend 2008–2022



classified in two ways. First, financial institutions embrace technology to advance their operations. Second, technology companies use their technology to develop financial technological services [6]. FinTech has evolved in three phases. The first phase is mobile payment, such as Apple Pay. The second phase is smart contracts, such as DocuSign. The third phase is blockchain. Although blockchain is still in its initial stages, the industry has sensed the pulse of this transformation and is eagerly waiting to understand the architecture, design, implementation, and maintenance of this technology. The lack of knowledge, understanding, cooperation, and communication among stakeholders creates barriers to this transformation.

4.2 Blockchain in finance research interests

The number of publications on blockchain technology in finance has recently increased. Although blockchain finance has not shown any interest since 2008, it has gradually gained attention and reached its peak in 2018, as shown in Fig. 7. The articles used in this research support the increased interest in blockchain finance since 2015 (Fig. 8). Banks and other financial institutions have realized that blockchain technology can optimize the finance sector. Furthermore, to be sustained in the industry, they must understand blockchain technology and embrace it sooner than later [2].

Blockchain technology has gained interest in many fields that require high performance, security, transparency, and cost efficiency since Nakamoto published his work on Bitcoin cryptocurrency. In the IEEE special issue [23], it is stated that 200 articles related to blockchain in banking and finance, manufacturing, energy, transportation, and other fields have been submitted. This indicates that researchers continue to be interested in the blockchain topic. Financial institutions and large accounting firms such as Deloitte, PwC, Ernst and Young (EY), and KPMG have seen the potential of blockchain and thus have started several projects in blockchain technology. The researchers identified in this review have explored blockchain in various areas, such as how this technology works, application management and smart contracts, challenges, banking, finance and payment systems, and FinTech (Fig. 9). Summary finding of each area has stated in the next section.

Fig. 9 Research areas (2008–2022), 50 articles, blockchain in finance

4.2.1 Blockchain technology and how it works

Research interest relates to the technology of blockchain refers blockchain as chronologically added immutable chain of cryptographically secured blocks that holds time-spanned transaction on a peer-to-peer network. This data sharing platform accepts the blocks verifying arithmetically produced code called hash that enable tamper proof chain. Researchers pay attention to understand the technology, security, consensus, and mining processors [1, 3, 4, 12, 17].

Blockchain technology is evolving, industry is getting ready to embrace the blockchain technology; however, researchers have mentioned that organizations need to leverage research on blockchain technology to better understand the critical insights to optimize the business strategies which assists in decision-making at the strategic level [21, 34].

4.2.2 Blockchain application management and smart contract

Bitcoin is the initial application of blockchain [24]. Research community refers blockchain as potential application for transaction-oriented process and therefore interest in application management in many areas such as supply chain, healthcare, finance, sustainability, and energy [17]. Furthermore, they suggest exploring the knowledge in application management that relates to the above field. Blockchain application includes transparency, trust, infrastructure, smart contract, and makes sure business availability and continuity. The consensus protocol defines the agreement to add blocks to the blockchain. The most common consensus mechanisms are proof-of-work (PoW), proof-of-stake (PoS), practical byzantine fault tolerance (PBFT), and delegated proof-of-stake (DPoS) [17].

Blockchain-based finance solutions provide a feasible solution to transaction big data digitization, verification, and monitoring. Smart contracts are computer codes designed to facilitate, verify, and enforce business rules automatically to satisfy the business logic, make sure the reliability, verifiability, and security of financial data on the chain [9, 12, 17, 21, 36].

4.2.3 Challenges

Blockchain creates opportunities in many sectors; however, there are risks and challenges related to successful chain implementation. Researchers have identified challenges associated to blockchain in the banking and finance sector in many forms: technical challenges, organizational and user-related, social, and regulatory [6, 7, 21, 23, 26, 33, 35]. Technical challenges include limited space, less network performance, lack of universal protocols and standardizations, and high-energy consumption [2, 21, 23]. End users challenges include user resisting the technology as its disruptive to the traditional banking and finance process. This alternative workflow requires systematic integrations to gain trust from end users as they worry about privacy, integrity, and security threats [6, 7, 21, 23]. Social risks create as the technology transforms financial industry and the labor market. Regulatory standardization is one of the significant challenges for government and regulators [33]. Additionally, the biggest obstacle is the immaturity of the technology [2, 7, 21, 23, 26]. Cyber risks, vulnerabilities, hardware requirements related the transaction big data management, mining performance, scalability handling, technical identification, risk identification, implementation difficulties, system integrations, regulatory restrictions, and social acceptancy are the highlights [21, 23, 26, 35].

At the same time, chained-oriented system in financial field is capable to solve issues related to the finance field such as financial frauds, money laundering, high audit risks, tax avoidance, and cross-border financial variances [21].

4.2.4 Blockchain in banking

Banking sector facing issues relates to user verification, transaction monitoring, assets management, and cross-border remittance management. Know your customer (KYC) and anti-money laundering (AML) regulations are essential business processors. Banks spent massive amount of money to comply with KYC and AML regulations. Literature suggests blockchain technology as a solution in this requirement. Furthermore, banks require faster, efficient, transparent, secure, intuitive, and cost-effective transaction platform that blockchain is capable to deliver [2, 5, 8–11, 21].

4.2.5 Blockchain in finance and payment systems

As research community has identified banking and finance sector has potential to enhance the business processes using blockchain technology [9, 12, 17, 21, 36], the banking platforms can be disrupted positively. Financial sector is looking solutions for verifying identification, high cost, slow transaction managing, cross-border transactions, and assets management. Major banks in the world are investigating how to solve the issues using blockchain technology [36] that has the ability to provide low cost and high-speed real-time monitoring features. Some financial institutes are investigating how to use blockchain to enhance security in the applications [21, 36].

4.2.6 FinTech

FinTech is a combination of technology and financial service interest in digitization of financial processes, particularly in banking and finance institutes. Researchers have identified

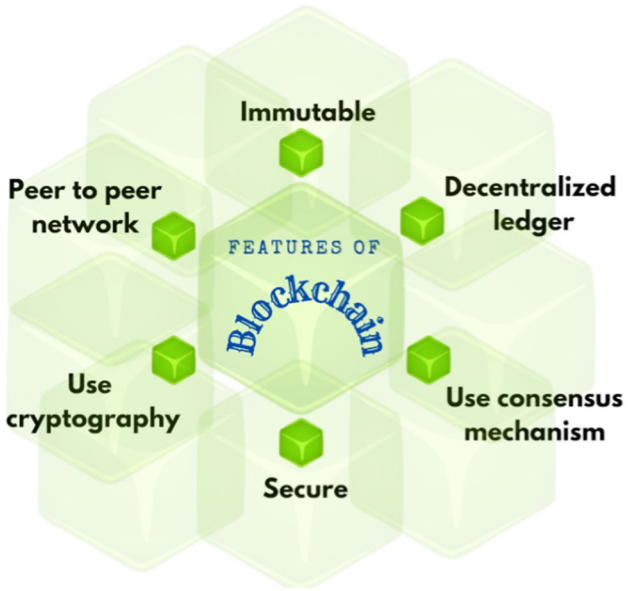


Fig. 10 Blockchain technology features

FinTech as a technology enabler of finance industry [20]. FinTech investments have shown exponential increase with blockchain, AI, and big data technology innovations [13, 14, 16]. Publications considered FinTech in different categories such as organizational structure, products and services, business processors, and as an IT enabler system [16, 20], further categorized as blockchain and crowdfunding as subsets of FinTech [34]. The economic, financial, and business and management areas are the most popular research areas related to FinTech [14, 16, 20, 34]. In contrast to the findings, researchers have identified FinTech as an IT enabler for business models [14, 16, 20, 34].

4.3 Blockchain features solve issues in the current financial sector

The maintenance of financial big data incurs significant costs for financial institutions. The current finance sector works on traditional activities that require a central trusted party such as the central bank to verify each transaction. Traditional financial institutions are not interoperable because maintaining ledgers in silos is costly. Furthermore, the lack of transparency, customer access restrictions, and centralized control are some of the problems with current financial operations [37]. The current centralized payment networks in financial systems, such as SWIFT, PayPal, and Visa, charge a high cost for their services. To ensure compliance and promote sustainability, governing bodies are linked to the current financial systems. Every transaction in the financial industry requires transparency, security, data validity, reliability, and integrity. Financial institutions will be able to give customers a proper service if they can lower the costs.

Blockchain technology addresses issues in the financial sector and offers a single platform that all stakeholders can use to gain a competitive advantage, as shown in Fig. 10. The enormous benefit of this technology is based on distributed trust that omits the requirement of a third party to manage payments, leading to transaction costs and time reductions [36]. Moreover, the compliance cost can be reduced, as this gives participants the chance to use a common compliance software package [33]. However, blockchain transactions cannot be reversed, and all transactions are transparent. This immutability feature aids in maintaining a record of each financial transaction, improving traceability during the audit process, and streamlining the compliance process for financial institutions. Distributed open-source protocols provide integrity that allows transactions to be executed without a trusted third party [19].

Although there is no centrally trusted agent, the consensus mechanisms used in the blockchain are broad and precise, enabling the validity and integrity of transactions that are required in the financial sector. Chang et al. [6] stated that the "most excellent value of blockchain is a decentralized system, whose security chain is very long." Therefore, the trusted decentralized ledger enhances the security of business processors by checking the history of transactions without an intermediary agent. Additionally, cryptography can mitigate cybersecurity risks.

Blockchain technology has been implemented in multiple fields and applied to multiple functions. Cocco et al. [2] and Trivedi et al. [12] mentioned that blockchain technology can be implemented in the financial sector in different areas such as banking, insurance, risk management, fraud control, e-finances, credit cards, digital payments, and innovations. Blockchain can also be applied to anti-money laundering (AML) and KYC requirements for financial applications [6]. Therefore, banks and financial institutions have already started to participate in this revolutionized journey in various ways. For instance, the central banks of different countries have begun using blockchain technology in their processors.

4.4 Blockchain still immature due to challenges

This section compiles the issues identified in blockchain implementation in the financial sector. Blockchain is a promising technology, but its potential remains unclear. It followed the same resistance and thoughts raised when the Internet, a technology that has revolutionized communication over computers, was introduced. This is because of the huge number of unknown factors, lack of knowledge, and issues that researchers have not yet resolved. For instance, suspected money laundering activities associated with

cryptocurrencies, instabilities, and vulnerabilities of digital currencies are major deterrents [33]. In the IEEE special issue [23], it is stated that although technological and business-related blockchain developments and challenges have been identified, engineering and management challenges of blockchain technology have not yet been addressed. Many Bitcoin scandals have decreased the trust, reliability, and accuracy of blockchains. For example, market downfalls, such as Mr. Gox in Japan in 2014, occurred due to a lack of security, and the security breach incident of Bitfinex in Hong Kong in 2016 has dramatically changed the public perception of blockchain technology [23, 33]. Cyberspace is full of unknown threats, and protecting business and financial big data is necessary. Consequently, new and growing blockchain security attacks are identified as ledger and consensus-based, smart contract-based, peer-to-peer network-based, and wallet-based attacks. Although blockchain intervenes to address these issues, it is still immature to convince the public to embrace them [26].

Blockchain technology has not yet attained the highest level of interoperability in the financial sector owing to energy consumption, privacy ethics, user trust, laws and regulations, compliance rules/protocols, supervision, and network integration. Cocco et al. [2] and other similar studies stated that blockchain consumes more energy and requires high computational power to mine, particularly when the chain is growing rapidly. Cheng's interviewees claimed that energy consumption depended on the consensus mechanism chosen in the mining process. There are still ethical issues related to privacy on the public blockchain that have not yet been resolved because encoded information in the blockchain is shared with all participants in the network by default. This extreme transparency may jeopardize data privacy. Yeoh [33] stated that the lack of rules and regulations for compliance and the absence of strategic governance enforcement are the reasons for losing trust in blockchain technology. Chen and Bellavitis [3] indicated that, although decentralization can work in interoperability among financial institutions, it has not yet received its highest limit of interoperability. Because of the complexity of implementation, high-development cost [26], knowledge and experience niche, blockchain developer niche, lack of regulators, and lack of communication among stakeholders generate a lack of trust in this technology. Therefore, financial institutions are hesitant to invest in this technology for purposeful solution artifact design [38] because of the associated risk in system solution for data governance. Chang et al. [6], Trivedi et al. [12], and Alam et al. [35] pointed out that scalability, latency, security, interoperability standards, standardization cost, data protection laws, regulations, legislation, and consensus are not yet at the required level to rely on this technology. As Feldman [39] summarized in Statista, the biggest barriers to adopting blockchain technology globally are 27% regulatory uncertainty, 25% lack of trust among users, 21% ability to bring networks together, 11% separate blockchain not working together, 6% inability to scale, 6% concerns of intellectual property, and 4% concerns of audit and compliance.

4.5 Future research

The findings show that the blockchain technology is evolving. This paper provides significant insights for both industry and academia to create new research paradigms. The practitioner can explore how the technology can be adopted. We focus on creating a new knowledge about blockchain-oriented solution design which will offer for early researchers with initial understanding how to use blockchain as a component of any smart data solution design. Researchers will achieve a lot of insights about the specific rules and policies in blockchain data solution that are important to be reflected into a solution design. Then, the future research can further analyze how the regulations will affect on the blockchain finance and can be implemented. Another further research may extend block chain and big data research in sub-fields (e.g. higher education [40, 41] and electronic government applications [42]) including healthcare information systems design [43].

5 Conclusion

Based on the findings of this research, we clarify blockchain technology in finance from three major pillars: business, technological, and social perspectives. There is a research gap in blockchain implementation in the finance sector owing to the lack of knowledge about blockchain technology, research on blockchain technology, and research on blockchain technology in the finance sector. Based on stakeholder needs, blockchain technology can be used in the finance sector to analyze, process, and manage big financial data effectively and efficiently. The main concerns in this implementation process are the financial big data, rules, and applications. Scientific research has identified ways to close these gaps in the application environment of finance blockchains from the perspectives of business requirements, technology, applicability, regulation, and supervision for improving the finance sector. Technical factors, such as network delay during the encryption process and authentication, information transmission, storage problems between modules, and block capacity, are also uncertain gaps. Furthermore, security and privacy breaches that occurred in cryptocurrency platforms demotivated society to believe in blockchain technology. It is widely believed that now is the ideal time for academics, researchers, banks, and other financial institutions to further

explore blockchain technology. Additionally, governments should have a strategic plan to deliver blockchain knowledge to industry professionals and create opportunities to explore financial blockchain models.

In conclusion, the future of finance will be dominated by blockchain technology, which society may eventually accept. This can be achieved once the following core areas are addressed. From a business perspective, it must satisfy business, security, and regulatory requirements. From a business technological perspective, the mining hardware requirements must be satisfied. From a business and social perspective, trust must be ingrained in society.

This will push toward transforming the finance sector into a decentralized finance model by reducing transaction costs, increasing transaction scope, avoiding intermediates, increasing transparency of transactions, increasing security, and enabling interoperability and borderless transactions. Although numerous challenges are yet to be addressed, many countries have paid attention to blockchain technology and financial institutions and have been experimenting with blockchain models in finance. The immaturity of blockchain development will be reduced and it will become a new landscape in the financial sector. This is possible if all parties cooperate to meet the commercial, technological, and social requirements related to this technology. As a recommendation, extensive research can be expanded by researching different perspectives in the literature and selecting various parameters, such as blockchain in banking and remittances.

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Declarations

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