

Review

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Review

Blockchain in Finance: A Systematic Literature Review

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Abstract: Many businesses, including finance, want to both understand and utilize blockchain technology. However, there is no detailed systematic literature review (SLR) analyzing blockchain technology in finance in order to understand it. This study emphasizes in detail the possible applications of blockchain in finance, its technical features, benefits and challenges. According to the literature review, blockchain technology has the potential to improve the efficiency of the financial sector, reduce costs and increase transparency and security. Regulatory constraints as well as concerns over scalability and interoperability are barriers that need to be resolved. In order to fully understand the potential of blockchain technology, this SLR explores the current state of research on blockchain in finance. In addition to analyzing the technical features of blockchain, the study also details its current and potential application areas, benefits and challenges. This research analyses the use of blockchain in finance in view of its infrastructure, technology, benefits and challenges for further research and application areas. In the study, 54 articles were evaluated and 34 of them were used for SLR questions. The usage of blockchain in finance is examined from a variety of aspects in this SLR. The study provides answers to nine questions about its application areas, benefits, infrastructure, technology, consensus methods, permission types, and challenges. In some cases, it also gives the correlation relationship between the answers.

Keywords: systematic literature review; blockchain; finance; blockchain Infrastructure

1. Introduction

The financial sector has undergone tremendous transformation as a result of the broad adoption of digital technologies, especially the emergence of blockchain technology. According to Nakamoto, the blockchain is a decentralized digital database that enables safe and transparent transactions. without the use of intermediaries. Blockchain technology has the potential to improve efficiency, save costs, boost transparency and improve security in the financial sector. Blockchain has been the focus of significant study and development over the past few years and its potential financial applications have received a lot of attention. The potential uses of blockchain in finance are numerous and range from reducing fraud in financial transactions to enabling new forms of digital currencies and decentralized financial systems [1].

Although blockchain adoption in the financial sector is still in its early stages, interest in its potential uses is growing. The application of blockchain in the financial services sector is being investigated for a number of goals, such as lowering financial transaction fraud, enabling new types of digital currencies and developing decentralized financial systems. Additionally, blockchain has the ability to enhance a number of financial procedures, such as banking operations, digital identity management and supply chain management. Despite all the excitement surrounding blockchain technology in finance, there are still issues that need to be resolved. For instance, legal concerns,

interoperability and scalability limitations, as well as a lack of standards, are all challenges that must be overcome for blockchain technology to be successfully implemented in the financial sector.

This study conducts a systematic literature review of the existing research on blockchain in finance, with a focus on its potential uses, benefits and challenges. The literature review offers a thorough summary of the state of research on blockchain in finance at present and emphasizes the need for more study to fully fulfill this technology's potential. The report also sheds light on the potential advantages of blockchain for various financial processes and services, such as supply chain management, digital identity management, financial services and infrastructure [2].

The rest of the paper is organized as follows. Section 2 provides a review of the existing literature on blockchain in finance. Section 3 provides the research methodology of the study. Results are presented in section 4. Finally, Section 5 concludes the study and provides recommendations for future research.

2. Related Work

There are some reviews about the blockchain used in the financial ecosystem. For instance, R. Böhme et al. [3] provide a detail review of the blockchain in finance. This study provides an overview of the current state of blockchain technology in the financial industry and discusses potential use cases, challenges and future directions for research. V. Gattesch et al. [4] conducted a study that examines the potential benefits and challenges of using blockchain technology in the insurance industry and discusses possible use cases and future research directions. This study conducted by D. K. Wardhani et al. [5] in order to provides an overview of the potential benefits and challenges of using blockchain technology in capital markets and discusses current and future use cases. Another study on blockchain technology in banking performed by M. U. Chowdhury et al. [6] that provides a value-based analysis of blockchain technology in the banking sector, examining how it could be used to create new value for customers and banks and discussing the challenges that need to be overcome for successful implementation. M. Mainelli et al. [7] examined the potential impact of blockchain technology on the securities transaction lifecycle, including the benefits and challenges that it could bring, as well as discussing its potential to reduce costs and improve efficiency. In this study, M. Javaid et al. [8] provided a comprehensive overview of the current and potential future applications of blockchain technology in the financial services industry, including use cases in payments, securities trading and insurance, as well as discussing the challenges and opportunities that it presents. S. Grima et al. [9] examined the potential effects of blockchain technology on the insurance sector, including the advantages and drawbacks it might present as well as how it might boost productivity, boost transparency and cut costs. Another study conducted by S. E. Chang et al. [10] provided an overview of the use of blockchain technology in trade finance and the opportunities it presents. It also examines the challenges that need to be overcome for successful implementation and the future possibilities of the technology. In research she conducted, M. Morini [11] gives a broad overview of the potential applications of blockchain technology in the capital markets, including both the advantages such as increased effectiveness and lower costs and the obstacles that must be overcome before adoption can take place. Another study examined by I. Amsyar et al. [12] provided a comprehensive review of the existing literature on blockchain and cryptocurrencies, examining the benefits and challenges of the technology, as well as the current state of research and future directions. In another blockchain study on banking P. Garg et al. [13] examined the feasibility of blockchain technology in the banking industry, including the benefits that it could bring, such as improved efficiency and increased security, as well as discussing its potential to improve transparency. A-E. Panait et al. [14] studied the possible effects of blockchain technology on digital identity management, as well as the difficulties it might pose in terms of increased privacy and security.

3. Research Methodology

The related study covers current trends and technologies used in the use of blockchain in finance. In addition, we aim to review the basic features of blockchain for finance studies to be

developed using blockchain. Thus, this study can provide an accelerating support to both academic and project studies in this field in the future. By doing this, we are conducting a preliminary SLR study of the benefits and challenges of using blockchain.

Before conducting the SLR, we developed a review methodology based on studies from [15,16] that were cited by field experts who emphasized that a protocol reduces bias among researchers and promotes repeatability. The review protocol is shown in Figure 1.

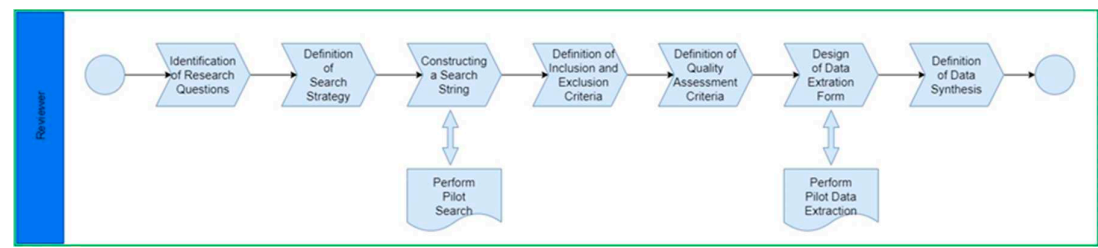


Figure 1. Systematic literature review protocol.

A list of research questions for the SLR is provided in Table 1. The SLR's scope, search techniques and search string are all described in Sections 3.2 to 3.2.3. The inclusion/exclusion criteria for the obtained literature are described in Section 3.2.4. and the quality evaluation criteria for the retrieved literature are included in Section 3.3.

3.1. Research Questions

We created a set of research questions that the SLR needs to answer. These inquiries came about from a developer's perspective. While conducting a blockchain study in finance, infrastructures (1), technology (2), benefits (3), consensus methods (4), permission types (5), future applications (6), most known use cases (7), smart contracts (8) and difficulties (9) were addressed as research questions.

Table 1. Research questions.

No	Research Question (RQ)
RQ1	Which blockchain infrastructures are used in finance?
RQ2	What technologies are used in finance with blockchain?
RQ3	What are the benefits of implementing blockchain in finance?
RQ4	Which consensus methods of blockchain are used in finance?
RQ5	What permission types of blockchain are used in finance?
RQ6	What are the potential future applications of blockchain technology in finance?
RQ7	What are the most common uses of blockchain technology in the financial industry?
RQ8	Which smart contracts programming languages of blockchain are used in finance?
RQ9	What are the challenges of implementing blockchain in finance?

3.2. Search Strategy

The literature search focuses on blockchain studies related to finance while excluding irrelevant studies. It needs a well-thought-out search technique to get high recall and precision levels. The review's search strategy is described in detail in this part, including the search string, search method and search scope.

3.2.1. Search Scope

While conducting the research, the criteria for publication date and publication venue were taken into account. The literature review is conducted in January 2023 and the papers were chosen

between January 2017 and January 2023. The following articles were searched according to the publication venue;

IEEE, Springer Nature, Elsevier, Mdpi, Wiley, Assoc Computing Machinery, British Blockchain Assoc, Emerald Group Publishing, Fac Law - Univ Zagreb, Federal Reserve Bank St Louis, Frontiers Media Sa, Higher Education Press, Incisive Media, Keai Publishing Ltd, Pageant Media Ltd, Springer Int Publ Ag, Slovensko Drustvo Informatika, Univ Illinois, Walter De Gruyter, World Scientific.

3.2.2. Search Method

We performed an automated literature search for this systematic review. Automatic search is the process of searching via electronic databases for specific search terms. For each publication venue, mainly "ISI Web of Knowledge Web of Science" website was used and an automatic search was conducted.

3.2.3. Search string

We used the following search string to find blockchain related articles in finance:

(ALL=(Blockchain) AND (ALL=(Finance) OR ALL=(Fintech)) AND ALL=(infrastructure) AND (ALL=(Smart Contracts) OR ALL=(Permission Types) OR ALL=(Distributed Ledger) OR ALL=(Consensus)))

Table 2 displays the search query results. The automatic search retrieved a total of 52 articles. Those who were unable to answer the SLR questions were removed and 34 articles were selected.

Table 2. An overview of search results at two phases of the SLR process.

Source	Source After Automated Search	Search After Quality Assessment
IEEE	14	6
Springer Nature	6	6
Elsevier	4	4
Mdpi	4	3
Wiley	4	2
Assoc Computing Machinery	2	1
Asoc Economia Aplicadad	1	0
British Blockchain Assoc	1	1
Emerald Group Publishing	1	1
Fac Law - Univ Zagreb	1	1
Federal Reserve Bank St Louis	1	1
Frontiers Media Sa	1	1
Higher Education Press	1	1
Incisive Media	1	1
Iop Publishing Ltd	1	0
Keai Publishing Ltd	1	1
Now Publishers Inc	1	0
Pageant Media Ltd	1	1
Springer Int Publ Ag	1	1
Slovensko Drustvo Informatika	1	1
Taylor & Francis	1	0
Univ Illinois	1	1
Walter De Gruyter	1	1

World Scientific	1	1
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3.2.4. Study selection criteria

The terms “Blockchain” and “Finance” provided many work output. We identified relevant studies using the study selection criteria given in Table 3. In this table, IC refers to the inclusion criteria.

Table 3. Study inclusion criteria.

No.	Criteria
IC1	The study is not published in a language other than English
IC2	The study is published after 2010
IC3	The study must be related to finance using blockchain
IC4	The study must have full text (e.g., abstract-only papers are not considered)

3.3. Study Quality Assessment

The quality of the selected literature was evaluated in addition to the inclusion criteria. To evaluate whether any variables would skew the study's findings, quality standards were developed. Table 4 lists the standards for quality. We used the summary quality checklist for quantitative and qualitative studies as recommended by [16] and [17] for creating the criteria for evaluating the level of quality. More than a hundred articles were checked against the inclusion criteria and quality checklist, resulting in 34 articles to be reviewed in the SLR.

Table 4. Quality checklist.

No.	Question
Q1	Are the aims of the study clearly declared?
Q2	Are the scope and context of the study clearly defined?
Q3	Is the proposed solution clearly explained and validated by an empirical study?
Q4	Are the variables used in the study likely to be valid and reliable?
Q5	Is the research process documented adequately?
Q6	Are at least three questions answered?
Q7	Are the challenge findings presented?
Q8	Are the main findings stated clearly in terms of credibility, validity, and reliability?

3.4. Data Extraction

We extracted baseline data from the thirty-four studies using a standardized procedure called a data extraction form. First, the research questions in Table 1 were used to develop an extraction form with key elements. The data extraction form was revised and improved after numerous pilot extractions were carried out and additional articles were read. Table 5 displays the completed data extraction form. This form comprises generic metadata, such as publication year and title, as well as the 10 data extraction items that address the research question. The table lists the ten components of the research questions as R1–R9.

Table 5. The data extraction form.

No.	Extraction Item
1	Author
2	Title

3	Inclusion criteria Status
4	Publisher
5	Article Source
6	Type
7	Language
8	Country
9	ISSN
10	Publication Year
11	DOI
12	Index
13	Category
14	Infrastructure
15	Technology
16	Benefits
17	Consensus methods
18	Permission types
19	Future applications
20	Most known use cases
21	Smart contracts
22	Difficulties

3.5. Data Synthesis

On the form of extracted data, we conducted data analysis. For important terms, many articles utilize synonyms. So, we started by standardizing these words. We produced several bar charts, pie charts and heat maps using Excel. These graphs reveal information about data patterns.

5. Result

The main statistics of the 34 selected studies are initially explained in the findings section. The outcomes for each study topic are then presented.

5.1. Main Statistics

Table 6 lists the 34 studies generated after criteria selection and quality queries. These 34 studies answer at least three research questions.

Table 6. The 34 studies used in this systematic literature review.

ID	Title	Year	Reference
1	Blockchain distributed ledger technology: An introduction and focus on smart contracts	2020	[18]
2	Finance infrastructure through blockchain-based tokenization	2020	[19]
3	Decentralized Finance: On Blockchain- and Smart Contract-Based Financial Markets	2021	[20]
4	Dizar: An Architecture of Distributed Public Key Infrastructure Based on Permissioned Blockchain	2020	[21]

5	Distributed ledger technology in payments, clearing and settlement	2017	[22]
6	DeFi-ning DeFi: Challenges & Pathway	2021	[23]
7	On the Blockchain-based General-Purpose Public Key Infrastructure	2019	[24]
8	Proof of Concept of Blockchain Integration in P2P Lending for Developing Countries	2020	[25]
9	The distributed liability of distributed ledgers: Legal risks of blockchain	2018	[26]
10	Scaling up sustainable investment through blockchain-based project bonds	2022	[27]
11	Blockchain Platforms in Energy Markets-A Critical Assessment	2022	[28]
12	Evaluation of Post-Quantum Distributed Ledger Cryptography	2019	[29]
13	An Architecture for Blockchain-Based Cloud Banking	2021	[30]
14	A blockchain and IoT-based lightweight framework for enabling information transparency in supply chain finance	2022	[31]
15	Blockchain-Based Implementation of Smart Contract and Risk Management for Interest Rate Swap	2020	[32]
16	Survey on Blockchain and Deep Learning	2020	[33]
17	An Efficient Supply Chain Architecture Based on Blockchain for High-value Commodities	2019	[34]
18	Blockchain: A Tale of Two Applications	2018	[35]
19	Blockchain technology design in accounting: Game changer to tackle fraud or technological fairy tale?	2021	[36]
20	Possibilities for Applying Blockchain Technology - a Survey	2021	[37]
21	Blockchain Applications for Industry 4.0 and Industrial IoT: A Review	2019	[38]
22	Application of analytical-network-process (ANP) for evaluation of key-performance-indicators (KPI) for application of blockchain technology in infrastructure projects	2022	[39]
23	Unchaining Collective Intelligence for Science, Research, and Technology Development by Blockchain-Boosted Community Participation	2021	[40]
24	Blockchains and the crypto city	2017	[41]
25	Know-Your-Customer (KYC) Requirements for Initial Coin Offerings Toward Designing a Compliant-by-Design KYC-System Based on Blockchain Technology	2021	[42]
26	An Overview of Regulatory Strategies on Crypto-Asset Regulation-Challenges for Financial Regulators in the Western Balkans	2020	[43]
27	Cryptocurrencies in finance: Review and applications	2019	[44]
28	A Blockchain-Based P2P Transaction Method and Sensitive Data Encoding for E-Commerce Transactions	2020	[45]
29	Eu search for regulatory answers to crypto assets and their place in the financial markets' infrastructure	2021	[46]
30	Cryptocurrency and Blockchains: Retail to Institutional	2019	[47]
31	Open-Source Operational Risk: Should Public Blockchains Serve as Financial Market Infrastructures?	2018	[48]

32	How should we understand the digital economy in Asia? Critical assessment and research agenda	2020	[49]
33	A Mixed Review of Cash Flow Modeling Potential of Potential of Blockchain for Modular Construction	2022	[50]
34	Technology-enabled financing of sustainable infrastructure: A case for blockchains and decentralized oracle networks	2023	[51]

Figure 2 shows the distribution of studies according to the research database in a bar diagram. There are 6 of them Springer Nature, 5 of them IEEE, 4 of them Elsevier, 3 of them Mdpi, 2 of them Wiley and other publishers. Of the studies included in SLR, 21 are articles, 9 are proceeding papers, 4 are review articles and 1 is a book chapter. The study by Angela Walch [48] is published as both an article and a book chapter.

Figure 3 shows the categories of papers included in the SLR. Many studies appear in journals related to computer science and its sub-branches. In addition, there are also journals whose categories are business, finance and economy. Apart from these, there are also a few journals that approach finance indirectly, such as law, construction building technology and urban planning.

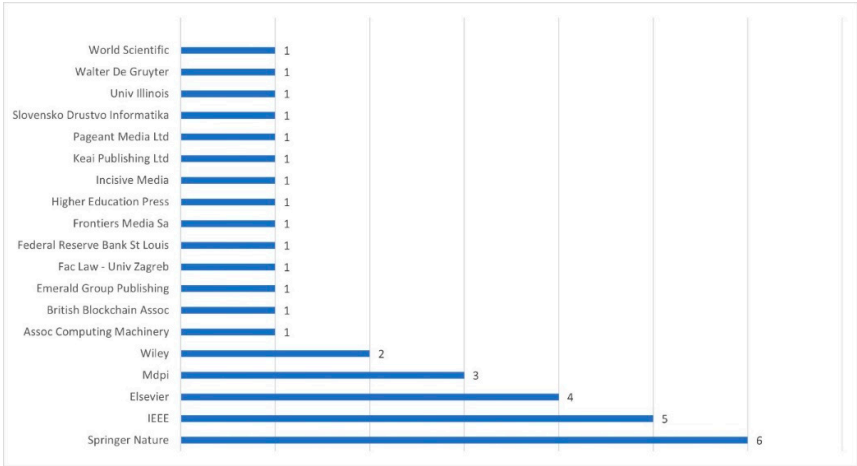


Figure 2. Bar diagram of the distribution of publishers.

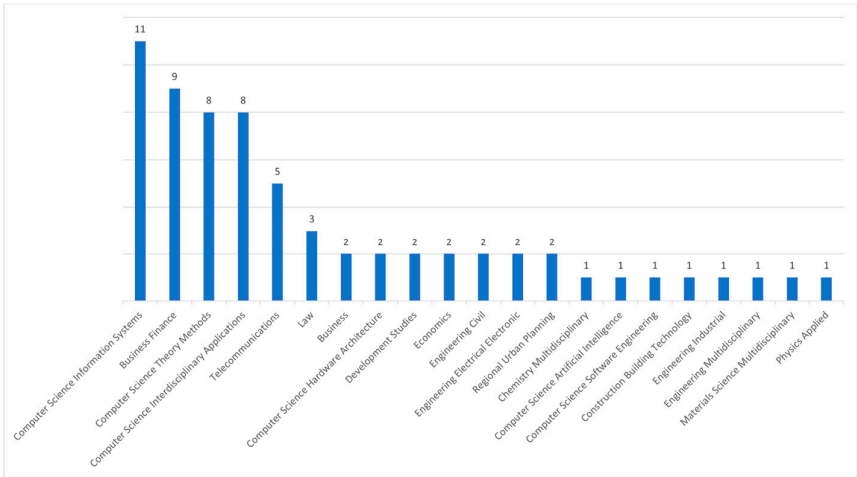


Figure 3. Bar diagram of the distribution of categories.

Figure 4 shows the index types of the papers. The study mainly includes journals of the Emerging Sources Citation Index, Conference Proceedings Citation Index – Science, Social Sciences

Citation Index and Science Citation Index Expanded types. There are also a few conference and book index journals.

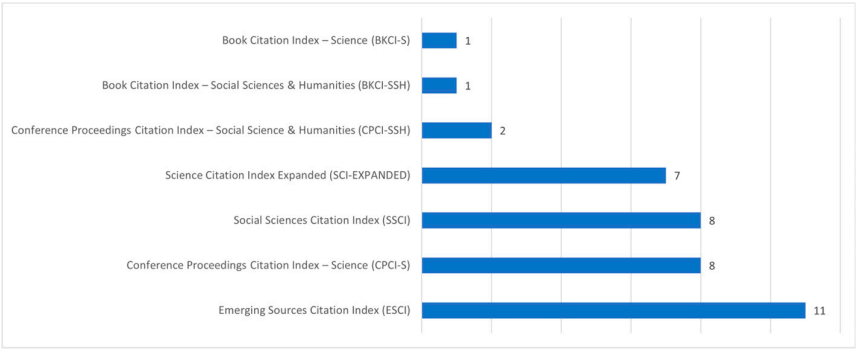


Figure 4. Bar diagram of the distribution of index types.

The countries of the authors are included in the bar chart in Figure 5. The United States and China are at the top of the list, followed by Germany, Australia, England, Italy and Switzerland. Other studies are shown as belonging to two or one country. Apart from these, one record does not contain data in the field being analyzed.

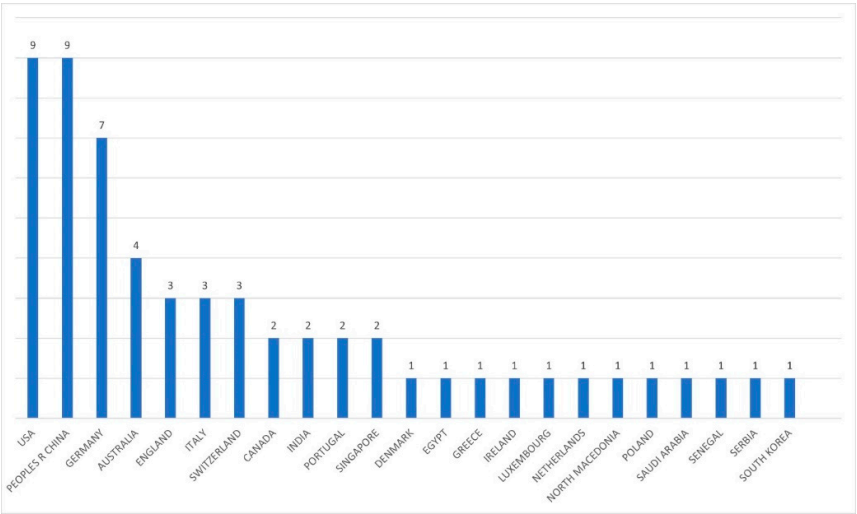


Figure 5. Bar diagram of the distribution of countries.

5.2. RQ1: Which blockchain infrastructures are used in finance?

Blockchain technology became known with bitcoin. However, bitcoin did not offer a programmable infrastructure. In 2013, Vitalik Buterin, the inventor of Ethereum [52], introduced the idea of a programmable blockchain. Ethereum is both a programmable infrastructure and a coin. Since then, different programmable blockchain infrastructures have emerged. Hyperledger Fabric [53], Corda [54] and Ripple [55] are the most well-known. Hyperledger Fabric is a permissioned blockchain infrastructure created by the Linux Foundation and can be used for different business areas. Corda and Ripple are blockchain infrastructures specialized for use in finance. Corda is a permissioned infrastructure created by R3 Company and is not associated with a crypto coin. Ripple is both a coin and a permissioned blockchain infrastructure developed by the XRPL Foundation. In addition to these blockchain infrastructures, there are many others such as Nem, Stellar, Eos, Tron and Neo.

Figure 6 shows the count of blockchain infrastructures used in the field of finance. In the SLR study, it is seen that Ethereum infrastructure is mostly used in finance. Ethereum is followed by

Hyperledger Fabric and Corda. Corda is created for the sole purpose of developing blockchain applications in finance. These blockchain infrastructures are followed by Ripple, Eos, Hyperledger Sawtooth and Stellar. One of each of the other blockchain infrastructures is seen in the study.

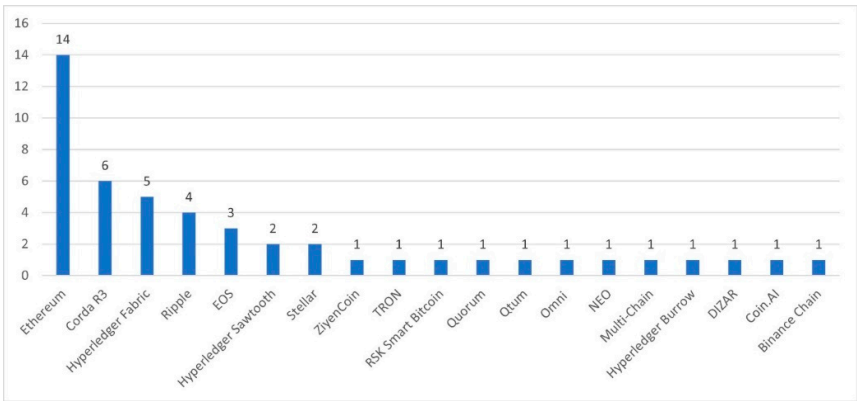


Figure 6. Blockchain infrastructures used in finance.

While existing blockchain infrastructures are generally used, specialized blockchain infrastructures such as Dizar [21] are also used. Among the infrastructures for the use of blockchain in finance, Ethereum is seen in 14 studies [20,23,26,28,34,35,38,40–42,45,47–49], Corda R3 in 6 [18,26,30,32,37,48], Hyperledger Fabric in 5 [18,24,29,36,37,48], Ripple in 4 [26,30,44,47], Eos in 3 [20,23,42], Hyperledger Sawtooth in 2 [24,29], Stellar in 2 [20,30] and different blockchain infrastructures in others.

5.3. RQ2: What technologies are used in finance with blockchain?

The uses of technology cover a wide range of fields. Technology is used in many different industries, including business, the health sector, finance, education, transportation, the entertainment industry and communication. In these fields, technology can boost output, present innovative goods and services and simplify people's lives.

Blockchain can often be used with different technologies. In the SLR study, Blockchain is also called as distributed ledger technology due to its distributed structure. That's why, blockchain is often mentioned together with distributed ledger technology. As seen in Figure 7, the "Distributed Ledger" is expressed 20 times [22–31,33,37,40,41,43,44,46–48,51], the "Financial" 3 times [44,46,47], the "Building information modeling" 2 times [39,50], the "Government" 2 times [41,43], the "Internet" 2 times [29,45] and other technologies is seen one time each.

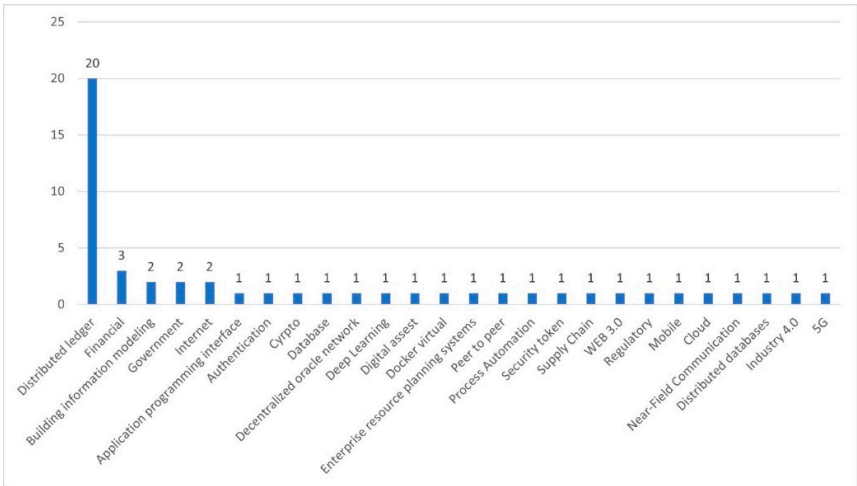


Figure 7. Technologies used with blockchain in finance.

Figure 8 shows the relationship between blockchain infrastructures and the technologies used with blockchain. Due to the distributed structure of the blockchain, distributed ledger technology is included in all infrastructures. In addition to distributed ledger technology, "Financial", "Government" and "Internet" technology are also used with Ethereum infrastructure. While Corda is only used with "Distributed ledger" technology, the use of Ripple with financial technologies is remarkable.

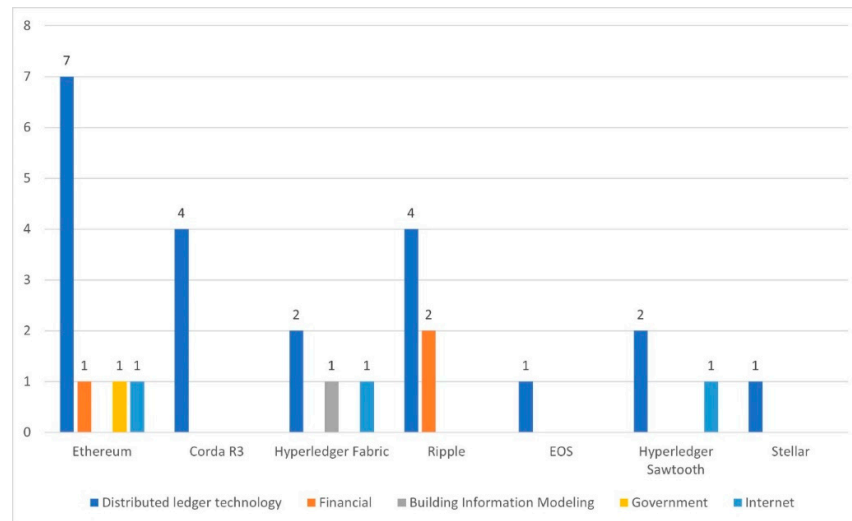


Figure 8. The relationship between blockchain infrastructures and the technology used with blockchain.

5.4. RQ3: What are the benefits of implementing blockchain in finance?

Blockchain is a system that enables real-time, immutable digital asset transactions without the need for a reliable third party. The financial sector benefits from blockchain in numerous ways, including increased transparency and confidence, decreased costs and simplified operations.

The SLR study contains different expressions for the benefits of blockchain in finance. We grouped these expressions and reduced them to 19. For example, we singularized expressions such as "improving network resiliency", "durability" and "improved fault-tolerance" as "Resilience". We performed this process for all expressions.

As seen in Figure 9, the "Transparency" expression is included in 11 papers [22–25,27,37,46–49,51], the "Low cost" expression in 11 papers [26,28,30,32,42,45–47,49–51], the "Security" expression in 8 papers [24,25,32,34,36,38,47,49], the "Without intermediaries" in 8 papers [18,20,22,23,26,40,42,48], the "Immutability" in 5 papers [18,24,37,40,48], the "Resilience" in 4 papers [22,24,41,48], the "Decentralization" in 4 papers [23,24,37,40], the "Efficiency" in 3 papers [26,46,51], the "Permissionless" in 3 papers [23,37,41], the "Prevent fraud" in 3 papers [24,30,36], the "Autonomy" in 2 papers [23,37], the "Integrity" in 2 papers [24,40], the "Interconnected" in 2 papers [23,31], the "Reducing regulatory pressure" in 2 papers [20,43], the "Reducing risk" in 2 papers [22,32], the "Reliable funding source" in 2 papers [19,39] and the others once in the papers.

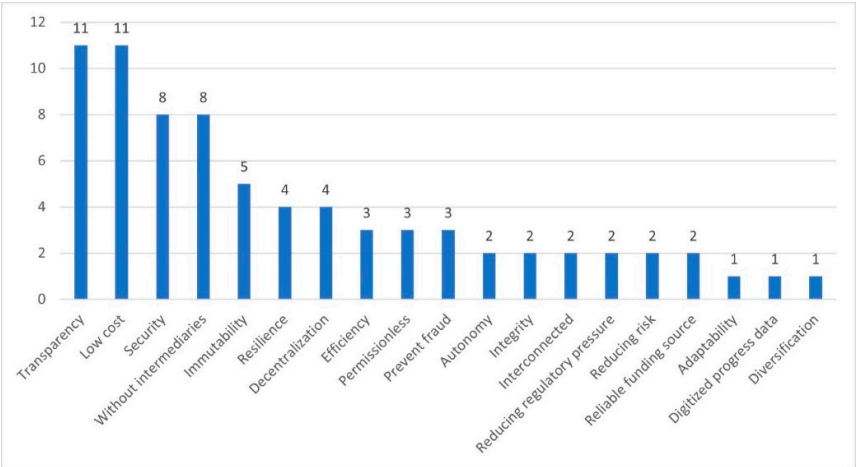


Figure 9. Benefits of implementing blockchain in finance.

5.5. RQ4: Which consensus methods of blockchain are used in finance?

The process by which a network of distributed nodes or participants agree on the validity of transactions and the state of the blockchain ledger is referred to as consensus in the context of blockchain technology. Consensus is essential for guaranteeing that all participants have a consistent and unchangeable record of transactions. There would be no trust in the blockchain network if there is no consensus.

Blockchain infrastructures have their own consensus methods. For example, Ethereum uses the Proof of Work consensus method, while Hyperledger Fabric uses the Byzantine Fault Tolerance consensus method.

As seen in Figure 10, the “Proof of Work” expression is included in 7 papers [18,21,26,36,40,45,47], the “Practical Byzantine Fault Tolerance” in 3 papers. [25,31,37], the “Proof of Stake” in 3 papers [28,43,47], the “Proof of Authority” in 2 papers [34,38] and the other consensus methods once in the papers.

Consensus methods are directly related to the blockchain infrastructure. For example, while ethereum used Proof of Work before 2022, it switched to Proof of Stake consensus method for energy efficiency, security and validation reasons. As mentioned above, blockchain infrastructures can change consensus methods. As seen in Figure 11, the "Proof of work" consensus method is valid in all blockchain infrastructures in the field of finance. The "Practical Byzantine Fault Tolerance" method is available in Hyper ledger Fabric and Corda R3, the "Proof of Stake" method is available in Ethereum and Ripple, the "Proof of Authority" method is only available in the paper related to Ethereum.

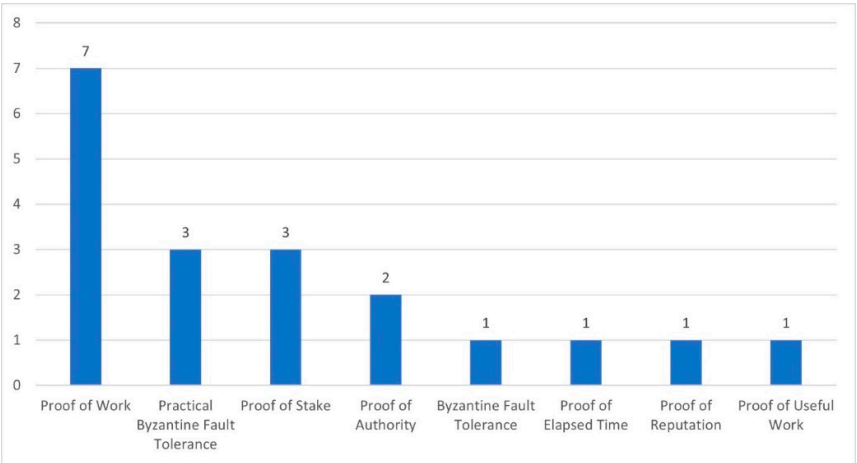


Figure 10. Consensus methods of blockchain in finance.

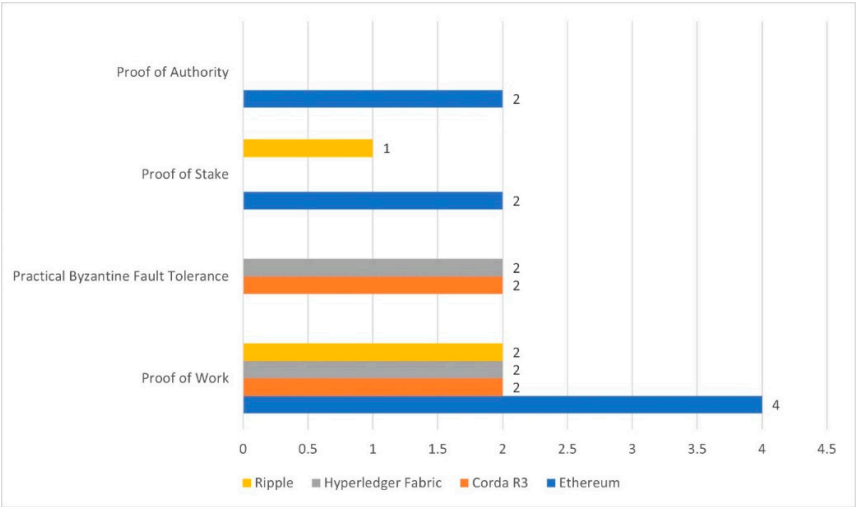


Figure 11. The relationship between blockchain infrastructures and consensus methods.

5.6. RQ5: What permission types of blockchain are used in finance?

There are four types of blockchain that are widely accepted. These networks are public blockchain networks, private blockchain networks, hybrid blockchain networks and consortium blockchain networks [56]. They can be permissioned or permissionless depending on their type and blockchain infrastructures support different types of permission. For example, Ethereum supports the permissionless, while Corda and Hyperledger Fabric provide the Permissioned type. Some blockchain infrastructures have both permissioned and permissionless types. Permission type is an important issue when developing blockchain-based applications in finance and permissioned type is generally preferred.

As seen in Figure 12, among the permission types for the use of blockchain in finance, the “Permissioned” is seen in 18 studies [18–22,24–26,28,31,32,36,38,40,41,45,47,48], and the “Permissionless” in 13 studies [20,23,24,26,30,34,36,40,42,45–48] in the papers. Some blockchain infrastructures provide either permissioned or permissionless functions, while others provide both. As seen in Figure 13, both permission types are at an equal in the papers where Ethereum infrastructure is included. In the SLR study, the number of permissioned is higher in Hyperledger Fabric and Corda R3, while the number of permissionless is higher in Ripple, EOS and Stellar. In Hyperledger Sawtooth, both are equal.

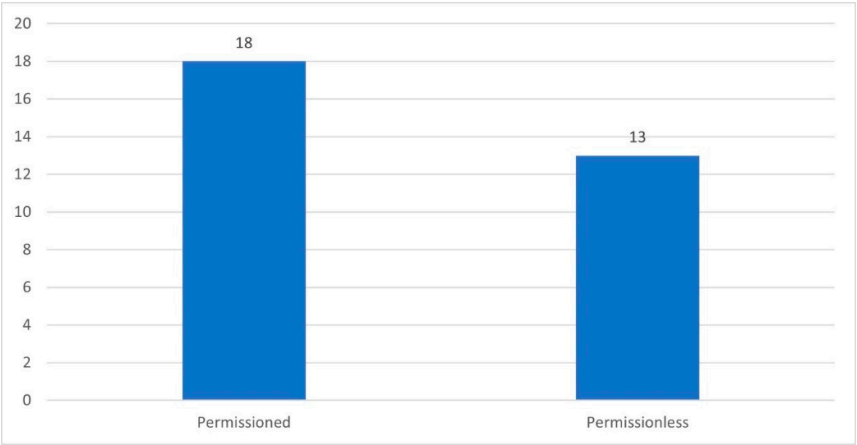


Figure 12. Permission types of blockchain in finance.

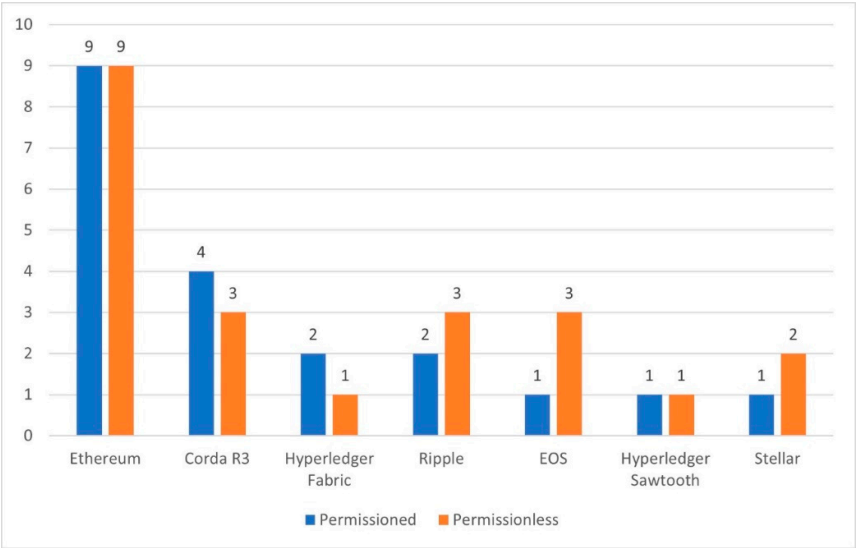


Figure 13. The relationship between blockchain infrastructures and permission types.

5.7. RQ6: What are the potential future applications of blockchain technology in finance?

Blockchain became a key subject after Bitcoin entered our lives. However, Bitcoin did not provide a programmable blockchain solution. Ethereum, founded in 2013 by Vitalik Buterin, provided both a crypto asset and a programmable blockchain technology. Since then, some apps utilizing blockchain technology have been developed. Although some blockchain-based applications have been made in the field of finance [56], they have not become widespread at the desired level.

Although we currently see a small number of blockchain applications, it has great potential for the future thanks to its transparency, security and without intermediaries.

Potential future applications of blockchain technology in finance is seen Figure 14. Among these, the “Loans” is mentioned 3 times [20,34,50], the “Smart cities” 3 times [19,41,51], the “Anti money laundering” 2 times [26,43], the “Crowdfunding” 2 times [20,40], the “Know your customer” 2 times [23,26], the “Stablecoin” 2 times [20,44], the “Token-based economy” 2 times [46,49] and the other future applications once in the papers.

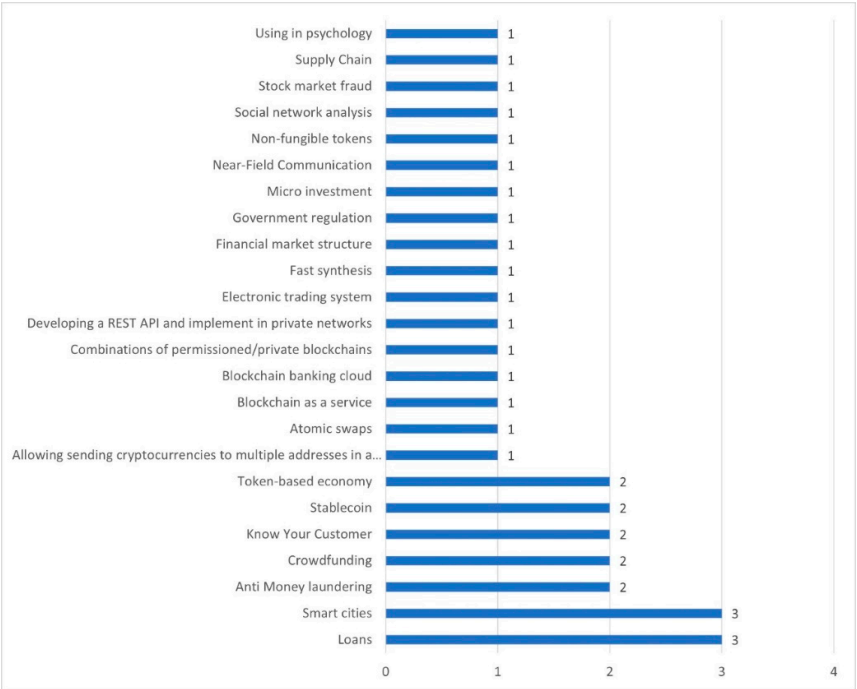


Figure 14. Potential future applications of blockchain in finance.

5.8. RQ7: What are the most common uses of blockchain technology in the financial industry?

Nearly a hundred answers are obtained for this question. These answers are then reduced to 13 different groups. For example, expressions such as "Digital currencies", "Digital asset exchange", "Tokenization process", "Digital rights to ownership" are grouped as "Digital currencies and assets". Similarly, expressions such as "Authentication", "Digital signature algorithm", "Identity verification", "Verification", "Identification", "Digital identity" are grouped as "Identity verification and security". This grouping process took place for eight groups.

As seen in Figure 15, expressions belonging to the group "Payment" in 16 papers [18,22,23,26–30,34,37,41,43,46,47,50,51], the "Financial services and infrastructure" are mentioned in 14 papers [23,27,28,30,35,37,44–51], the "Lending and loan services" in 9 papers [18,20,23,25–27,30,38,45], the "Digital currencies and assets" in 8 papers [18,19,27,30,37,40,42,46], the "Compliance and risk management" in 6 papers [31–33,40,42,43], the "Financial reporting and auditing" in 5 papers [24,29,30,34,37], the "Identity verification and security" in 4 papers [18,30,36,37], the "Clearing and settlement" in 3 papers [22,26,30] and other non-group expressions once in the papers.

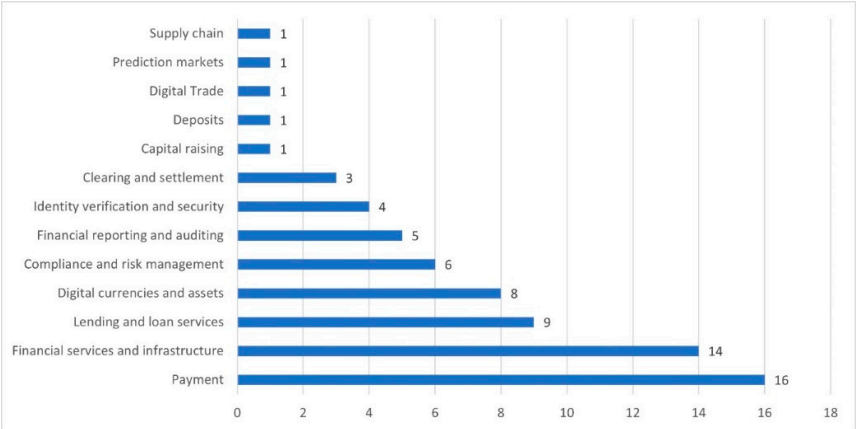


Figure 15. Most common uses of blockchain in finance.

5.9. RQ8: Which smart contracts programming languages of blockchain are used in finance?

Although the idea of smart contracts is not new, Ethereum is the first to apply them in the field of blockchain technology. Solidity, a programming language, is used to create smart contracts on Ethereum. A variety of smart contract software languages are available on other blockchain infrastructures that came into existence after Ethereum. Kotlin in Corda, Go, Node.js, Java in Hyperledger Fabric, JavaScript, Java, Go in Stellar, and JavaScript, Java, Python in Ripple are a few examples of programming languages that can be used to build smart contracts.

As seen in Figure 16, among the smart contracts programming languages of blockchain in finance, the “Solidity” appears in 5 papers [18,19,34,35,45] and the other programming languages (C++, Go, Java, JavaScript, Kotlin, Python, Rust) once in the papers.

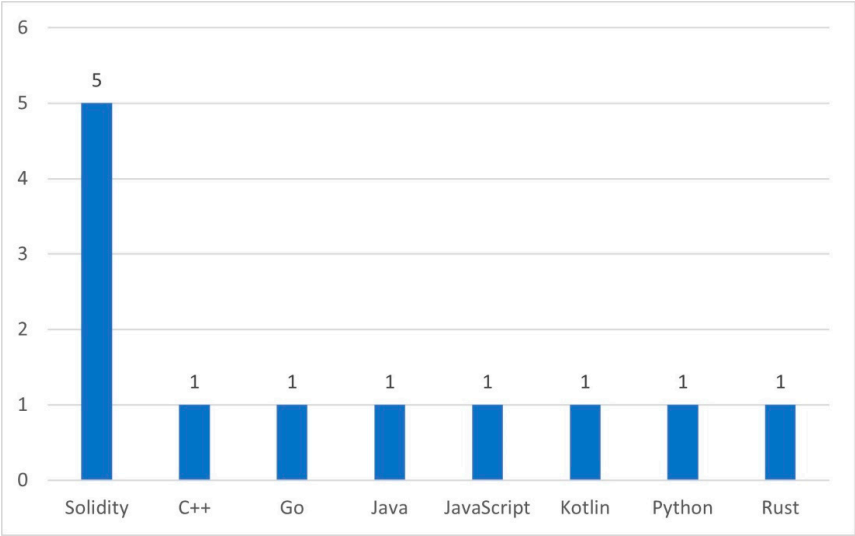


Figure 16. Smart contracts programming languages of blockchain in finance.

5.10. RQ9: What are the challenges of implementing blockchain in finance?

The implementation of blockchain in finance has some challenges. Especially on the side of regulated institutions such as banks and insurance companies, difficulties are more common. In this SLR study, 45 different challenge expressions are identified in the papers. Then, these difficulty expressions are categorized into 5 groups. For example, expressions such as "Computing power", "Energy consumption", "Scalability of block data", "Run smart contracts" are grouped as "Technical Challenges". Similarly, expressions such as "Legal", "Open source", "Regulatory", "Settlement", "Oracles" are grouped as "Regulatory and Compliance".

As seen in Figure 17, expressions belonging to the group “Regulatory and Compliance” in 12 papers [22,23,28,30,31,37–39,41,46,48,49], the “Operational Challenges” in 11 papers [19–22,28,36,37,39,47,50,51], the “Technical Challenges” in 10 papers [18,20,23,25,29,36,38,40,47,48],the “Financial Risks” in 7 papers [22,23,26,27,32,40,43] and the “Security and Privacy” in 5 papers [19,23,25,26,38] are included.

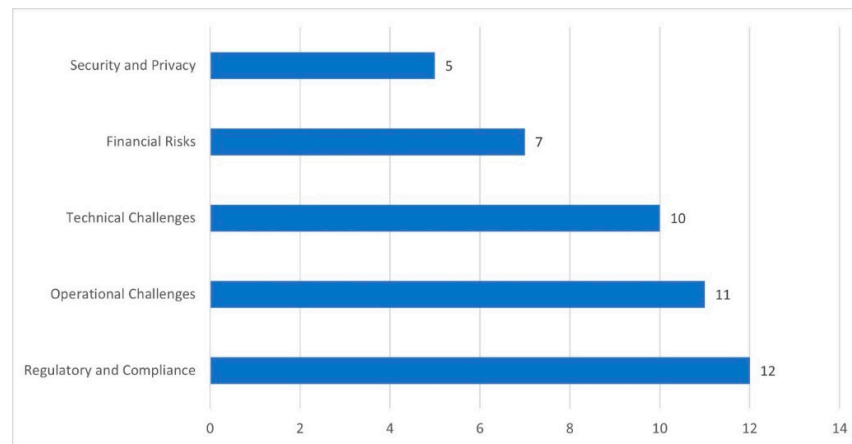


Figure 17. Challenges of implementing blockchain in finance.

5. Citations

The most comprehensive systematic literature review on blockchain technology in the field of finance is presented in this paper. Nine questions were evaluated as research questions, covering both the technology of blockchain and its benefits and challenges. Technical questions were not adequately answered at the necessary level. However, the responses to the questions about benefits and challenges were quite good. The answers to the research questions varied widely as technical aspects such as blockchain infrastructure, consensus method, permission type, smart contract programming language, etc., varied. However, the answers to the questions on benefits, challenges, use cases, and potential future applications were similar. Blockchain cannot be used at the desired level in the financial sector due to issues like regulation and compliance. This is why the majority of studies are still theoretical. If the regulatory issues are resolved, systematic literature review studies can be conducted more effectively in the future with the use of blockchain technology.

While blockchain technology is generally closely related to the field of finance, there are not enough articles and real-life applications available. Therefore, based on the search results, 52 articles were identified. After conducting a quality assessment and applying selection criteria, this number was reduced to 34 articles. Due to the fact that Ethereum is older than other infrastructures, the number of statistics of Ethereum stands out. Although some studies on infrastructures such as Hyper Ledger, Corda R3, Ripple and Stellar are available, other blockchain infrastructures are not available in academic publications.

6. Conclusion and Future Work

This study is a systematic literature review (SLR) on the use of Blockchain technology in finance. In the study, 52 articles were evaluated and 34 articles were included in the study after quality and evaluation checks. We asked 9 research questions to these articles and tried to find answers. The questions were generally in three categories. The first type of questions tried to find technical answers. For example, which Blockchain infrastructure is used, which technology is used with blockchain technology, which permission and consensus method is applied. The second category of questions tried to find the benefits and challenges. The most satisfactory answers came from these research questions. Almost all articles included expressions showing the benefits and challenges of blockchain. Questions in the third category were related to current and future application areas. We tried to find answers to the use cases of blockchain in finance and potential use cases in the future. The answers to these questions were also satisfactory. Thanks to the study, it is predicted that it is applied in different areas and potentially its use will become widespread in the future.

The study's findings will clear the way for individuals who choose to pursue this field of study. There has never been an SLR study that examined blockchain's use in finance. In-depth information

about the sectoral sectors that can apply blockchain technology is provided in this study, along with its infrastructures, benefits and challenges. This initiative is for those who plan to work on this topic.

Future SLR studies can be carried out for several industries. In addition to finance, a similar study might also be conducted in other fields, such as insurance, supply chains, government relations, and health. Additionally, with the growth of blockchain in the financial sector, a more in-depth study can be conducted in the near future.

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