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Blockchain for Project and Construction Management; A Systematic and Scoping Literature Review

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Abstract

At this time in history that the world is becoming smaller every day due to globalization; it is important to achieve an acceptable degree of trust and confidence in any field; and blockchain can put the world on this path. Since there is no central authority governing blockchain, its decentralized nature can turn it into an appropriate platform for project management. Implementing blockchain eliminates project management bureaucracies and allows a single, unchangeable, controllable, and encrypted source to be accessible to everybody and extensible throughout the project life cycle. This approach is the key to achieve an integrated information system and is one of the important reasons for blockchain applicability as an ideal platform for project management and construction. This issue that using blockchain technology in project management will bring about capacities and capabilities has not yet been seriously addressed. Changing the management of construction projects by blockchain is just an idea for now. This study aims to identify the capacity and platforms for developing blockchain technology in project management and construction using systematic and scoping literature reviews. Moreover, it provides some suggestions about the development and improvement areas of this technology. The review results showed that in all areas of project management and construction, there are applications relevant to blockchain technology that confirm the gradual understanding of the significance and positive impact of this technology on enhancing project management and construction performance. According to the results, a major part of blockchain studies was focused on “program and project management”, and two fields of human resources and behavioural areas and research in project management and schools of thought with a share of less than 2% of existing studies were neglected.

Keywords: Blockchain; Project management; Smart contract; Distributed Ledger Technology (DLT); Digital transformation, construction.

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Introduction

The construction industry is highly resistant to changes and faces many challenges, including low productivity, poor regulations, insufficient cooperation, and inadequate information sharing and payment methods (Aghimien, Aigbavbo, & Matabane, 2019; Demirkesen & Tezel, 2021; Newman et al., 2020; Reddy & Kone, 2019). While over the years, most industries have achieved reasonable productivity through the implementation of new technologies and other factors; since the 1960s, the construction industry productivity has decreased to half and comparing to the production sector that has had doubled productivity over the same period, it has had even less productivity (Barbosa et al., 2017). Therefore, the construction industry is ready for a revolution. According to the National Association of Professional Engineers, considering the construction productivity, a lack of continuous interaction between construction managers and project stakeholders has made the flow of project information difficult and chaotic. Their contracts are often awkward and full of conflicts and cliches. Therefore, each party has as much legal support as possible for its coverage (Engineers, 2014). Usually, contractual relationships require companies to prioritize their performance over project performance, resulting in an inefficient system. Some approaches and technologies such as Building Information Modeling (Heiskanen, 2017; Succar & Kassem, 2015) and project management software such as Procore and Plangrid have been developed to facilitate collaboration between stakeholders; however, due to the perceptual risks and obstacles, adoption and development of technology- and supporting processes and standards- their growth is slow (Ghaffarianhoseini et al., 2017; Kinnaird & Geipel, 2018), and there is no plan to integrate information for sharing between the parties. Blockchain allows single, unchangeable, controllable, and encrypted sources to be shared and developed throughout the project life cycle. This is the key to achieve an integrated information system (Soleimaniamiri, Mahmudkhani, & Ahmadi, 2019). Signs of Progress in Distributed Ledger Technology (DLT), including blockchain, are increasingly considered as a component of the digital transformation of the construction industry and its response to these challenges.

Blockchain is defined as a distributed database that keeps digital asset records secure and transparent (Mackey & Nayyar, 2017; Treiblmaier, 2018). Blockchain has many benefits for various industries. For example, in New York, some companies are trying to sell solar energy to their neighbours using blockchain to prevent the interference of third parties. In Vienna, the energy of the country's largest commercial complex is developing a blockchain program widely used in the energy trade. This program is supposed to secure the exchange process by increasing transparency of the performance. The German Electricity Authority (Innogy) is developing a blockchain platform for the billing of electric vehicles (Basden & Cottrell, 2017). Cryptocurrencies, supply chains, scientific data storage centres, public health, and smart cities are other areas of using this emerging technology (Bamakan, Faregh, & ZareRavasan, 2021; Rezaei & Taeizadeh, 2019; P. K. Sharma, Moon, & Park, 2017; Tucker & Catalini, 2018). However, in the studies conducted by Li et al. (2019), one of the most important obstacles to the progress of the construction industry is its inability to adopt technological advances compared to other industries, including the ones mentioned above (Barima, 2017; Mason, 2017).

Therefore, in contrast to the common belief, registration of foreign exchange transactions is just one of the blockchain applications. Cryptography employers have long been working on new ways to implement an unchangeable general ledger considered a special and main parameter in project management. If the project team records project-related activities in the blockchain, everybody will access it, and project managers can easily monitor their progress. It means that the blockchain implementation will eliminate any bureaucracy in project management. As everyone is connected through blockchain, no one can exaggerate for others in terms of existing performance. Therefore, blockchain is responsible for the accountability of project team members. Moreover, other processes such as reports, payment, and releasing money, sharing information, completing the job, and more can be registered using blockchain. This is one of the important reasons why blockchain can be used as an ideal platform for project management. Any evolving technological advancement with the ability to affect a project and its sustainability also have some impact on the project management performance and practices in the organization (Marco Iansiti & Lakhani., 2017).

These innovations move the construction industry and construction project management towards creating a digital age with more productivity and providing real-time data and project reports for key macro projects and infrastructure development factors. However, it can be claimed that the construction industry is not digitally mature enough to be affected by these positive changes (Agarwal, Chandrasekaran, & Sridhar, 2016). The development of technology in recent decades has raised many needs for customers, designers, contractors, and generally, the way of managing a project in the 21st century. Anyhow, digitalization is inevitably on the way, whether this industry is ready for it or not. Those who can effectively use new technologies in their business model will undoubtedly have an advantage over their

competitors and provide more advanced services to their customers. Some studies are conducting to determine which areas (industries, operational processes, etc.) are the most prominent candidates for using blockchain technology and taking advantage of its capabilities, such as creating added value, transparency, and effectiveness. Blockchain research is growing rapidly in all aspects. Project practitioners have realized the requirements for developing technologies; however, there is a need to search and study the examples of using blockchain in integration with project management and construction to increase efficiency. Identifying the features and capacities of blockchain technology for project management and construction has not been studied seriously, and changing project management through blockchain is now only hypothetical and experimental (Lacity, 2018). This study aims to identify the capacity and platforms of blockchain technology development in project management and construction. Accordingly, at first, 95 selected articles relevant to applying blockchain in various fields of project management and construction published in reputable databases and journals were analyzed statistically and quantitatively using scoping review. This job aimed to prevent the entrance of misleading claims and incorrect information into the research field as much as possible and to clarify the generalities of the relevant studies. The generalizations of blockchain-related studies integrated with project management and construction were identified using scoping review. Then, using systematic review and model analysis, the potential and actual features and capacities of blockchain technology for application in project management and construction were evaluated. Some suggestions on developing and improving this technology in this field were provided.

Research Background

Blockchain and Distributed Ledger Technology (DLT)

The in any industry and business, trust is one of the most valuable intangible assets at different levels in the organization and between the management and employees. However, it is also an integral part of any transaction between the organization and its partners or customers. Usually, this trust has been made possible by third parties and intermediaries who ensure that the contract parties have the authority, transparency, and legal right to trade with each other. Nevertheless, this approach is very difficult in a rapidly growing economy with increasing complexities and volume of interactions. The trust and transparency activated by third parties have added to this complexity. Information is often hidden, and achieving it is usually time-consuming and costly (Penzes, 2018). In addition, after the recent financial crisis in 2008, it became clear that this system is very vulnerable. Since then, the trust and confidence guaranteed by third parties have been shifted to alternative solutions. The central technical innovation made possible in the blockchain is Distributed Ledger Technology (DLT), defined as the authentic application of a decentralized digital trust test with an encrypted digital signature (Ward, Oswald, & Galante, 2016). Blockchain as a type of

Distributed Ledger Technology allows the creation of a database, eliminates the need for reliable intermediates such as banks and other institutions, and facilitates transactions. By eliminating intermediaries in institutions that previously needed to build trust, the blockchain has the potential for a "world without intermediaries" (Nassiry, 2019).

Blockchain is an open-source technology and does not belong to anybody (Bamakan et al., 2021; Santoro, Vrontis, Thrassou, & Dezi, 2018). There is no central authority governing the blockchain mechanism and approve the transactions that operate in a self-regulating manner (Aafaf Ouaddah, Anas Abou Elkalam, & Ouahman, 2017; Bocek & Stiller, 2017). In this technology, it is impossible to rewrite and change materials, and permanent historical documents and records are continuously created. Each transaction generates a 64-character hash code (a cryptography technique). This code is combined with the previous hash code and creates a new block. Information is stored in nodes, and functions are computed in a shared form. There is no data leakage in this structure because no node has access to the complete data, and each has a vague part of it. Blocks generate a string of disposable characters. In this situation, it is almost impossible to manipulate, change, and create erroneous and unrecognizable information (H. Wang, Zheng, Xie, Dai, & Chen, 2018). One of the most important achievements of blockchain applications is ensuring the accuracy of information and non-distortion of data, which at the macro level, guarantees the availability of reliable knowledge.

Smart contracts under blockchain, in addition to their key role in automating payments, have widespread consequences for IT of construction rules and dispute resolution and contract performance. This section focuses on two main impacts: (1) increased independence and less need for trust in stakeholder collaboration; and (2) creating an independent plan and a common project information view. Smart contracts introduce hardware rules into the system, and their self-executive feature guarantees stakeholder coherence (Sadeghi & Naser, 2018). This issue reduces dependence and reliance on trust. This calculation makes zero trust possible. The resulting independence, using secure protocols, in turn, reduces the need for manual data verification (Gad, J. S. Shane, K. C. Strong, & Choi., 2016).

Blockchain in Project Management and Construction

Given the initial and relatively wide applications of blockchain in financial and organizational issues, a large part of the older studies in this field was focused on the financial and organizational sectors of project management and construction. The study conducted by Paquette (2006) indicated that facilitating blockchain implementation among individuals and internal groups of the organization is very important. However, this study emphasized that as long as this knowledge is not owned by the individuals inside the organization and comes from outside the organization, it will be a little more difficult to adopt it. This study concluded that focusing on creating social structures, business processes, and technology as a solution to

facilitate the flow of customer knowledge, can have a significant impact on improving the performance of the organization, and by involving customers in creating a two-way flow of knowledge, a new source of knowledge is applied. Ha et al. (2011) studied the four key aspects of the blockchain (including customer orientation, organization, blockchain, and blockchain technology) to develop a reliable measurement scale for blockchain. The components considered for customer orientation are customer-oriented marketing, identifying the value of the key customer lifetime, customization and interactive marketing. Organizational structure, the commitment of organizational resources, and human resources management were considered key components of the organization. Learning, creating, and disseminating knowledge by blockchain and knowledge accountability were introduced as blockchain components. Finally, these three researchers examined the results obtained from blockchain implementation regarding two financial and marketing aspects.

The study conducted by Chua et al. (2013) examined the impact of social media and communication management on blockchain in their case study at Starbucks. In this study, data retrieved from various sources such as newspapers, newsletters, magazines, scientific journals, books, and social media services have been analyzed textually. Three main conclusions are obtained from this article. First, Starbucks develops a wide range of social media tools for blockchain that acts as effective advertising and marketing tools. Second, Starbucks redefines the role of its customers through using social media by changing them from inactive recipients into active innovation participants. Third, Starbucks uses efficient strategies to encourage customers to share their knowledge, increasing interaction on social media voluntarily. Gohary et al. (2016) presented an integrated model of factors affecting the success of blockchain by considering the mediating role of organizational factors. They concluded that the organizational factors have the greatest impact on the success of blockchain. These two researchers finally reviewed the successful implementation of blockchain in terms of two financial and marketing aspects. Panni et al. (2017) conducted a study to examine blockchain in the communication industry in Bangladesh. This research shows that project management with the Six Sigma approach of the customer is recognized as an innovative concept in communities. Accordingly, this study attempts to identify the level of focus of blockchain activities in the communications sector in a developing country such as Bangladesh through the data analysis method. The results obtained from data analysis indicated that marketing capabilities, as an aspect of blockchain among companies active in the communication industry of Bangladesh, have a significant impact on customer value creation and market performance.

The study conducted by Antony et al. (2018) examined blockchain with the Six Sigma approach at the level of Italian universities. This study showed that understanding the significance of knowledge as a vital source for organizations increases in today's business environments. In this regard, knowledge management has been proposed as a strategic tool

that increases the power and effectiveness of organizations through knowledge sharing and usage. Many organizations have used knowledge management as a tool for achieving success, and of course, universities are no exception. This study examines the impact of blockchain on the organizational environment of universities. The effect of ten factors of blockchain was discussed, including perceived organizational rewards, received behavioural control, mutual perceived benefits, perceived increased reputation, perceived loss of knowledge power, the perceived pleasure of helping others, organizational learning climate, taking advantage of competencies, the possibility of developing competencies, and using tools and technology. Then, the effective role of 9 blockchain factors on the organizational climate of the university was confirmed; and the effectiveness of the perceived loss of knowledge power factor was not confirmed. In another study on the management of organization, company and firm, one of the significant issues was the relationship between digital artifacts and organizational design (for example, roles, teams, and processes) (Holotiuk & Moormann, 2018; Walsh, O'Reilly, Gleasure, McAvoy, & O'Leary, 2020). Holotiuk et al. (2018) emphasized that the competition between the need for standardization and automation in long-term organizational plans and the need for adaptation with changes due to technical innovation is a major challenge for companies, and tried to identify the blockchain technology adoption fields in organizations.

Considering the review nature of this research, the details of the background process and the relevant literature are addressed quantitatively and qualitatively, and the steps of scoping and systematic review are explained.

Methodology

The present review research is performed by combining two methods of scoping review (objective-based (Maria J. Grant & Booth., 2009) and systematic literature review (SLR) (method-based review))Petticrew, 2001). In the initial evaluation, using a scoping review, the scope and extent of existing blockchain technology studies in the field of project management and construction was estimated. Since the purpose of this review is to identify the nature and volume of examined evidence, it is, in fact, a comprehensive and immediate review of what has been done. Therefore, considering its comprehensiveness, there is no concern for the quality of research in this group of articles. In addition, the scoping review involves many features of systematic review; therefore, this method can be considered a subset of systematic methods (Peters et al., 2015). Contrary to systematic review research, scoping review research does not seek to evaluate the quality of texts, synthesize them, add findings to each other, and increase the power or generalizability of findings. However, this type of research can provide an appropriate context for systematic review. For this reason, and to evaluate the quality of texts, after a scoping review and in the second evaluation using SLR method and CASP evaluation, the existing articles were ranked qualitatively and using Nvivo encryption, and model analysis, the known and overlooked collections of the potentials of using this

technology in project management and construction were specified, and some suggestions on developing and improving this technology in this field were provided. In both reviews, the selection criteria for articles are done according to the degree of coherence of the article content with the title and objectives of the research. In this study, the 5-step method of O' Malley (2005) was used for scoping review, and the 7-step method of Kitchenham was used for systematic review (2009). Steps 1 to 3 are common in both reviews, and the output of step 3 of the scoping review, i.e. search and selection of the relevant studies, is used for SLR. Figure 1 shows the research steps. Following that, the details of these steps are explained with reference to the desired steps.

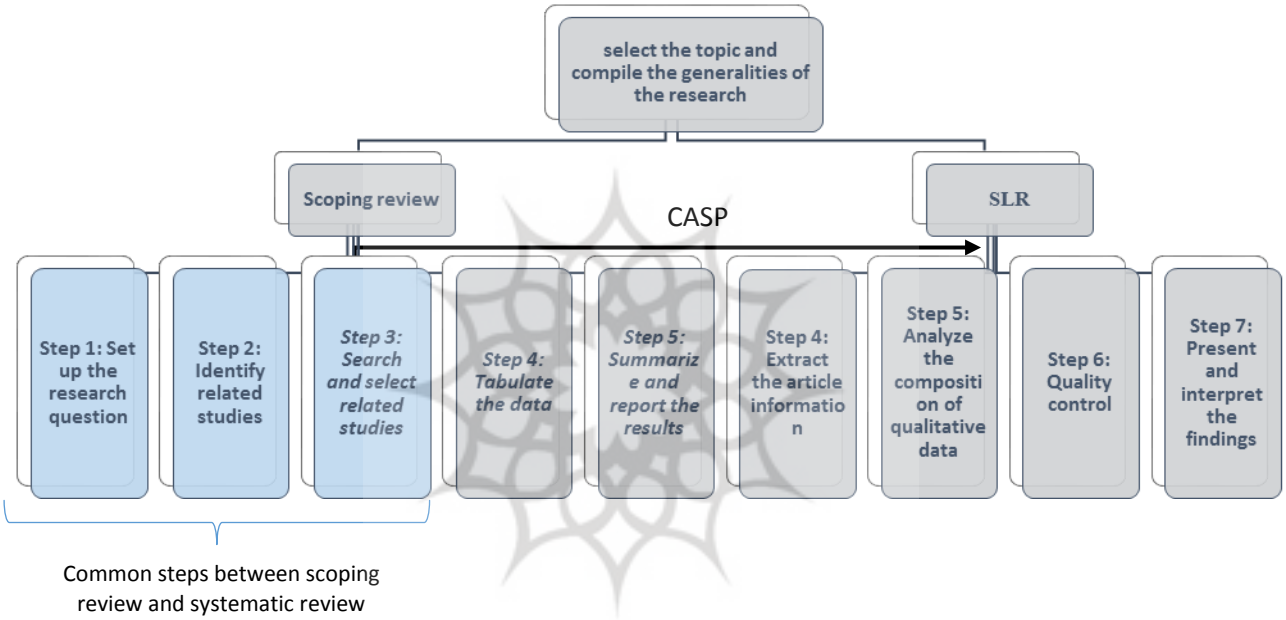


Figure 1. Steps of research

Scoping Literature Review

In the first step, the main research question tries to identify the capacity and platforms of developing blockchain technology in project management. In the second step of the review, five English databases were searched in this study without time limitations. In this study, the main database for review was Scopus, which was searched by applying a time limit from 2008 onwards when the blockchain concept was introduced for the first time. The Scopus institution is a reputable global citation database that stores bibliographical information on almost 22000 scientific fields. This database indexes nearly 77 million records from 5000 reputable journals. Compared to PubMed, Web of Science (WOS), and Google Scholar, this database indexes a significant number of journals)Falagas, Pitsouni, Malietzis, & Pappas, 2008; ZareRavasan & Krčál, 2021). In addition, Scopus provides 20% more coverage than WOS)Vieira et al., 2009). However, to ensure comprehensive coverage of materials, the same search process was performed in 4 other databases: ASCE, Springer, Science Direct, and

Google Scholar. In the third step of the review, the studies with the defined inclusion and exclusion criteria were selected, presented in Table 1.

Table 1. Inclusion and exclusion criteria of studies

EXCLUSION CRITERIA	INCLUSION CRITERIA
Language of articles: Non-English Type of study: book / Thesis / report / gray articles / critique Unrelated articles in the field of project management and construction	Language of articles: English publication time: Due to the invention of blockchain technology since 2008, this year became the basis of search. Research Method: No Limits Type of studies: Articles published in prestigious scientific journals or conferences Field of study: project management and construction

After searching with the keywords "blockchain" and "project management" and "blockchain or smart or contract or distributed or ledger or technology," because of the large number of studies and in order to remove irrelevant studies to the field of research, the titles, and abstracts of articles were searched. As a result, 430 articles were found, 7 of which were repeated in some databases, 22 studies were not an article (they were books/dissertation/reports/gray articles/critique), and 306 articles were irrelevant to the field of project management and construction and were deleted; so, 95 articles were remained to study. The processes of searching and screening, and removing studies, and applying inclusion and exclusion criteria are presented in Table 2.

Table 2. The name of databases and screening steps in the current study

Database name	Initial search	After the first screening (title)	After the second screening Abstract and) field of study)	After the final screening
ASCE	10	6	6	**5**
Springer	21	11	11	**3**
Science Direct	98	16	16	**14**
Google Scholar	256	71	52	**52**
Scopus	48	36	27	**21**
Total	430	140	112	**95**

In the fourth step, the key information obtained from the searches was presented in a categorized form (Arksey & O'Malley, 2005). Then, Citavi 6 software was used for note-taking. A sample summarizing the selected sources is presented in Table 3. This classification includes title, author (s), year of publication, journal, and site of publication, research method, article theme. Then, Citavi 6 software was used for note-taking.

Table 3. A sample of summarizing the selected studied sources

Author, editor or organization	Title	Periodical	Data base	Year	Research method	Theme
Ahmadisheykhsarmast, Salar; Sonmez, Rifat	A smart contract system for security of payment of construction contracts	Automation in Construction	science Direct	2020	Case study	Program and Project management

In the fifth step, the results of 95 selected articles were summarized and reported. Then, the research method was analyzed according to the distribution of the studied topic, the year of publication, and the frequency of the relevant articles published from 2008 onwards.

✓ Database

According to Figure 2, it is observed that about 55% of blockchain studies in the field of project management and construction indexed with 52 articles are selected from Google Scholar database. Since indexing articles in Google Scholar does not have the limitations of other chosen databases for this research, millions of different articles and publications are added every year; such an output is reasonable.

✓ Year of publication of the article

According to Figure 3, since 2010, the trend of blockchain studies in project management and construction has been growing. This growth indicates that more researchers have focused on this issue and identify the hidden capabilities of using blockchain as an ideal platform for project management and construction.

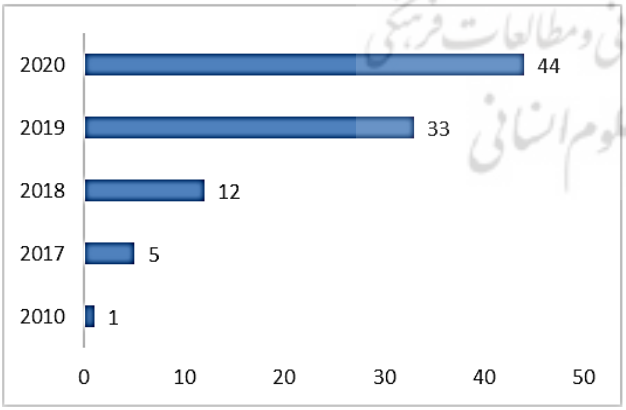


Figure 3. Frequency of articles based on the year of publication

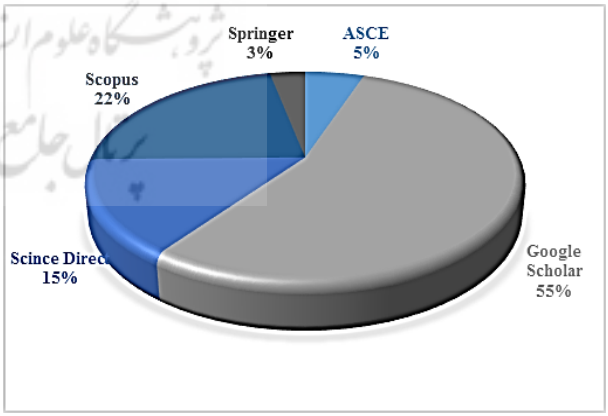


Figure 2. Frequency of articles in the selected databases

✓ Type of publication

According to Figures 4 and 5, the analysis of the status of articles based on their type of publication indicated that 62% of the selected articles were journals, and 38% were conference papers. More than half of them were indexed in Google Scholar. Of course, the share of journal articles in this database was higher than in other databases. However, about 30% of the journal articles and 33% of conference papers were of review type, which shows that blockchain studies in the field of project management and construction are still at their initial stages.

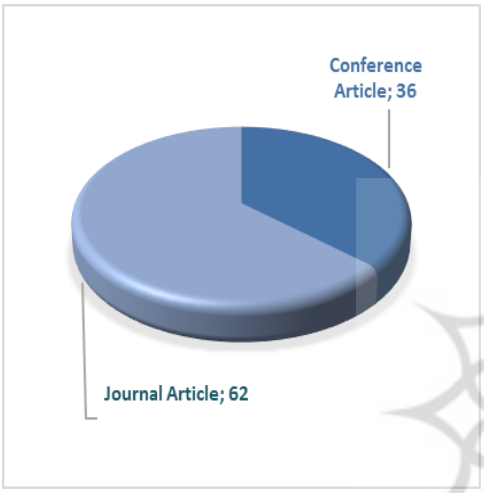


Figure5.Type of publication of the selected articles

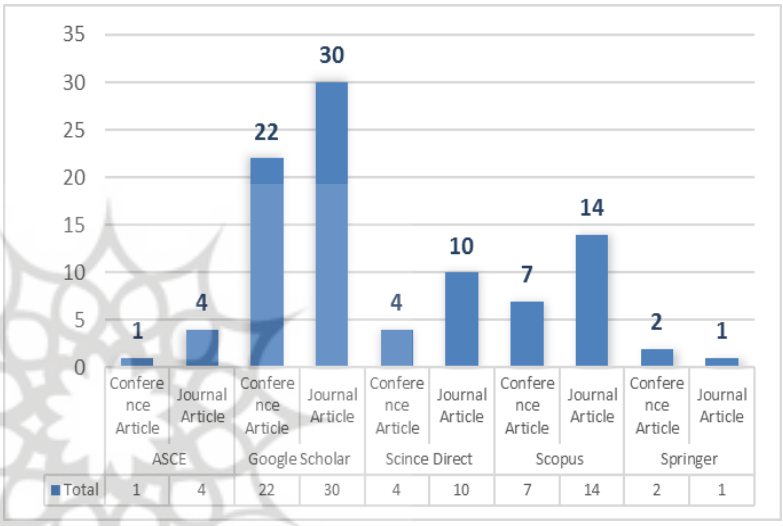


Figure 4. Frequency of articles based on the type of publication in the selected databases

✓ Research method

According to Figure 6, the analysis of the status of articles to evaluate the research methods of blockchain studies in project management and construction indicated that in 27% of the published articles, the research method was not clearly defined. Interestingly, some of the research methods, such as systematic and non-systematic review with the frequency of 32%, had the highest share in these studies. As mentioned above, this issue shows that blockchain studies in project management and construction are still at their initial stages. However, a lack of quantitative articles is evident in these methods. Quantitative studies aim to develop and apply mathematical models, theories, and hypotheses relevant to natural phenomena. The measurement process to make a fundamental relationship between experimental observations and the mathematical expression of quantitative relations is the focal point of quantitative studies. While quantitative methods use random sampling with a large number of observations, the novelty of the studies on this technology in the field of project management and construction is a reason for the limited use of quantitative methods.

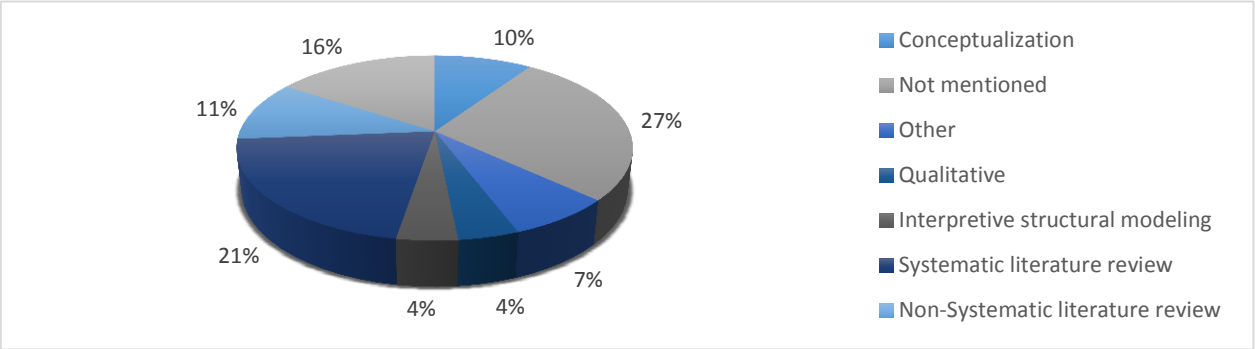


Figure 6. Research method of the selected articles

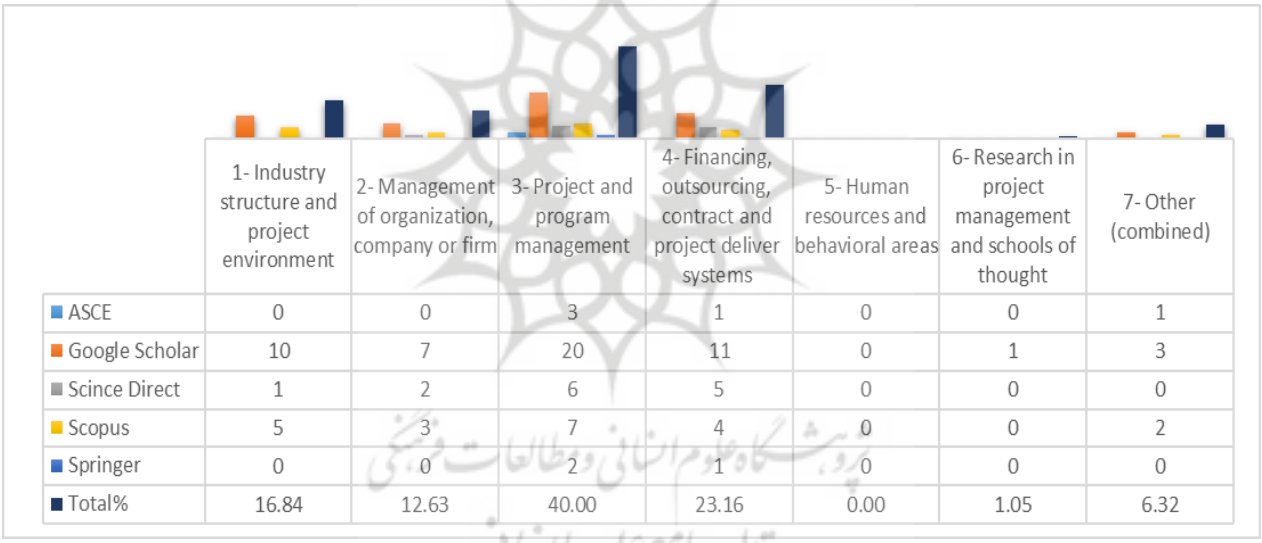
✓ Field of study

The areas of study in this field were classified to determine the field of study of the review articles published in project management. Carden (2008) and Pietroforte (2005) classified the topics of reputable articles into six main groups, and one group was a combination of these topics. Each group includes defined subsets specific to their field of study. A part of this classification is presented in Figure 7.

1.Industry structure and project environment	codes, standards, and information systems
	internal construction methods and issues
	structure and performance of domestic industry, economic issues and their effect
	external construction methods and issues
	research adn development trends
	role and collaboration in the industry
	industrial relations, union and non-union onstruction
	professional development and training
	…
2. Management of organization, company or firm	organizational project management office
	organizational structure
	project portfolio management
	organizational governance
	organizational maturity models of project management
	management of firm operations
	management of information systems, IT applications
	….
3. Project and plan management	project integration management
	agile management
	stakeholders management
	sustainability management
	management of change andintegration in the project
	virtual construction and design
	management of desin, value engineering, pre-design, and design estimations
	project MIS and IT applications
	…
4. Financing, outsourcing, contract, and project conduction systems	bidding activities and strategies, and tendering practices
	project financing issues
	analysis and selection of systems and project delivery contracts
	public-private partnership
	outsourcing
	…
5. Human resources and behavioral areas	team building and team work
	problem-solving skills
	recruitment and allocation of personnel
	personnel evaluation
	factors affecting humanbehavior and performance
	leadership and negotiation
	behavior management
	…
6. Research in project management and schools of tought	positivist, interpretative, pragmatic, post-modernism, etc.
	the first and second order in project management
	research strategies and methods in project management
	artificial intelligence
	decision-making techniques
	…

Figure 7. Fields of study of project management (Source: (Carden & Egan, 2008; Pietroforte & Aboulezz, 2005))

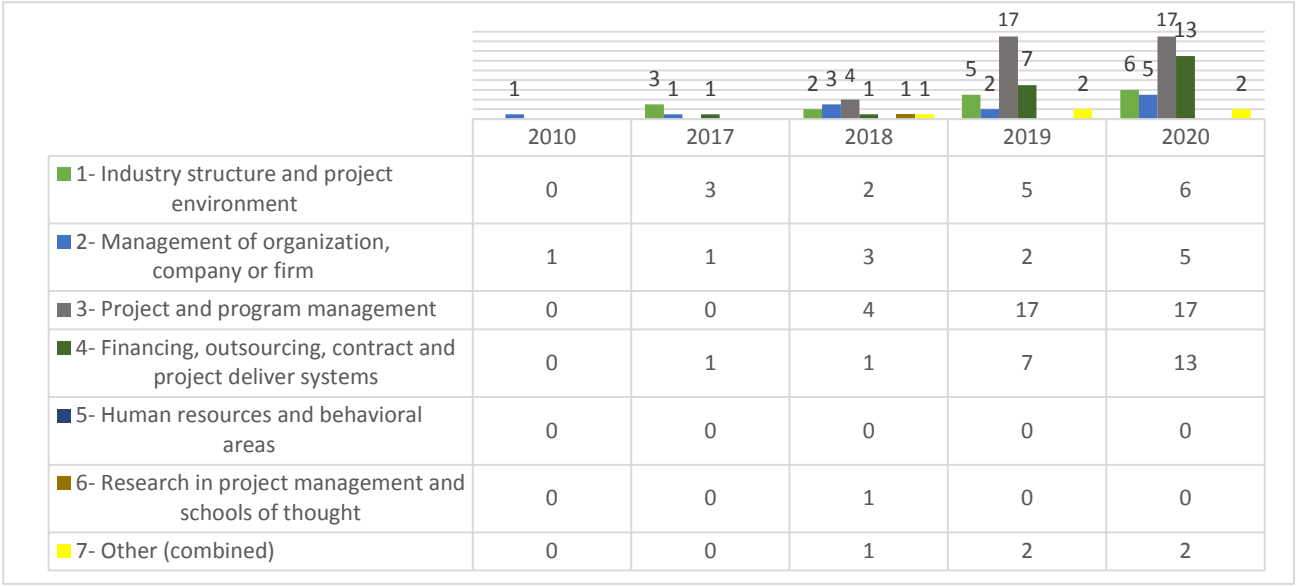
These topics reflect six main items, including 1- the structure of industry and project environment, 2- management of organization/ company or firm, 3- Program and project management, 4- financing, outsourcing, contractual, and project implementation systems, 5- human resources and behavioral areas, and finally, 6- research in project management and schools of thought. Some articles are shared in two or three groups of this classification in terms of topic, classified as "combined topics." These selected articles have been done in more than one field of study. These studies were classified in combination, and according to Figure 8, a total of six articles out of 95 articles, equivalent to 7.37% of the total articles, have addressed multiple topics. A significant part of blockchain studies was focused on "Program and project management" with 36 articles more than 37.89 % of the evaluated studies. Out of the articles in this field, 22 articles, more than 64.7%, were about "virtual construction and design". Studies on "financing, outsourcing, contractual, and project implementation systems" covered 23.16% of the studies. At a glance, the topics such as "human resources and behavioral areas" and "research in project management and schools of thought", as well as combined topics, need to be studied more.



	1- Industry structure and project environment	2- Management of organization, company or firm	3- Project and program management	4- Financing, outsourcing, contract and project deliver systems	5- Human resources and behavioral areas	6- Research in project management and schools of thought	7- Other (combined)
ASCE	0	0	3	1	0	0	1
Google Scholar	10	7	20	11	0	1	3
Scince Direct	1	2	6	5	0	0	0
Scopus	5	3	7	4	0	0	2
Springer	0	0	2	1	0	0	0
Total%	16.84	12.63	40.00	23.16	0.00	1.05	6.32

Figure 8. Frequency of topics in the selected databases

It should be noted that in evaluating the trend of topic application in the last decade, according to Figure 9, it was found that the studies related to three groups of 1- the structure of the industry and project environment, 2- management of organization/ company, or firm, and 4- financing, outsourcing, contractual, and project implementation systems, have also had an increasing trend. This issue indicates that over time, studies in this field are more focused on industry concerns and are directed towards applied approaches.



	2010	2017	2018	2019	2020
1- Industry structure and project environment	0	3	2	5	6
2- Management of organization, company or firm	1	1	3	2	5
3- Project and program management	0	0	4	17	17
4- Financing, outsourcing, contract and project deliver systems	0	1	1	7	13
5- Human resources and behavioral areas	0	0	0	0	0
6- Research in project management and schools of thought	0	0	1	0	0
7- Other (combined)	0	0	1	2	2

Figure 9. The trend of topic application in the last decade

Then, in the review and the second evaluation using SLR and in vivo encryption and model analysis, the known and neglected collections on the potentials of using this technology in the project management were analyzed. The seven-step method of Kitchenham was used for meta-synthesis review. Steps 1 to 3 are common in both reviews, and the output of the third step of the scoping review explained earlier, i.e., search and selection of the relevant studies, is used for SLR. In the following, the fourth step of SLR is described.

Systematic Literature Review (SLR)

The quality of the remaining articles was evaluated by CASP in the second review. To accelerate and facilitate the evaluation of articles, this method provides a model consisting of ten indicators, similar to a checklist, that helps the researcher to evaluate the accuracy, validity, and significance of the studies. According to the ten indicators for evaluating the articles, a score was considered for each article. The available articles were ranked in terms of quality, and finally, the remaining articles entered the fourth step of implementing this method to extract the necessary information. These ten indicators are 1- research objectives, 2- method logic, 3- research plan, 4- sampling method, 5- data collection, 6- reflexivity, 7- behavioral considerations, 8- accuracy of data analysis, 9- a clear expression of findings, and 10- research value.

This tool is one of the methods for measuring the validity and reliability of qualitative research. It is mainly used for measuring the validity and reliability of the meta-synthesis method. This tool provides a model consisting of ten indicators, similar to a checklist, that helps the researcher evaluate the accuracy, validity, and significance of studies. Using this tool, the researcher assigns a score between 1 to 5 (very good to very poor) to each of these

ten indicators that show the article's qualitative rank. Then, they classify the articles based on a 50-point scale of CASP. Since this method's "inclusion" and "exclusion" criteria depend on the type of study and the opinion of the researcher or research group, this scoring is valid. It may be different for each researcher, depending on applying their knowledge and idea, enhanced during the project process. For example, the researcher can enter the numbers for scores in the checklist as very good (5), good (4), average (3), poor (2), and very poor (1). These numbers are scored according to the application and position of the desired article in that research. In another research, or based on the opinion of another researcher, the same article may receive a different score. Generally, the quality of articles is evaluated according to the 50-point scale as very good (41-50), good (31-40), average (21-30), poor (11-20), and very poor (10). The researcher can manipulate this type of classification, and the zero and one point of view should be avoided. Table 4 shows a sample of a qualitative evaluation of the articles searched in the final screening.

Table 4. A sample of qualitative evaluation of the searched articles

Row	Title	Research value	Clear expression of findings	Accuracy of analysis	Ethical considerations	Reflexivity[1]	Collecting data	Sampling method	Research plan	Method logic	aims of research	Total
۱	Blockchain as a project management platform	5	5	4	5	5	4	4	5	5	5	**47**

Finally, the content of the remaining 95 articles was studied and, the articles that couldn't get the minimum quality score according to the checklist were deleted (47 articles deleted and 48 remained).

Step four: Extract article information

Throughout the SLR process, the researcher continuously reviews the selected and finalized articles to obtain intra-content and separate findings in which the initial and original studies have been conducted. The basis for extracting components from the selected texts is based on the answers to this question: What are the appropriate capacities and platforms for developing blockchain technology in project management and construction? In this step, it is better to design and develop a form to extract data, in which it is already determined what data should be extracted from the whole of data in the articles. This form is presented in Table 5, and its content has been specified based on the research objective and to complete the fifth step (qualitative data analysis).

[1] It involves the relationship between the researcher and the participants

Step five: Qualitative data analysis

One of the approaches provided by Miles and Huberman (1994) was used for encryption. The methods presented by the mentioned researchers are:

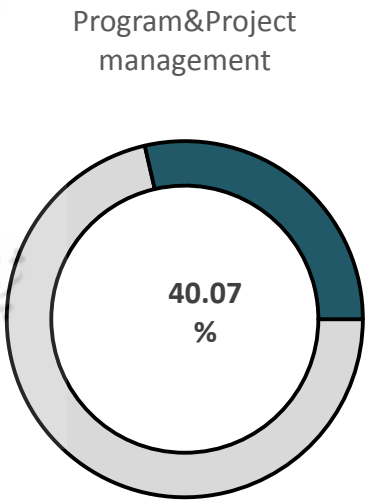
- ✓ The first method, which according to Miles and Huberman is a reference method, starts from a predefined list of codes. This list uses the same primary structures suggested by Eisenhardt (1989). However, this list does not remain constant during the analysis and changes.
- ✓ The second method also uses the codes inductively generated while studying texts. In vivo codes can also be added to the code set in this method. This method aims to adopt new concepts and categories with an open mind and not limit ourselves to pre-defined codes and structures. As the analysis continues, the generated codes are changed and continuously reviewed. Some unused codes are removed; some others are. There are also some very general and abstract codes in the first place, so they are divided into smaller and more specific codes. Possibly, the titles of some codes will also change during the analysis, and it will be attempted to use words more relevant to the desired concept and text.

The second method was used in this research. In other words, from the beginning, by studying the first source and according to the questions, the codes were extracted, and their references were determined. By researching the following sources, new codes were added to the previous ones, and sometimes the codes were modified, combined, and deleted. Each code, according to its meaning, was categorized in a similar concept. Then, the overlapping codes were determined, and their overlap was removed. Codes with common content were also determined, and a common code was assigned to them. Again, the same codes were put in a subgroup, and new codes were assigned to each subgroup. Some of the identified codes had several frequencies. Finally, the number of final codes reached 33 items provided in Table 5. In Table 5, thematic classification in project management and construction is provided based on the number of relevant resources and the frequency of examples applying blockchain in that field. Given the diversity and widespread coverage of project management science, some of the articles evaluated in several fields of blockchain application have been assessed or critiqued in general for blockchain. And for this reason, these articles were considered in several fields to determine the frequency, which is the reason of repetition of some sources in some rows of Table 5.

Table 5 presents the essential features and capacities of blockchain technology for application in project management and construction, extracted through literature review. To answer this research question, that what are the potential features and capacities of blockchain technology in project management and construction, the frequency percentage of the topics in the field of project management and construction was obtained based on the number of

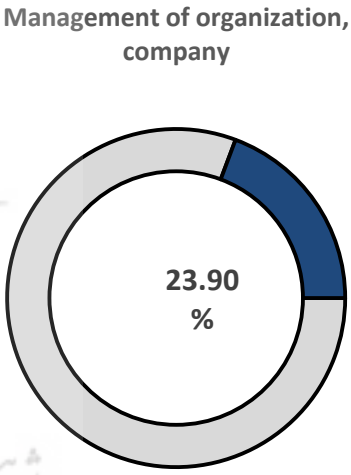
available sources and the frequency of examples of using blockchain in this field was calculated. These frequencies are presented in the diagrams of the first column.

Table 5. Summarization and thematic classification of literature

References	Functional description Thematic classification in the field of project management and construction	Thematic classification and frequency in the field of project management and construction
(Lee, Yoon, Lee, & Um, 2020; Norta, Wenna, & Udokwu, 2020)	Research and development on building project management platforms and building on blockchain platform: Intelligence and availability of information on construction projects on an intelligent platform	
(Berglund Emily et al., 2020; Ćirić, Sedlak, & Ivanišević; Kim, Lee, & Kim, 2020; Scott, Broyd, & Ma, 2020)	Building and maintaining smart cities: Using information and the Internet on a blockchain platform to optimize processes, municipal services, and communication between citizens	
(Adriana Erica Amaludin & Taharin, 2018; Alkhudary, Brusset, & Fenies, 2020; Azhar, Khan, & Zafar, 2019; Belle, 2017; Chi et al., 2020; Dakhli, Lafhaj, & Mossman, 2019; Duchin, Ozbas, & Sensoy, 2010; Fitriawijaya & Hsin-Hsuan, 2019; Graham, 2019; Hewavitharana, Nanayakkara, & Perera, 2019; Kim et al., 2020; Lee et al., 2020; Lin & Qiang, 2019; Liu, Jiang, Osmani, & Demian, 2019; Mason, 2019; Meng & Sun, 2020; Nanayakkara, Perera, Bandara, Weerasuriya, & Ayoub, 2019; Nawari & Ravindran, 2019a, 2019b, 2019c ;Perera, Nanayakkara, Rodrigo, Senaratne, & Weinand, 2020; Renwick & Tierney, 2020; Salama & Salama; Sheng, Ding, et al., 2020; Shojaei, Flood, Moud, Hatami, & Zhang, 2020; Turk & Klinc, 2017; Walsh et al., 2020; J. Wang, Wu, Wang, & Shou, 2017; Werner & Zarnekow, 2020; Zhong et al., 2020)	**Smart Contract:** These are the rules that govern transactions on the blockchain, and Ethereum/ Allows you to exchange money, assets, stocks, and anything of value without the need for third parties/ The smart contract acts as a constitution and translates each data recording into a series of payments and changes in the status of guarantees.	
(Adriana Erica Amaludin & Taharin, 2018; Alkhudary et al., 2020; Belle, 2017; Fitriawijaya & Hsin-Hsuan, 2019; Hewavitharana et al., 2019; Hijazi, Perera, Al-Ashwal, & Neves Calheiros, 2019; Kim et al., 2020; Lin & Qiang, 2019; Lokshina, Greguš, & Thomas, ;۲۰۱۹ Nanayakkara et al., 2019; Pastor, Olaso, & Fuente, 2020; Perera et al., 2020; Scott et al., 2020; M. G. Sharma & Kumar, 2020; Sheng, Ding, et al., 2020; Sivula, Shamsuzzoha, & Helo, 2018; Walsh et al., 2020; J. Wang	Supply Chain /Procurement (for example, through Walmart and IBM): Managing, tracking resources from source to destination, tracking digital-specific identifications, hiring and contracting contractors for investors and project managers	

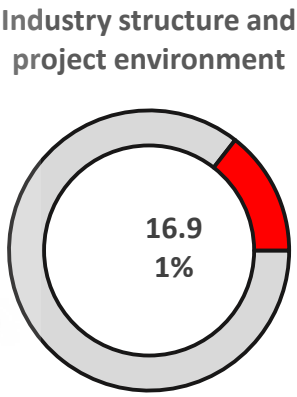
et al., 2017; Ye, Yin, Tang, & Jiang, 2018)		
(Adriana Erica Amaludin & Taharin, 2018; Belle, 2017; Erri Pradeep, Yiu, & Amor, 2019; Fitriawijaya & Hsin-Hsuan, 2019; Graham, 2019; Hewavitharana et al., 2019; Hijazi et al., 2019; Kim et al., 2020; Liu et al., 2019; Lokshina et al., 2019; Mason, 2017, ;۲۰۱۹Nanayakkara et al., 2019; Nawari & Ravindran, 2019a, 2019b, 2019c; Perera et al., 2020; Salama & Salama; Scott et al., 2020; M. G. Sharma & Kumar, 2020; Shojaei et al., 2020; Siountri, Skondras, Mavroeidakos, & Vergados, 2019; Turk & Klinc, 2017; Zheng et al., 2019; Zhong et al., 2020)	Building Information Modeling (Ex: BIM CHAIN / BIM COIN): At the forefront of CAD and BIM organizational solutions from the COINS Center for sales, development, and training of the CAD / BIM Software Training Center, job analysis codes for 4D and 5D, To manage COINS services / track the progress of BIM-based work	
(Alkhudary et al., 2020; Chi et al., 2020; Fitriawijaya & Hsin-Hsuan, 2019; Hewavitharana et al., 2019; Lokshina et al., 2019; Mason, 2017; Nawari & Ravindran, 2019c; Norta et al., 2020; Perera et al., 2020; Scott et al., 2020; Siountri et al., 2019; Walsh et al., 2020; Ye et al., 2018; Zhong et al., 2020)	Internet of Things (Ex: ADEPT[2]): Integration of technologies, innovative equipment, and new business models	
(Alkhudary et al., 2020)	Digital Thinking System: Information Intelligence Proof Model to Replace Proof of Work and Proof of Stocks	
(Kim et al., 2020)	EOS-based CAD management platform named 'CADEOS': In connection with the design phase, exploration efforts such as blockchain-based BIM, CAD management operating systems	
(Adriana Erica Amaludin & Taharin, 2018; Hewavitharana et al., 2019; Meng & Sun, 2020; Pastor et al., 2020; Perera et al., 2020; Scott et al., 2020; J. Wang et al., 2017)	Digital storage and data recovery (Ex: File coin, Track Transfer Trust, IPFS[3]) "Improved centralized web servers and storage space providers / Extra storage space without the use of hard disk / Database of competent members of the construction industry stakeholders / Digitize paper-based certificates (e.g., birth certificate, contractor license) and ownership documents (e.g., land title, home title)	
(Azhar et al., 2019)	Using Quantum Encryption to Implement PMO Office: Quantum Encryption Knowledge of exploiting quantum mechanical properties to perform cryptographic tasks means securing communication in the presence of a third party called an enemy or rival.	

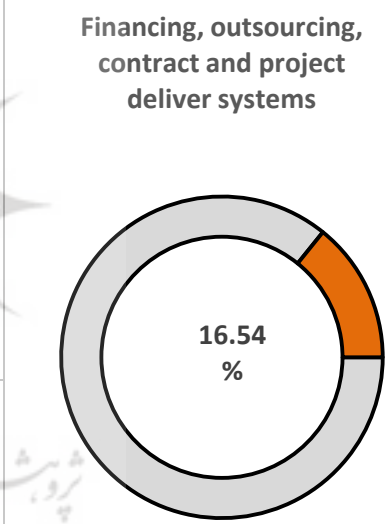
[2] Samsung and IBM have developed a decentralized IoT system called ADEPT (Decentralized Automated P2P Telemeter) that allows billions of devices to trade and support each other extensively.
[3] IPFS Global Distributed File Database, a Scientific-Practical Research Project Management System / Increasing the Confidentiality of Scientific Research Project Processes

(Nanayakkara et al., 2019; Nawari & Ravindran, 2019a, 2019c; Scott et al., 2020; Sheng, Ding, et al., 2020; J. Wang et al., 2017; Zhong et al., 2020)	Conformity and Assurance Management / Quality and Audit (Ex: HLF[4] platform): Tracking the supply of each product or service by tracking authenticity in terms of compliance or quality assurance	
(Graham, 2019)	SiteSense: Material management / Used to store these transactions securely and privately, allowing multiple shared stakeholders (or peers) to connect and sync transactions	
(Adriana Erica Amaludin & Taharin, 2018; Alkhudary et al., 2020; Azhar et al., 2019; Belle, 2017; Chi et al., 2020; Dakhli et al., 2019; Duchin et al., 2010; Fitriawijaya & Hsin-Hsuan, 2019; Graham, 2019; Hewavitharana et al., 2019; Kim et al., 2020; Lee et al., 2020; Lin & Qiang, 2019; Liu et al., 2019; Mason, 2019; Meng & Sun, 2020; Nanayakkara et al., 2019; Nawari & Ravindran, 2019a, 2019b, 2019c; Perera et al., 2020; Renwick & Tierney, 2020; Salama & Salama; Sheng, Ding, et al., 2020; Shojaei et al., ;۲۰۲۰Turk & Klinc, 2017; Walsh et al., 2020; J. Wang et al., 2017; Werner & Zarnekow, 2020; Zhong et al., 2020)	Smart Contract / Confirm or execute the contract.	
(Berglund Emily et al., 2020; Ćirić et al.; Kim et al., 2020; Scott et al., 2020)	Building and maintaining smart cities: Using information and the Internet on the Chinese blockchain platform to optimize processes, municipal services, and communication between citizens	
(Norta et al., 2020)	Inter-organizational collaboration, e-Sourcing Reference Architecture (eSRA): is a conceptual framework that provides the technical governance for managing complex inter-organizational collaboration between businesses. Thus, the current difficulty in implementing team-building collaborations due to different software systems can be easily controlled by eSRA. In addition, eSRA provides a way to manage processes in inter-organizational collaboration.	
(Alkhudary et al., 2020; Hewavitharana et al., 2019; Holotiuk & Moormann, 2018; Lin & Qiang, 2019; Mason, 2017; Scott et al., 2020; Walsh et al., 2020; J. Wang et al., 2017)	Digital Payment / Transaction Management: Enabling more direct transactions by replacing intermediaries, reducing the number of steps in payment processes, and enabling direct communication between parties / Solving transaction tracking difficulties in existing payment systems.	

[4] Hyper ledger fabric-based

(Alkhudary et al., 2020; Belle, 2017; Erri Pradeep et al., 2019; Pastor et al., 2020; Scott et al., 2020)	Intellectual Property Protection: Registration of intellectual property rights in the databases used in this technology / Due Diligence operations in IP valuation and transactions	
(Alkhudary et al., 2020; Nanayakkara et al., 2019; Perera et al., 2020)	Social Media Advertising / Marketing: Validating and Analyzing the Customer Path During an Ad Approval	
(Alkhudary et al., 2020)	Digital Thinking System: Information Intelligence Proof Model to Replace Proof of Work and Proof of Stocks	
(Adriana Erica Amaludin & Taharin, 2018; Hewavitharana et al., 2019; Meng & Sun, 2020; Pastor et al., 2020; Perera et al., 2020; Scott et al., 2020; J. Wang et al., 2017)	Digital storage and data recovery (Ex: File coin, Track Transfer Trust, IPFS) Improve centralized web servers and providers of storage space / additional storage space without the use of complex disk/database of competent members of the construction industry stakeholders / Digitize paper-based certificates (e.g., birth certificate, contractor license) and ownership documents (e.g., land title, home title).	
(Belle, 2017; Chang et al., 2020; Dakhli et al., 2019; Pastor et al., 2020; Scott et al., 2020; Ye et al., 2018)	Decentralized autonomous organizations (DAOs) are a complete set of long-term smart contracts that can replace the decision-making processes of a business organization and significantly reduce the level of management staff.	
(Dakhli et al., 2019)	**Digital signature:** Using asymmetric encryption methods creates a kind of trust between you and the webserver in question, which means that the response received was undoubtedly sent by the web server and was not sent by hackers.	
(Azhar et al., 2019)	Using Quantum Encryption to Implement PMO Office: Quantum Encryption Knowledge of exploiting quantum mechanical properties to perform cryptographic tasks means securing communication in the presence of a third party called an enemy or rival.	
(Sheng, Ding, et al., 2020; Zhong et al., 2020)	Product Organization Process (POP) qualityChain: Defines the relationship between an organization, its product, and the process dimension / Online collaboration between project participants	
(Hewavitharana et al., 2019; Werner & Zarnekow, 2020)	Governance (Ex: Ethlance, Dmarkt, Steemit, Token Holder Tribunal, Blocklancer): The power mechanism to decide whether to pay freelancers or repay the employer on a blockchain platform / operating system governance mechanisms on blockchain-based operating systems	
(Renwick & Tierney, 2020)	Blockchain-Based Virtual Organizations: A Distinctive Way to Organize Workers Remotely About Joint Project Objectives Integrated	

	with blockchain technology in agreement, management, execution, as well as a platform for workflow and payment transparency	
(Berglund Emily et al., 2020; Perera et al., 2020; Scott et al., 2020; Ye et al., 2018)	Energy flow / renewable energy: decentralization and digitalization of energy systems / strengthening local energy markets / reducing intermediate costs	
(Berglund Emily et al., 2020; Hewavitharana et al., 2019; Nanayakkara et al., 2019; Perera et al., 2020)	Solid Waste / Waste Management: Licensing of China Block-Based Waste / Blockchain-Based System Financial management for municipal waste collection with the aim of better health and social education and financial and social involvement of volunteer citizens through the use of currency Social / printed cards called Green Coins	
(Adriana Erica Amaludin & Taharin, 2018; Alkhudary et al., 2020; Azhar et al., 2019; Belle, 2017; Chi et al., 2020; Dakhli et al., 2019; Duchin et al., 2010; Fitriawijaya & Hsin-Hsuan, 2019; Graham, 2019; Hewavitharana et al., 2019; Kim et al., 2020; Lee et al., 2020; Lin & Qiang, 2019; Liu et al., 2019; Mason, 2019; Meng & Sun, 2020; Nanayakkara et al., 2019; Nawari & Ravindran, 2019a, 2019b, 2019c; Perera et al., 2020; Renwick & Tierney, 2020; Salama & Salama; Sheng, Ding, et al., 2020; Shojaei et al., ;۲۰۲۰Turk & Klinc, 2017; Walsh et al., 2020; J. Wang et al., 2017; Werner & Zarnekow, 2020; Zhong et al., 2020)	Smart Contract / Confirm or execute the contract.	
(Kim et al., 2020)	Construction Coins Including Hyundai Pay (HDAC) Hyundai BS & C: Hyundai Digital Access Currency, Commercial Construction Machinery Brand and Construction Arm, Companies Collaborate on a DLT Solution to Build and Manage Quality Data, Cars New products can be tracked at all stages of production, and their quality data can be recorded unchanged.	
(Perera et al., 2020)	Arcade City: A decentralized transportation ecosystem	
(Perera et al., 2020);)Nanayakkara et al., 2019)	Crowdfunding (Ex: Usizo): uses advanced blockchain technology to invest in tokens. Each token indicates the investor's stake in the startup / uses blockchain technology to inform the investor of the amount of liquidity needed for startups.	
(Graham, 2019)	SiteSense: Material management / Used to store these transactions securely and privately, allowing	

	multiple shared stakeholders (or peers) to connect and sync transactions	
(Graham, 2019)	Brickschain: Digitizes the entire building process in the blockchain and describes the whole construction process.	
(Berglund Emily et al., 2020)	Crowdsourcing[5]: A new set of protocols called NF-Crowd that solves the problem of scalability by reducing the low total cost of a decentralized resource project / is a reliable solution for scaling decentralized public resources	
(Adriana Erica Amaludin & Taharin, 2018; Alkhudary et al., 2020; Azhar et al., 2019; Belle, 2017; Chi et al., 2020; Dakhli et al., 2019; Duchin et al., 2010; Fitriawijaya & Hsin-Hsuan, 2019; Graham, 2019; Hewavitharana et al., 2019; Kim et al., 2020; Lee et al., 2020; Lin & Qiang, 2019; Liu et al., 2019; Mason, 2019; Meng & Sun, 2020; Nanayakkara et al., 2019; Nawari & Ravindran, 2019a, 2019b, 2019c; Perera et al., 2020; Renwick & Tierney, 2020; Salama & Salama; Sheng, Ding, et al., 2020; Shojaei et al., ;۲۰۲۰Turk & Klinc, 2017; Walsh et al., 2020; J. Wang et al., 2017; Werner & Zarnekow, 2020; Zhong et al., 2020)	Smart Contract / Confirm or execute the contract.	
(Alkhudary et al., 2020; Hewavitharana et al., 2019; Holotiuk & Moormann, 2018; Lin & Qiang, 2019; Mason, 2017; Scott et al., 2020; Walsh et al., 2020; J. Wang et al., 2017)	Digital Payment / Transaction Management: Enabling more direct transactions by replacing intermediaries, reducing the number of steps in payment processes, and enabling direct communication between parties / Solving transaction tracking difficulties in existing payment systems	
(Kim et al., 2020)	Construction coins including Hyundai Pay (HDAC) Hyundai BS & C	
(Dakhli et al., 2019)	**Digital signature:** Using asymmetric encryption methods creates trust between the user and the relevant web server, which means that the received response was certainly sent by the web server and was not sent by hackers.	
(Lin & Qiang, 2019)	democratic virtual economic system (DVES: It can verify payments, agree, and store encrypted data in virtual economic systems.	

[5] A resource model in which individuals or organizations acquire goods and services, including ideas, voting, micro-work, and finance, from a large, open, and rapidly evolving group of participants.

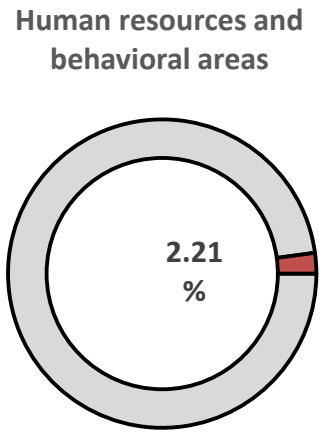
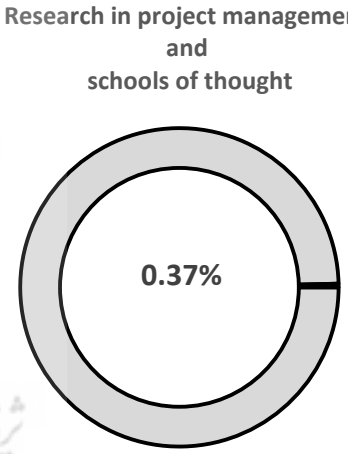
(Adriana Erica Amaludin & Taharin, 2018; Perera et al., 2020; Scott et al., 2020; J. Wang et al., 2017)	Identity Protection (IBM): Identification Solutions / Chinese Block Identity Systems with a User-Oriented Approach / Using blockchain technology, workers with the appropriate skills and qualifications can be identified by a digital ID card, which The relevant authorized body can identify should be shared / The credit of the worker or supplier of materials can be traced over time.	
(Graham, 2019; Renwick & Tierney, 2020)	Approve or Execute Negotiation (Ex: UpWork, TaskRabbit): Contract negotiation, settlement, and arbitration, as well as processes to facilitate short-term contract workers who work digitally through peer-to-peer job markets.	
(Bai et al., 2018)	Scientific Research Project Management System (SRPMS): The research chain using blockchain for scientific research project management / scientific research management operating system / was proposed as a major solution to problems such as forgery and plagiarism in the project application. In addition, the collection and misuse of funds during projects and the qualitative analysis and evaluation of the expected results of projects, including articles, monographs, reports (experiments), and patents, are also used during project review.	

Table 5 shows that in summarizing the scoping and systematic review of literature, the studies on human resources and behavioral areas and research in project management and schools of thought with minimum studies included 2.21% and 0.37%, respectively. In other words, they are neglected or not studied enough. In contrast, the studies on program and project management with 40.07% had the highest focus of studies. The results obtained from Table 5 are as follows:

- ✓ Most of the studies on applying blockchain in project management and construction were focused on program and project management and the management of the organization/company or firm.
- ✓ The study gap related to two topics of human resources and behavioral areas and research in project management and schools of thought was evident and required more attention.

- ✓ In all six fields of project management and construction, there were some applications for blockchain technology in project management and construction. This issue confirms the significance and gradual understanding of the importance and the positive impact of this technology on enhancing the performance of project management and construction. However, still, the relationship between these two sciences plays a small role in the existing studies and requires more basic and applied studies.
- ✓ Despite the conducted studies and considering the need for relevant studies, many of the available articles in this review were theoretical and non-applied ones. According to Table 5, a considerable number of applications were just at the level of concept and only referred to the available capabilities. No specific application or applied platform was defined for them, so this section required coherent studies.

Step six: Quality control and maintenance

In this research, it was attempted to select the articles to form reputable journals and databases. Articles that were not valid enough were removed from the scoping review and SLR process. CASP tool was used to evaluate the quality of these articles based on the mentioned criteria. Finally, the time of extracting the available potentials and capacities from the texts and combining the information, their encryption, and classification were repeatedly reviewed and criticized. These steps and measures guarantee the quality of findings of this research significantly.

Implication for research and practice

Step seven: Presentation and interpretation of findings

Following the summarization and analysis of the scoping and systematic review of literature, the results of model analysis of the codes extracted from Table 5 show that the studies on applying blockchain were mainly focused on program and project management. In the field of program and project management, in the subset related to project management plan, most of the research in the field of research and development on making project management and construction platforms were conducted on a blockchain platform (Kim et al., 2020; Lee et al., 2020). In this regard, Norta et al. (2020) evaluated all aspects of implementing a platform called CoPM to integrate and enhance information flow to reduce costs and time and to increase quality. The main suggestion of the CoPM platform was providing a decentralized platform for supply chain and project management in the construction sector, particularly modular construction. In this study, Ethereum, Qtum, and Cardano networks were determined as the potential blockchain networks for implementing smart contracts from the CoPM platform. IPFS and BigchainDB were considered as an extensive database for storing digital assets generated in the operating system. Moreover, the BIM standard was introduced as a science for displaying digital assets such as building models and objects in the operating

system. Similarly, the new IBM chip computers combining with RFID were introduced as IoT scanners for real-time monitoring and transmission of the status of a building object on the suggested platform.

Another study, referring to the considerable investment in research and development projects in 2020 in Korea, considers blockchain technology as a key solution to share reliable information and to prevent forgery in various fields, and has designed the Perfect Sharing Project (PSP)-Platform on the blockchain platform to manage national ICT research and development projects with appropriate performance in preventing forgery (Lee et al., 2020). This platform was analyzed to prevent unwanted sharing of project results in blockchain technology-based planning, evaluation, and management information. In addition, it is a platform that shares information about the life cycle of ICT national R&D projects. A large part of the studies in this field was related to Building Information Modeling (Erri Pradeep et al., 2019; Fitriawijaya & Hsin-Hsuan, 2019; Hijazi et al., 2019; Liu et al., 2019; Lokshina et al., 2019; Mason, 2019; Nawari & Ravindran, 2019a, 2019b, 2019c; Salama & Salama; Shojaei et al., 2020; Siountri et al., 2019; Zheng et al., 20(١٩. For example, Shojaei et al. (2020), in their study evaluated the concluding of smart contracts using the integration of BIM and blockchain. The results of their study showed that blockchain is a suitable system for managing building projects contracts, and automating the consequences of each transaction, and maintaining the history of a trend and changes in project progress is valuable for resolving any conflict. The blockchain network developed in this study concludes smart contract as logic for its network performance. As a result, it seems improper to think that all of the clauses of a traditional contract should be translated into a computer program due to the complexity, fluidity, and uncertainty of any project. It is demonstrated how semi-automated blockchain can be used to implement smart contracts and link the digital and physical worlds (BIM model) to maintain and control the physical cyber space and facilitate the flow, entrance, and inspection of materials and jobs to achieve more automation.

In the field of studies related to the management of the organization, company, and firm, one of the discussed issues was related to developing systems for managing high-quality information (Sheng, Ding, et al., 2020) In this research, referring to the uncertainty of the accuracy of documented data provided to the stakeholders as one of the challenges at the organizational level due to exclusively maintain the data by the contractor, a blockchain-based framework is presented. This framework aims to provide the organizations the capability to record their quality management information and thus improve their capacities for business learning and performance. Noting that the contractor has the motivation and chance to change data to acquit itself in the event of an NCR6, it was concluded that existing centralized, contractor-controlled organizational systems may still have problems in tracking NCR. Under

[6] Non-conformance report

such a condition, the existence of a uniform, secure, and transparent system under the control of stakeholders was necessary to manage high-quality information. The framework for managing high-quality information, which defines the relationship between an organization, its product, and the process aspect, is called the "quality chain of the product of the organization process (POP)".

Moreover, in this research, an architecture based on Hyperledger-Fabric and some blockchain solutions (e.g., consensus mechanism, smart contracts for processing high-quality information, licensing sequences, and implementation processes) were provided to support managing high-quality information. The study conducted by Duchin et al. (2010) in the field of organization examines the impact of blockchain technology on organizational strategy and the role of senior strategy managers. This paper discusses the new elements of strategic design and delivery- joint offices, smart contracts, and token assets- and develops the concept of strategic liquidity.

In the studies related to the topic of the industry structure and the project environment, most of the concerns were related to internal construction methods and issues or challenges related to the implementation of blockchain technology in the industry (Alkhudary et al., 2020; Azhar et al., 2019; Berglund Emily et al., 2020; Dakhli et al., 2019; Kim et al., 2020; Lin & Qiang, 2019; Meng & Sun, 2020; Nanayakkara et al., 2019; M. G. Sharma & Kumar, 2020). One of the topics that were also classified in this field was smart cities. A study conducted by Berglund et al. (2020) on the use of powerful technologies such as blockchain in the field of civil engineering, including transportation systems, water systems, air quality, energy infrastructure, solid waste engineering, and construction management, geotechnical structures and systems, discussed and emphasized that the civil engineer may not have an insight on how to understand and use these technologies publicly, Still, of course, they can provide an insight into how these technologies change the performance of infrastructures. This research addresses the challenges related to the implementation of blockchain technology in the construction industry in issues about the defects in technology structure, internal and external organizational obstacles, external obstacles such as government obstacles, regulatory frameworks, and the possibility of replacing classical financial institutions or traditional business models with blockchain technology. The role of civil engineers for conventional and smart infrastructure programs was also identified, and these roles in the conventional infrastructure plans were compared to smart plans. The obtained result indicated that the emergence of smart technologies that enable the development and construction of smart cities, including measurement, big data analysis, data visualization, IoT, and blockchain technology, can make significant changes in receiving, monitoring, and managing city services. Moreover, blockchain technology can develop tools and methods to manage dependent systems and the complexities of interactions between sectors such as water, power, and transportation networks and achieve new service and efficiency levels.

In this regard, the study conducted by Kim et al. (2020), using a questionnaire in the form of a survey, evaluated the application of blockchain technology in special construction tasks. The participants in this survey included general contractors, engineering companies, public institutions, and research institutions. The survey content included the possibility of convergence of blockchain technology in the construction industry and applying blockchain technology in structural tasks based on the project life cycle and project knowledge fields. Among the most popular applications of blockchain technology, including smart contracts, securities, digital currency, and record- keeping, the "smart contract" with a response rate of 45.8% had the highest potential of the application. In this research, IPA analysis was used to identify the areas of applying blockchain technology, considering the "application of technology" and "the impact of using technology". Finally, considering the PMI knowledge fields, "procurement management" and "cost management" were identified as the main areas of applying blockchain with high application and impact. Finally, it was concluded that most of the blockchain applications are at the research level and developing or at the pilot study stage. There are not many resources to integrate and apply this technology in project management and construction. Despite many potentials of blockchain, such as excellent security, decentralization, and scalability of the technology, more effort should be made to improve it, both in research and practice. Generally, the studies of this section, considering the challenges to the construction industry and construction companies, analyzed the effectiveness of blockchain system on the process of confidentiality, source tracking, inflexibility, proof of existence, multilateral collection, change tracking, data ownership, and the possibility of continuous collaboration between all stakeholders in the construction process.

In the field of financial systems, outsourcing, contracting, and project implementation, most of the studies were focused on contracting approaches and areas (Ahmadisheykhsarmast & Sonmez, 2020; Elghaish, Abrishami, & Hosseini, 2020; Emmanuel, 2020; Kosba, Miller, Shi, Wen, & Papamanthou, 2020; Sheng, Luo, & Zhong, 2020). For example, Sheykhsarmast et al. presented a new smart contract payment security system called SMTSEC to stop or reduce payments in the construction sector. This system guarantees the security of construction payments through an automated computer protocol and is implemented on a decentralized blocked chain)Ahmadisheykhsarmast & Sonmez, 2020). Similarly, the study conducted by Sheng et al. (2020) noted that encryption and confirmation of smart contracts in the construction industry are challenging due to the gap between the general existing modeling approaches for such contracts and the logic of business in the construction industry and its management. This research provides a formal model for smart contracts to adopt quality in the construction industry and reduce the threshold of using smart contract technology. At first, the conceptual scenario of adopting quality based on smart contracts in construction is analyzed is analyzed. Then a machine-based model is introduced to recognize

smart contracts in terms of adopting quality of construction. This study contributes to the industrial application of formal modeling approaches for smart contracts in construction.

All in all, in these studies, the smart contract is considered a code that runs on blockchain. This contract contains specific rules that all parties of the contract should observe. Once the terms of the contract are fulfilled, the smart contract is automatically implemented and completed. In projects whose management is complex, smart contracts can potentially be used as a tool to manage interdependent tasks. Smart contracts can merely be used to issue specific orders to suppliers.

Another study in this field addressed integrated contractual approaches such as IPD (Elghaish et al., 2020). This research was focused on providing a framework to develop the use of blockchain technology in IPD projects. According to the obtained results, this framework enables the primary project team members to automatically perform all financial transactions by encrypting three main transactions of IPD projects, including refunded costs, profits, and cost savings, as a function of a smart IPD contract. A Hyper ledger network (IBM® Blockchain Cloud Beta 2) developed in a case study was used to demonstrate the application of the proposed framework and its confirmation. The user-friendliness feature of the proposed financial system and its efficiency in automating all transactions in this case study confirmed that there was no shortage in the components of the blockchain network in this regard.

The only research in the field of "research in project management and schools of thought" was related to the scientific research on project management based on the blockchain system (Bai et al., 2018). In this research, problems such as forgery, manipulation, and literary theft in applying the project were addressed. In addition, withdrawal and misuse of funds during the project implementation and qualitative analysis and evaluation of the project's expected results, including articles, monographs, reports (experiments), and patents during the project review, are still serious challenges to scientific research project management. This paper proposes the research chain using blockchain for scientific research in project management and analyses the main technologies of each module in this model. This approach provides a new method for developing an operational system for scientific research management.

According to the results obtained from this review, it is worthwhile to conduct more studies in the neglected fields, including two topics of human resources and behavioural areas and research in project management and schools of thought, to identify the potential features and capacities of blockchain technology to be applied in project management and construction. Regarding the fields covered by more studies, such as the studies related to program and project management and management of the organization/company or firm, despite a large number of studies, they were theoretical primarily and non-applied. A

significant number of the proposed applications were just as a concept and only referred to the available capabilities, and no application or applied platform was defined for them. Therefore, this sector needs coherent studies. In terms of the practical impacts of blockchain on construction project management, a significant part of the findings was related to the security of payments for construction contracts, smart contracts, securities, digital currency, and record keeping. Another part of the findings indicated the effective use of blockchain in presenting digital assets, such as model building and IoT. According to the obtained results, what has been addressed more in recent years confirms the impact of blockchain on the transparency of organizational environment and firms' governance. What is worth pondering; Ability to use blockchain in all areas of project management and construction. From large sections to details related to economic and organizational issues can be upgraded by this technology. More coherent studies should be conducted to identify the potential benefits of this technology to cover other aspects of project management and construction that are less addressed. It is also necessary to provide the essential basis for implementing and applying this technology in line with these studies in the industry. Stakeholder action during studies as well as technology implementation can be effective in addressing needs or shortcomings.

Conclusion

It is expected that with the increasing expansion of technology and the alignment of the project management and construction science with new developments and technologies, the capabilities and application of this science be upgraded, too. The development of project management and construction science with blockchain is still a hypothesis. However, it is expected that since there is no central authority governing the blockchain mechanism, the decentralized nature of blockchain turns it into a suitable platform for project management. This research aimed to identify the capacity and platforms of blockchain technology development in project management and construction and provide some suggestions about the development and improvement of this technology in the field of project management and construction. To realize these goals, using the scoping and systematic literature review methods and applying the defined criteria, 95 articles in the scoping review and 48 articles in the systematic review were selected, studied, and evaluated.

Moreover, blockchain has been considered as the main solution for sharing reliable information and preventing various fields. However, most of the studies in this field are theoretical and non-applied, and a significant number of the proposed applications were just suggestions and referred to the available capabilities. No application or applied platform was implemented for them. Therefore, this sector requires a coherent and functional platform for using these capabilities.

Regarding the results obtained from the scoping review in this research, at first, using scoping review, the scope and domain of the studies on blockchain technology in the field of project management and construction were estimated. It was found that since 2010, when the first blockchain article on project management and construction was published, these studies have increased. This growth indicates more focus of researchers on this issue and identifying the hidden capabilities of using blockchain as an ideal platform for project management and construction. Moreover, about 30% of the journal articles and 33% of the conference papers in this research were of the review type, which can indicate that blockchain studies on project management and construction are still at their initial stages. In addition, most of the available studies are theoretical, and the lack of quantitative studies is evident. A large part of blockchain studies was focused on "Program and project management" that 64.7% of articles were studied "virtual construction and design". Moreover, it was found that two topics of human resources and behavioral areas and research in project management and schools of thought with a share of less than 2% of the existing studies have been neglected and need more research. In the systematic review, after qualitative evaluation of the existing articles, 48 articles were selected, and the results obtained from the model analysis of the codes extracted from the systematic review showed that in all six areas of project management and construction, there are some applications for blockchain technology in project management and construction. This issue confirmed the significance and gradual understanding of the importance and positive impact of this technology on enhancing project management and construction performance. However, the relationship between these two sciences still plays a small role in existing studies and requires more basic and applied studies.

Recommendations

There are a lot of areas related to applying blockchain in the field of project management and construction that are neglected, and focusing on them efficiently provides a suitable platform for improving the performance of project management and enhancing its capabilities, and identifying and implementing them can provide an appropriate platform for the future studies. Considering the existing study gap and lack of addressing two topics of human resources and behavioral areas and research in project management and schools of thought, it is suggested that future studies consider the output of the model analysis of this study as a basis for designing a model to examine the adoption degree of this technology in these two fields, and while identifying the neglected applications, try to identify the obstacles as well as the available enablers through field research, to facilitate their implementation. In addition, a large proportion of studies were performed qualitatively. For future studies, it is recommended to focus on quantitative research and simulation methods so that while validating qualitative studies, they will have a more practical and applied aspect and will be useful in the industry.

Conflict of interest

The authors declare no potential conflict of interest regarding the publication of this work. In addition, the ethical issues including plagiarism, informed consent, misconduct, data fabrication and, or falsification, double publication and, or submission, and redundancy have been completely witnessed by the authors.

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