Assessment of barriers to the implementation of blockchain technology in construction supply chain management in Nigeria

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Abstract

Purpose – The purpose of this study is to assess the barriers to the implementation of blockchain technology in construction supply chain management in Nigeria.

Design/methodology/approach – This study employed a quantitative research approach through a questionnaire survey that was conducted among professionals in the Nigerian construction industry using the snowball sampling method, which resulted in a selection of 155 respondents. The collected data were analysed using descriptive and exploratory factor analysis (EFA), while Cronbach's alpha was used to assess the reliability.

Findings – The analysis revealed that all barriers ranked above the average mean item score. It also revealed that all professionals have a convergent opinion on the barriers. EFA was used in clustering the identified barriers into two categories: technological and socio-political barrier.

Research limitations/implications – This research was carried out in the Southwestern region which is one of the six geo-political zones in Nigeria using a cross-sectional survey method.

Practical implications – The findings provide valuable insights into the barriers to the implementation of blockchain in supply chain management for professionals and practitioners in the Nigerian construction industry.

Originality/value – The research categorised the barriers into technological and social-political barrier and identified that lack of digitalisation is the major barrier to the implementation of blockchain technology in construction supply chain.

Keywords Blockchain, Construction supply chain, Innovation, Nigeria, Barrier

Paper type Research paper

1. Introduction

The construction industry is a major driver of economic growth in all countries (Suliman and Jamal, 2022). However, its development is impeded by its resistance to change in promoting innovative ideas (Li *et al.*, 2019) and its fragmented nature (Xu *et al.*, 2022). This underline recent reports indicating that the industry is stagnant, owing primarily to the construction industry's unwillingness to invest in technological innovations (Shemov *et al.*, 2020). This has led to the industry's unsatisfactory productivity, lack of transparency, failure to meet stakeholders' expectations and poor supply chain management (Chen *et al.*, 2018). However, in order to boost

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its productivity and transparency, the integration of innovative technologies into the construction supply chain process is required (Shemov *et al.*, 2020). The construction supply chain is a vital artery in the lifecycle of a project (Yevu *et al.*, 2021). It encompasses all aspects of construction, from initial demand, design and construction to building and other structural maintenance, replacement and final destruction (Studer and De Brito, 2021). Despite being a significant segment of the industry, it has been criticised for its wastefulness, inefficiency, frequent schedule delays, cost overruns, lack of trust, poor coordination and communication (Studer and De Brito, 2021). However, these problems could have been fixed (Li *et al.*, 2019) if the industry had used integrated technological innovations in its supply chain. Some of these technological innovations include Building Information Modelling (BIM), cloud computing, and the Internet of Things, as well as blockchain technology (Hamma-adama *et al.*, 2020), which have altered data exchange, storage and analysis (Mahmudnia *et al.*, 2022) in different industries. Blockchain is a decentralised system based on cryptographic procedures and smart contracts, and it is considered an emerging information and communication technology (ICT) in "Industry 4.0" (Zhong *et al.*, 2020). It has a decentralised database that records every transaction and shares it with all parties involved (Rana *et al.*, 2021), and it also serves as a platform for the management and exchange of digital assets such as cryptocurrencies like bitcoin and Ethereum (Allison and Warren, 2019). However, it has also been reported to have the potential to handle various safety attacks because it abolishes the need for centralised authority to perform various operations. Recent research on technological advancements revealed that blockchain technology is capable of resolving the transparency problem within the construction supply chain (Hamma-adama *et al.*, 2020). Despite being a recent innovation, blockchain technology has significantly attracted the attention of several individuals from diverse backgrounds (Allison and Warren, 2019). This innovation has numerous advantages to the construction projects, including increasing productivity and minimising project delays (Sepasgozar *et al.*, 2015), and this has led to an increase in global efforts to integrate blockchain technology into the construction industry. This will allow for the development of integrated and transparent services throughout the construction supply chain (Li *et al.*, 2019). Despite the many ways in which blockchain technology can improve the construction industry, integrating it into supply chain processes will not be as simple as anticipated due to the existence of a variety of barriers (Öztürk and Yildizbaşi, 2020).

Conversely, similar studies have been carried out in order to investigate the application of blockchain technology to the supply chain process. For instance, Oztürk and Yildizbaşi (2020) evaluated the hindrances to the implementation of blockchain technology into supply chain management. Their study focused on the logistics industry. Gurgun *et al.* (2022) investigated the obstacles that prevent the use of cryptocurrencies in managing construction supply chain in the Turkish construction industry. Furthermore, Akinradewo *et al.* (2022) evaluated the barriers that prevent the implementation of blockchain technology in the built environment of South Africa. This research appears to be generic. The results of these studies come from countries with construction industries that are well-structured and have embraced innovative ideas, and the findings are specific to the nations in which they were conducted. There is no evidence that blockchain technology has been implemented in the Nigerian construction industry, despite the fact that this technology could significantly improve the processes involved in the construction supply chain. Therefore, the objective of this research is to examine the barriers preventing the Nigerian construction industry from using blockchain technology to manage the construction supply chain.

2. Literature review

This section discusses blockchain technology in the construction industry, including architecture, industry applications, supply chain impact and implementation challenges.

Its goal is to summarise existing research, highlight benefits and challenges and provide recommendations for future development.

2.1 Blockchain architecture

Blockchain technology is a distributed ledger platform composed of blocks (Six *et al.*, 2022) that, like a traditional public ledger, stores a comprehensive list of data (Zheng *et al.*, 2017). These blocks connect information in a chain-like pattern (Nanayakkara *et al.*, 2016), which can advance data reliability, and are made up of some basic components such as transactions, a hash and nonce value (Kim *et al.*, 2020). Transactions in this context may be described as data intended to be stored by participants on the blockchain platform and protected by a network of decentralised nodes to prevent modification (Nanayakkara *et al.*, 2016) and aided by protocols that require users to confirm transactions before posting to ensure their validity (Baiod *et al.*, 2021). A hash value is an alphanumeric code of a block generated by a hash function that depicts the contents of the block and is commonly 64 characters long (Guo and Yu, 2022), which changes as any change occurs to the block (Nofer *et al.*, 2017), whereas a nonce value is a random value that makes the first digits of corresponding hash values equal zero (Kim *et al.*, 2020). Nanayakkara *et al.* (2016) found that the number of zero digits is closely linked to how hard it is to make blocks, which is also how secure blocks are. According to Kim *et al.* (2020), the operational system of blockchain begins with the construction of blocks, and the first block is known as the "Genesis block," which is formed by storing a pre-set quantity of transactional data that must be encrypted with a hash value generated by using a nonce value. This process is repeated until the last block is created, with the preceding block serving as the genesis block for the next one (Kim *et al.*, 2020), and this chain process makes it difficult to manipulate data in the last block (Nth block) because all of the previous blocks' hash values must be changed to make this manipulation legitimate (Nanayakkara *et al.*, 2016). This makes the technology exceptional in terms of data reliability and security and also allows participants to collaborate with one another in recording, verifying, storing, and extracting information in a transparent manner (Kim *et al.*, 2020). However, leveraging on the architecture of blockchain technology in the construction supply chain is a fairly recent development. Hu *et al.* (2019) reported that blockchain application in the industry is capable of maintaining cyber protection and streamlining energy demand and supply, especially when it is integrated with BIM.

2.2 Blockchain technology and the construction supply chain

The construction supply chain includes client, consultant, contractor, subcontractor, supplier and manufacturer organisations with connections in both upstream and downstream networks (Watt, 2020). It encompasses all aspects of construction from initial demand, design and construction to building and other structural maintenance, replacement and ultimate destruction (Studer and De Brito, 2021). Hence, due to its complex nature, it has given room for fraudulent activities (Studer and De Brito, 2021), which has affected the overall productivity of the industry (Shemov *et al.*, 2020). A hidden goal of the construction industry (Hamledari and Fischer, 2021) has been to use blockchain technology to improve transparency, trust, security and strategic collaboration among all the construction stakeholders. However, by counting on the advancements in technological innovations such as blockchain technology, IoTs, etc., professionals and concerned stakeholders can manage the construction supply chain properly (Khan *et al.*, 2021). This will foster teamwork, transparency, increase trust and traceability to authenticate the sustainability of resources (Khan *et al.*, 2021), enhance collaboration (Čuš-Babič *et al.*, 2014) and also improve the performance of the industry (Li *et al.*, 2019). Considering the aforementioned benefits of integrating technological innovations within the supply chain and the distinctive qualities of blockchain technology, among other technological advancements, it stands out as a strong fit in terms of altering the growth and structure of the construction supply chain (Khan *et al.*, 2021). There have been studies that have explored the applicability of blockchain technology. Scholars have paid a lot of attention to how the technology can be used in the construction supply chain (Xu *et al.*, 2022), and it has been revealed that blockchain technology can help in all phases of supply chain management in the industry, from design to materials procurement, incorporation, and construction (Chew, 2019).

Furthermore, Kshetri (2018) stated that blockchain technology can help supply chains achieve their primary objectives in terms of cost, flexibility, speed, trustworthiness and sustainability and can also help in tracing the sources and processes of products or services (Khan *et al.*, 2021). Furthermore, blockchain technology and the most recent advancements in smart contract applications have also demonstrated potential for addressing the bottlenecks in the supply chain for the construction industry by offering a dependable way to condition payments on the completion of work and the delivery of material, thereby closing the gap between product and cash flows (Hamledari and Fischer, 2021). Similarly, with the implementation of blockchain technology in the construction process, each component can be traced to the site and linked to the digital version of the exact object in the building information process model (Khan *et al.*, 2021). In this manner, the unchallengeable data archive can be conserved and retained for the duration of the project's life cycle (Zheng *et al.*, 2017). Blockchain technology also provides better protection and fosters trust between suppliers and customers (Qian and Papadonikolaki, 2019), as well as accountability for reporting and auditing purposes (Khan *et al.*, 2021). Table 1 shows the benefits and the potential impacts of blockchain technology on the construction supply chain.

2.3 Barriers to the implementation of blockchain technology

Blockchain technology has tremendous opportunities for industries because it executes transactions in a permanent manner (Biswas and Gupta, 2019). However, blockchain technology implementation in various industries is a difficult task (Xu *et al.*, 2021), and these challenges need instant attention (Biswas and Gupta, 2019). Some of the germane barriers are lack of validity or authorisation issues, which as a result of inadequate testing of the new technology impedes the implementation and adoption of the technology (Akinradewo *et al.*, 2022), the absence of required regulations, laws and other legal issues is also a barrier to the adoption of blockchain (Biswas and Gupta, 2019). There are other numerous barriers to the adoption of blockchain technology, especially in the construction industry. However, based on an extensive literature review, this study found 13 barriers to blockchain adoption. Table 1 lists these barriers.

3. Research method

This study employed a quantitative research approach, which was conducted using a questionnaire survey to evaluate the barriers to the implementation of blockchain technology in construction supply chain management. Quantitative research assists in generating objective data that can be communicated clearly using statistics and numbers (Chih-Pei and Chang, 2017). The barriers to blockchain implementation in the construction industry were obtained through an extensive review of literature, and these barriers were prepared in a closed-ended questionnaire, which was used to collect information from respondents within the Nigerian construction industry, particularly in the south-west geopolitical zone. This study, like a similar one by Akinradewo *et al.* (2022), used a closed-ended questionnaire to collect data because its quantitative nature facilitates statistical analysis and its respondents' answers are easy to interpret (Kothari, 2004). However, in order to test the reliability of the

Code	Barrier	Implied meaning	Authors/Sources
B1	Authorisation issues	The blockchain technology has not been adequately tested in pilots, and a lack of verification may obstruct its implementation and use	Akinradewo *et al.* (2022), Rejeb *et al.* (2022)
B2	Legal issues	Legal issues (such as smart contracts, data protection regulations, litigation, and dispute resolution) can halt blockchain implementation and use in the construction industry	Biswas and Gupta (2019), Gurgun *et al.* (2022)
B3	Vulnerability of smart contract	Human error and poorly coded contracts could have disastrous consequences	Akinradewo *et al.* (2022)
B4	Energy consumption	Massive amounts of energy are needed to run Proof-of-Work protocols, which has an impact on the built environment in terms of emissions, grid capacity, and demand	Farooque *et al.* (2020), Petri *et al.* (2020)
B5	Transactional uncertainties	Fluctuations in cryptocurrency valuations means they are not yet stable enough for use in construction projects	Beer and Weber (2015), Nofer *et al.* (2017), Akinradewo *et al.* (2022)
B6	Interoperability	When different applications need to communicate, data transfer challenges arise, which is a major challenge for BIM in construction	Akinradewo *et al.* (2022)
B7	Reluctance to adopt	Individuals' reluctance to use blockchain due to cutting-edge technology will prevent it from being implemented and used	Rana *et al.* (2021), Wang *et al.* (2020)
B8	Lack of infrastructure	Sufficient server capacity is required for system stability, as is continuous Internet connectivity, and elements of the supply chain delivery system may fail if connectivity is lost	Singh and Kim (2019)
B9	Security issues	Endpoint vulnerabilities, vendor risks, unsubstantiated at full scales, untested code, and other factors can all harm blockchain implementation	Mendling *et al.* (2018), Li (20181), Öztürk and Yildizbaşi (2020), Rana *et al.* (2021)
B10	Resistance to change	Traditional industries, which are generally resistant to new technologies, find it difficult to adopt new technologies	Mahmudnia *et al.* (2022), Hamma-adama *et al.* (2020)
B11	Skills	Inadequate blockchain technology skills among employees and executives will have an impact on how blockchain is planned to be implemented and used in the construction industry	Risius and Spohrer (2017), Hawlitschek *et al.* (2018), Vidan and Lehdonvirta (2019), Akinradewo *et al.* (2022)
B12	Technological state of the industry	due to the delayed digitalisation, the construction industry's productivity has essentially lagged behind that of other sectors	Hamma-adama *et al.* (2020)
B13	Poor digitalisation of the construction industry	Despite technological advances in the majority of industries, the construction industry has been among the slowest to embrace digital technology	Hamma-adama *et al.* (2020)

(*continued*)

Table 1.
Barriers and benefits of blockchain technology implementation on construction supply chain

Code	Benefits	Implied Meaning	Authors/Sources
BE1	Increased transparency	Enhanced visibility and accountability in construction processes and transactions	Chakma *et al.* (2021), Singh and Kim (2019), Omanwa (2023)
BE2	Improved traceability	Ability to track and verify the origin, history, and movement of construction materials and components	Omanwa (2023)
BE3	Enhanced security	Strong cryptographic mechanisms protect data integrity and prevent unauthorised access or tampering	Javaid *et al.* (2022), Okanlawon *et al.* (2023)
BE4	Streamlined payment	Facilitates secure and efficient payment processes, reducing delays and eliminating intermediaries	Chakma *et al.* (2021), Singh and Kim (2019), Chen *et al.* (2022)
BE5	Smart contract automation	Self-executing contracts and automated processes enable efficiency, accuracy, and cost savings	Mahmudnia *et al.* (2022), Hamma-adama *et al.* (2020)
BE6	Improved dispute resolution	Tamper-proof records and transparency aid in resolving disputes quickly and fairly	Allison and Warren (2019)
BE7	Efficient supply chain management	Real-time monitoring and automated tracking of construction supply chain activities	Okanlawon *et al.* (2023)
BE8	Increased collaboration	Facilitates secure and transparent collaboration between project stakeholders	Okanlawon *et al.* (2023), Öztürk and Yildizbaşi (2020)
BE9	Improved quality control	Transparent and immutable records help ensure adherence to quality standards	Mahmudnia *et al.* (2022)
BE10	Efficient asset management	Digitally tracking and managing construction assets throughout their lifecycle	Hamma-adama *et al.* (2020)

Table 1.

Source(s): Authors' own creation

scale and the internal consistency of the questionnaire, Cronbach alpha was used, yielding a value of 0.880 which is higher than the acceptable value of 0.70 as stated by (Oyewobi *et al.*, 2017). Furthermore, since this study is exploratory in nature, exploratory surveys were utilised to select individuals with specific characteristics that may aid in comprehending the subject being studied as the sample. This approach was employed to obtain a better understanding of the factors that hinders the adoption of blockchain technology. This helps to connect ideas and understand the background of the research without introducing any preconceived biases.

Participants were to complete the questionnaires by rating their level of agreement or disagreement with the barriers listed in Table 1 using the five-point Likert scale provided in the survey. Prior to conducting a large-scale study without sufficient familiarity with the methods proposed, a pilot study was conducted with two academics and three professionals identified to have possessed adequate knowledge of the subject matter to test the questionnaire's adequacy and to make sure the questions were easily understood by the respondents (Polit and Beck, 2017). The identified target population for the main survey includes both government and private sector professionals who are quantity surveyors, architects, engineers, builders and others. This is because blockchain technology is a relatively new innovation in the construction industry, the people who were chosen as respondents were those who knew about blockchain technology and how it could be used in the construction industry, as well as those who were directly involved in the industry.

However, due to the inability to accurately determine the population for the research, researchers have employed a mix of non-probability methods, including snowball sampling, quota sampling and purposeful sampling, to select participants (Lau, 2017). Snowball sampling, commonly used in qualitative research, entails the researcher reaching out to individuals who, in turn, aid in connecting them with potential research participants (Naderifar *et al.*, 2017). Nevertheless, quantitative researchers have acknowledged the merits of snowball sampling and have utilised it as a pragmatic approach to recruit study participants who are challenging to reach. This is exemplified in a similar study conducted on blockchain by Akinradewo *et al.* (2022). Therefore, the snowball sampling strategy was employed to access the population of this study, whereby study participants actively enlisted others to take part in the research (Kothari, 2004). Hence, only construction professionals who are familiar with blockchain technology were used for this study. A total of 175 questionnaires were administered electronically using Google Forms to those professionals identified, and 160 of them were retrieved, but only 155 were completely filled out by the study population, vetted and ascertained to be useable for further statistical analysis presented in this paper. Descriptive statistics and exploratory factor analysis (EFA) were used to analyse the collected data with the aid of Statistical Package for Social Science (SPSS) version 26. EFA is a statistical analysis tool that can be used to cluster large amounts of data into a small and manageable size by investigating the variables' fundamental theoretical structure (Oyewobi, 2014). Hence, to assess the appropriateness of the dataset collected for EFA, the Kaiser–Meyer–Olkin (KMO) and Bartlett's test were conducted. The outcome of these tests indicated a KMO value of 0.876, surpassing the recommended threshold of 0.6 (Pallant, 2011), and a statistically significant Bartlett's test of Sphericity with a significance level of 0.00.

3.1 Research findings

3.1.1 Demographic information. From the analysis of respondents' information, it was revealed that the majority of the respondents are quantity surveyors (48.40%), followed by builders (22.60%) while other professionals had (7.10%). It was revealed that majority of the respondent were male (83.9%), and 16.10% were females. Furthermore, it also shows that most of the respondents are BSc holders (38.10%). Furthermore, the table shows that 27.10% of the respondents have 2–3 years of experience, 25.80% have more than 5 years of experience and 10.30% have less than a year of experience. This indicates that the respondents are experienced and have the requisite educational background. Hence, this makes all respondents of this study capable of providing required information to actualise the objective of this study.

3.1.2 perception of construction professionals on the barriers to the implementation of blockchain technology. Table 2 displays how respondents across various categories ranked the barriers to implementing blockchain technology in construction supply chain. The table also shows the significant *p*-values for each barrier, which were derived from the Kruskal–Wallis test. Upon analysing the *p*-values, it is evident that all identified barriers have a significant *p*-value of over 0.05, indicating a shared perception among the respondents regarding the severity of the challenges. The overall ranking of the barriers reveals that poor digitalisation of the construction industry, the technological state of the sector, authorisation issues and resistance to change are the top-rated barriers. These barriers had an overall mean importance score (MIS) of 4.34, 4.29, 4.22 and 4.22, respectively. However, all the barriers identified scored above the midpoint of 3.0, which suggests that the construction industry is yet to fully adopt technological innovation and digitalisation in all aspects of its operations. Furthermore, since blockchain is a relatively new technological innovation, it has not undergone adequate testing for full verification, which poses a significant obstacle to its adoption in the construction industry. The findings further confirm that the construction sector is rigid and resistant to change in adopting technological innovations.

3.1.3 Barriers to the implementation of blockchain technology. Table 2 reveals the respondents' ranking of the barriers to the implementation of blockchain technology in the management of the construction supply chain. Therefore, to enhance decision on the level of

Barrier variables	Quantity surveyor	Rank	Architect	Rank	Engineer	Rank	Builder	Rank	Others	Rank	Overall	Rank	Kruskal–Wallis H	DF	*p*-value	MIS	Rank
	Mean rank																
Authorisation issues	4.16	5	4.06	6	4.25	4	4.43	3	4.18	2	4.22	3	4.90	4	0.30	4.22	*3*
Lack of infrastructure	4.19	3	4.11	5	4.25	4	4.14	11	4.27	1	4.19	7	0.50	4	0.97	4.18	*7*
Vulnerability of smart contract	4.15	6	4.11	5	4.19	5	4.20	9	4.00	4	4.13	9	0.58	4	0.97	4.15	*9*
Energy consumption	4.04	7	4.06	4	3.81	9	4.17	10	4.27	1	4.07	13	2.16	4	0.71	4.06	*13*
Transactional uncertainties	4.15	6	3.78	8	3.88	8	4.37	5	4.09	3	4.05	11	7.09	4	0.13	4.12	*11*
Interoperability	3.92	8	4.11	5	4.06	7	4.40	4	4.09	3	4.12	12	7.11	4	0.13	4.08	*12*
Legal issues	4.04	7	4.06	9	4.38	1	4.26	8	4.09	3	4.17	10	2.52	4	0.64	4.13	*10*
Security issues	4.15	6	4.17	4	4.13	6	4.31	7	4.27	1	4.21	6	1.40	4	0.85	4.19	*6*
Reluctance in adoption	4.15	6	3.94	7	4.31	3	4.46	1	4.09	3	4.19	5	7.72	4	0.10	4.21	*5*
Resistance to change	4.17	4	4.22	3	4.25	4	4.29		4.18	2	4.22	4	0.44	4	0.98	4.21	*4*
Skills	4.19	3	4.06	6	4.06	7	4.34	6	4.00		4.13	8	4.27	4	0.37	4.18	*8*
Technological state of the industry	4.20	2	4.33	1	4.50	2	4.34	6	4.09	3	4.29	2	2.70	4	0.61	4.27	*2*
Poor digitalisation of the construction industry	4.24	1	4.28	2	4.56	1	4.43	2	4.18	2	4.34	1	2.72	4	0.61	4.32	*1*

Source(s): Authors' fieldwork

Table 2.
Perception of construction professionals on the barriers to the implementation of blockchain technology and descriptive analysis of the barriers to the implementation of blockchain technology

agreement of the respondents to the factors identified, the study used decision espoused by Oyewobi *et al.* (2017), where (1.0–1.49 – Strongly disagree, 1.50–2.49, Disagree, 2.50–3.49 – Somewhat agree, 3.50–4.49 Agree, 4.50–5.00 – Strongly agree). The MIS of each barrier was indicated in Table 2 to shows the respondents' level of agreement with each barrier. Remarkably, all of the identified barriers have a MIS greater than the study's average of 3.00 on a five-point Likert scale. This indicates that respondents agree that the impediments to blockchain technology implementation in the construction industry exist. From Table 2, "poor digitalisation of the construction industry" and the "technological state of the industry" are the major barriers to adopting and implementing technological innovations such as blockchain technology. This finding is consistent with a study by Hamma-Adama *et al.* (2020) that found the construction sector to be among the last to adopt digital technology, despite technological advancements in other sectors. Furthermore, it is also in line with the research of Mahajan (2018), who asserted that the construction industry's productivity has essentially lagged behind that of other sectors as a result of the delayed digitalisation. The least ranked barriers according to this study are "energy consumption," as corroborated by Farooque *et al.* (2020), who stated that the enormous energy needed to run proof-of-work protocols of blockchain technology has an impact on the built environment in terms of emissions, grid capacity, and demand. "Interoperability" and "Transactional uncertainties" were also ranked least, and this is in line with the studies of Akinradewo *et al.* (2022) and Nofer *et al.* (2017), respectively.

3.2 Discussion of findings

Based on the analysis presented in Table A1 (Appendix), two clusters were formed from the identified barriers. The following subsections name these clusters based on their characteristics.

3.2.1 Cluster 1 – technological barrier. A total of seven variables were loaded in this cluster, and they are "authorisation issues" (78.8%), "lack of infrastructure" (79.4%), "vulnerability of smart contracts" (71.3%), "energy consumption" (59.2%), "transactional uncertainties" (57.3%), "interoperability" (58.5%), and "reluctance in adoption" (53.3%). These factors are more related to the technological barriers in the construction industry, and they explain 41.06% of the total variance. The finding agrees with the study of Rejeb *et al.* (2022), who stated that blockchain adoption may be hampered by the technology's relative immaturity and a scarcity of commercial applications and also falls in line with the study of Shojaei *et al.* (2021), whose study upheld the fact that the technology appears to be promising for enabling circular economy in the built environment sector. However, the technology's application remains limited. This reflects that the authorisation issue, which is as a result of limited usage of the technology, is a major barrier that impedes its implementation in the management of the construction supply chain. This study further revealed that energy consumption is another vital barrier to the implementation of blockchain technology, and this finding resonates with the study of Böckel *et al.* (2021), who found that a significant number of studies examined the amount of energy required to run a blockchain system and concluded that the technology is inefficient in terms of energy consumption.

Interoperability, which is the ability of various information systems, applications and devices to connect in an integrated manner within and across firm boundaries in order for stakeholders to access, share and jointly utilise data (Rejeb *et al.*, 2022), is another major barrier identified by this study and this in tandem with the findings of Yildizbasi (2021), who argued that one of the most significant barriers to deploying blockchain in the circular economy is the difficult process of integrating it with existing legacy systems.

3.2.2 Cluster 2 – social–political barrier. A total number of six variables were loaded in this cluster, and they are "legal issues" (45.5%), "security issues" (54.6%), "resistance to change" (61.4%), "skills" (53.9%), "technological state of the industry" (65.4%) and "poor digitalisation"

(38.4%). One of the loaded factors has a link to the political aspect of the barriers, while the other five were viewed to be social barriers, and they explained a total variance of 11.57%.

Poor digitalisation and technological state of the industry is a key factor that hinders the implementation of blockchain technology, and this stands with the findings of Hamma-adama *et al.* (2020), which stated that despite technological advances in many industries, the construction industry is still among the last to go digital. In line with the study of Rejeb *et al.* (2022), which stated that due to the technology's recent emergence, there are no defined regulations for implementing the technology, and regulations may be a barrier to using blockchain for better resource management. Resistance to change, as corroborated by Hamma-adama *et al.* (2020), Mahmudnia *et al.* (2022), is also a major barrier that militates against the adoption and implementation of blockchain technology in the management of the construction supply chain.

4. Limitations and implications of the research

The study was carried out in Southwest Nigeria among construction experts who have knowledge of blockchain technology. However, the lack of an all-inclusive list of professionals from this region limits the results of the study. Therefore, the findings cannot be generalised to all construction professionals in Nigeria. Moreover, the study did not explore the interconnections among the identified categories of barriers, which is another drawback. Therefore, in order to obtain a more comprehensive understanding of how construction professionals perceive the hurdles to adopting blockchain technology, future studies could be conducted in other geopolitical zones in Nigeria. Furthermore, additional research could be conducted to evaluate the factors that drive the implementation of blockchain technology in the management of the Nigerian construction supply chain and determine the relationship between the drivers and barriers to adoption. The research employed a quantitative approach and a survey questionnaire to examine the factors that impedes the adoption of blockchain technology in the Nigerian construction sector. The outcome of the study has practical implications, such as the potential of blockchain technology to resolve transparency and accountability concerns in the management of the Nigerian construction industry's supply chain. It can also significantly impact operations, trust management among stakeholders, and business processes. These conclusions can aid practitioners in making informed decisions when considering the incorporation of blockchain technology into their business processes. Overall, the study evaluated the conditions and factors that impede the construction industry's transition to blockchain technology.

5. Conclusion and recommendations

The construction supply chain is frequently confronted with issues related to transactions, a lack of trust and transparency, as well as poor communication and coordination between the stakeholders. As a result, the construction supply chain's performance in terms of efficiency and productivity has been negatively impacted. To improve the effectiveness of the supply chain, it is necessary to have a very high level of trust between all parties, to be able to track the origin of all construction materials and to exchange data in the appropriate manner. Despite this, facing difficulties of this nature is still business as usual in this sector. The purpose of this research was to assess the barriers that may arise during the process of integrating blockchain technology into the management of supply chains for construction projects. The study identified obstacles to its implementation in other industries, and then, through an extensive review of the relevant literature, it evaluated those obstacles in relation to the construction industry. The Kruskal–Wallis test was carried out on the identified barriers to examine the perception of all professionals on the barriers. An exploratory analysis was also performed on the barriers in order to reduce them into a cluster group that is more manageable. These barriers were then ranked according to the severity of the obstacle they posed. According to the findings of this study, the primary challenges to the implementation of blockchain technology in construction supply chain management include insufficient digitalization of the construction industry, the technological state of the industry, authorisation issues, resistance to change, reluctance in adoption, security issues, energy consumption, and a lack of skills. The study also examined the perception of all the professionals as regards the identified barriers to the implementation of blockchain technology in the management of construction supply chain and it was discovered that all the professionals have a synonymous perception on all the barriers. The exploratory analysis employed assisted in clustering the barriers into two (2) groups, namely technological and socio–political barriers. These groups were named after the names of the respective types of barriers. This provides an explanation for the positions taken by the respondents regarding the use of blockchain technology in the construction industry. The level of technological innovation adoption in the built environment is relatively low, and this could be linked to the poor digitalisation of the industry, which is a major challenge in the implementation of blockchain technology. In addition, the immaturity of the technology (authorisation problems), the policies of the government and the absence of the necessary infrastructure all present significant obstacles to the implementation of this technology in the construction industry. As a consequence of this, it is of the utmost importance that the numerous parties involved in the built environment identify and comprehend the potential obstacles that could prevent the implementation of blockchain technology in the process of the construction supply chain. This will make it easier to overcome these barriers and encourage construction professionals to consider adopting blockchain technology as an alternative solution to the persistent trust and transparency problems that are often encountered in the construction supply chain, particularly in construction-related projects. This will be especially helpful for construction projects that involve the construction of buildings. Governments at all levels, policymakers and other interested parties are also urged to implement policies that will facilitate the industry's adoption of technological innovations. This study paves the way for the application of blockchain technology in the process of construction supply chain management, which will help bridge the trust, transparency and coordination gap between participants in the industry, particularly in the south-western region of Nigeria. In order to get a better overall picture of the development of technology in Nigeria's construction sector, additional research into the barriers that exist in other regions of the country can be carried out. The construction sector in Nigeria presents another opportunity for analysing the applicability, effects and implications of the technology.

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Further reading

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Appendix

The supplementary material for this article can be found online.

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