Benefits of Blockchain Technology in the Prefabricated Construction Industry

Peter Adekunle[1], Cliton Aigbavboa[1], Osamudiamen Otasowie[1], Matthew Ikuabe[1]

[1] acidb Centre for Excellence & Sustainable Human Settlement and Construction Research Centre, Faculty of Engineering and the Built Environment, University of Johannesburg, South Africa.
Adekunlepeter90@gmail.com

Abstract

The blockchain technology is currently undergoing a global transformation in various industries, including the construction sector. Blockchain technology is required by the construction industry to overcome the present centralized technology's limitations throughout the numerous project life cycles. The ability of the construction sector to take advantage of new technological options to increase productivity has long been criticized. This research looks at the advantages of using blockchain technology in the prefabricated building sector and how it may revolutionize for increased efficiency. In order to collect information from architects, civil engineers, quantity surveyors, mechanical and electrical engineers, construction managers, and project managers, the study used a quantitative survey approach. Using SPSS, the data were evaluated, and the appropriate dispersion measure and inferential statistics were used. The findings showed how blockchain technology might boost efficiency in the construction sector by considering certain project management situations. The study came to the conclusion that, despite being predominantly associated with Bitcoin and other cryptocurrencies, blockchain technology has the potential to provide clarity to the prefabricated building industry's sometimes muddled supply chain.

Keywords

Blockchain, Prefabricated construction, Decentralise, Construction Stakeholders

1. Introduction

The construction sector significantly increases employment across the economy, not simply in the building sector (Kim et al., 2020). The construction industry generates its goods and services using a wide range of inputs from several sources in other industries, and it indirectly helps to create jobs in a number of other industries. The construction has had a challenging several years due to a persistently poor economy, disruptions at construction sites, corruption-related activities, and the sector's reaction to COVID-19. According to Perera et al., (2020) for construction enterprises to remain relevant and competitive, they must take the lead in identifying, appraising, and adopting new technological breakthroughs. Prefabrication applications, which aim to make construction more efficient, effective, productive, and improve the quality of delivered projects in less time than traditional construction methods, have drawn a lot of interest and are gradually coming to be recognized as an effective technological advancement with significant economic, social, and environmental benefits in the construction sector.

Buildings that are constructed using off-site created components fall into the four categories of pre-cut, panelized, modular, and manufactured prefabricated buildings, which are further classified into two types, assembled and unassembled structures (Belle, 2017). Pre-cut construction materials are made from raw materials and processed to be sent in packages or ready-to-assemble kits. They have been machined to a specified size and have been notched and drilled in compliance with standards. Panelized construction is similar to pre-cut manufacturing in that it assembles the component parts into complete panel units in addition to converting raw materials into useable two-dimensional (2D) prefabricated panel pieces. By having whole three-dimensional (3D) building modules produced and preassembled at an offsite facility before being deployed on the construction site, modular building, also known as mobile houses, adds another degree of manufacturing to panelized construction (Prakash & Ambekar, 2020). The use of blockchain technology is anticipated to present a possible possibility for the market adaption of prefabricated

buildings due to the intricacy of prefabricated construction. Blockchain is a distributed public ledger of data records of all completed digital events or transactions that is available to all ledger members, according to Wang et al., (2017). The public ledger's every completed transaction is recorded on the blockchain, which is unchangeable and traceable. Due to a verifiable and secure chain of records, blockchain enables authorized parties to access information in the distributed ledger with a high level of trust and transparency (Lanko et al., 2018).

Making sure that payments to stakeholders are made on time is one of the challenges faced by the prefabricated construction sector. Using blockchain technology will improve the accountability and integrity of the payment process by offering secure, traceable payments (Wu et al., 2022). The decentralized and project-based nature of the prefabricated construction sector makes contact between many parties over a long period of time necessary. As a result, coordination problems such as a lack of trust, poor information flow, and supply chain fragmentation occur. The potential advantages of blockchain-based trustworthy transactions are consistent with these coordination problems. Blockchain technology has the potential to improve accountability, transparency, efficiency, and effectiveness for all stakeholders engaged in the prefabricated building process (Wang et al., 2022). Validating why the study aims to assess the benefits of blockchain technology across various prefabricated construction industry stages. Blockchain technology uses a network of servers to maintain a distributed ledger of data, including transactions and agreements that are shared across ledger participants. Although the data is available to a network of users and stored in chronological order, it is decentralized and not controlled by a single entity, such as a bank or government (Azmi et al., 2022). Even if it has consequences for many industries, project management in the prefabricated building industry is made easier by blockchain. Construction projects frequently run into problems, and poor communication between contractors, suppliers, and staff can delay project completion. Applications of blockchain technology are being adopted more often, which will eventually boost the efficiency of the prefabricated construction sector. Thanks to blockchain technology, the prefabricated construction industry now has a great possibility to become more efficient, transparent, productive, and sustainable (Singh, 2020).

According to Hultgren & Pajala, (2018), the detailed structure of blockchain technology is a peer-to-peer distributed ledger that is secure and used to record transactions across many systems. Only by attaching a new block to the one before the contents of the blockchain may be modified. According to business vernacular, another way to think about it is as a peer-to-peer network resting on top of the internet. This platform enables users to conduct transactions of any sort without the need for a central or credible arbiter. The benefit of blockchain is that once the data has been verified by all nodes, it cannot be changed or removed from the public ledger, giving blockchain its qualities for data security and integrity (Kim et al., 2020). Similar to how the blockchain of Bitcoin operates, which has no central authority and has proven to be incredibly resilient to attacks since its inception in 2009, operates, if one block is changed, the entire chain must also be changed, which cannot be done without the consent of the majority of the network (Teisserenc & Sepasgozar, 2021).

Blockchain creates an audit trail that documents an asset's origins at every stage of its journey, according to Yang et al., (2020), and this helps to provide the proof in economic sectors that deal with fraud and counterfeiting. Data on traceability may also disclose weaknesses in any supply chain because items may be parked on a loading dock while awaiting transportation, which is made possible by blockchain, and provenance information can now be directly sent to customers. Since every network user with permissions can view the same data at once and all transactions are time and date stamped records with immutability, blockchain technology uses a distributed ledger to keep identical records of transactions and data across many websites. This ensures complete transparency. Members get access to the complete transaction history, virtually eliminating the chance of fraud. A virtual currency like Bitcoin is used by blockchain, also known as distributed ledger technology, to build secure, private networks where transactions may be made and records kept (Figueiredo et al., 2022). Since these networks are totally transparent and work as trust circles, every member of a private network has their own password, just like any private network does, and every member of the group can see every transaction and the person who approved it. All transactions must input these passcodes to be permitted, and full of them are logged and made publicly available to everyone in the group. Cryptography is used to ensure all payment security and transaction protection. According to (Alnahari & Ariaratnam, 2022), transactions may even be automated with the use of smart contracts, increasing your efficiency and quickening the process even more. Smart contracts reduce the need for human intervention and rely less on third parties to verify that a contract's terms have been followed since the next stage in a transaction or process is automatically triggered whenever pre-specified conditions are met.

Smart contracts may formalize trust between businesses and promote effective cooperation by offering tamper-proof storage, workflow and rule automation, and decentralized identity provision. According to Kiu et al., (2022), blockchain technology in procurement provides transparency throughout the entire supply chain lifecycle because it has the capacity to keep track of every transaction that has ever occurred. With such a high level of transparency, everyone involved in the supply chain is always aware of what is happening.

2. Methods

A structured questionnaire was employed in this study's quantitative technique, and it was distributed to quantity surveyors, architects, engineers, construction managers, and project managers. These specialists were picked from the contracting and consulting industries in both the public and private sectors. These professionals were picked from Gauteng, the province with a large percentage of construction professionals in the nation. Also, due to its strategic location and ability to perform administrative tasks, the province was chosen. Additionally, the province serves as the hub for the provision of high-end services to a variety of sectors, including manufacturing, technical and industrial services, and construction. The target professions for the construction sector were those who were members of the various professional associations in South Africa and other Southern African nations. This safeguard was judged necessary for the survey to ensure that the results truly represented the public's impression of the benefits of implementing robotic technology. The sample size was determined by non-randomly selecting 100 experts. Similar to the closed-end questionnaire used in Adekunle et al., (2022) study that was also divided into two parts. In the first section, the respondents' demographic information, such as their level of education, line of work, and experience—was gathered. The second section's goal was to assess the advantages of employing blockchain. Using a 5-point Likert scale, the benefits of robotic usage were assessed. A response was given to 81 out of the 100 questionnaires that were handed out, or 81% of them. Percentages were utilized to evaluate the benefits of utilizing blockchain technology in pre-fabricated homes when the data was analyzed, and Mean Item Score (MIS) was used to grade the information on the respondents' backgrounds. Additionally, the Kruskal-Wallis test was employed to contrast respondents' viewpoints according to their level of experience. The reliability of the data sets was assessed using the Cronbach's alpha reliability test, which produced a value of 0.805, which indicates a good level of consistency.

3. Results

The research states that 37 percent of responses are clients, and the next highest percentages are project managers (10.1%), architects (9.3%), civil engineers (9.7%), quantity surveyors (18.3%), and project managers (10.1%). 35.5% of respondents reported having one to five years of construction-related work experience, and 40.2% reported having six to ten years. Only 5.5% of the population had experience of between 11 and 15 years, compared to 18.8% of respondents who had worked in the construction industry for at least 16 years or more.

Table 1 shows the respondents' ranking of benefits of blockchain technology applications in the prefabricated construction industry. According to the respondents results indicated that the top six ranked benefits were: promote accountability ranked first with (MIS= 4.44; SD=0.665), streamline procurement and supply chain ranked second with (MIS= 4.39; SD=0.712), promote transparency ranked third with (MIS= 4.38; SD=0.675), promote traceability ranked fourth with (MIS=4.37; SD= 0.757), immutable and unalterable record keeping ranked fifth with (MIS= 4.35; SD= 0.703) and promote security of payment transactions ranked sixth with (MIS=4.32; SD=0.714). The middle six ranked stages were: accelerated payment transactions was ranked seventh with (MIS=4.30; SD=0.617), Hinder corruption and fraud ranked eighth with (MIS=4.27; SD=0.812), ease accessibility of all information and transactions ranked ninth with (MIS=4.26; SD=0.642), auditability trace ranked tenth with (MIS=4.24; SD= 0.688), advanced and clear record keeping ranked eleventh with (MIS=4.24; SD= 0.754), enhancing of trust and instantaneous collaboration ranked twelfth with (MIS=4.23; SD=0.812) and smart contracts that are always on track ranked thirteenth with (MIS= 4.20; SD=0.788. The bottom six ranked stages were: time efficient ranked fourteenth with (MIS=4.11; SD=0.792), promote privacy ranked fifteenth with (MIS=3.94; SD= 1.134), keeping track of project work progress ranked sixteenth with (MIS=3.88; SD= 0.884), scalable to any project size ranked seventeenth with (MIS=3.85; SD=0.963), eliminate suspicious and duplicate transactions ranked eighteenth with (MIS=3.48; SD= 1.135) and cost reductions ranked nineteenth with (MIS=3.33; SD= 0.986).

Table 1. Benefits of Blockchain

Benefits	N	Mean Item Score	Std. Deviation	Rank
Promote accountability	84	4.44	0.665	1
Streamline procurement and supply chain	84	4.39	0.712	2

Promote transparency	84	4.38	0.675	3
Promote traceability	84	4.37	0.757	4
Immutable and unalterable record keeping	84	4.35	0.703	5
Promote security of payment transactions	84	4.32	0.714	6
Accelerated payment transactions	84	4.30	0.617	7
Hinder corruption and fraud	84	4.27	0.812	8
Ease accessibility of all information and transactions	84	4.26	0.642	9
Auditability trace	84	4.24	0.688	10
Advanced and clear record keeping	84	4.24	0.754	11
Enhancing of trust and instantaneous collaboration	84	4.23	0.812	12
Smart contracts that are always on track	84	4.20	0.788	13
Time efficient	84	4.11	0.792	14
Promote privacy	84	3.94	1.134	15
Keeping track of project work progress	84	3.88	0.884	16
Scalable to any project size	84	3.85	0.963	17
Eliminate suspicious and duplicate transactions	84	3.48	1.135	18
Cost reductions	84	3.33	0.986	19

4. Discussion

The most notable benefits of blockchain technology applications in the prefabricated construction industry are ranked as: promote accountability, promote transparency, promote traceability, immutable and unalterable record keeping, promote security of payment transactions, accelerate payment transactions, and hinder corruption and fraud. The results were consistent with research by Mohammed et al., (2021) &(Adekunle, Aigbavboa, et al., 2022). According to Perera et al., (2020) research, blockchain will encourage transparency, traceability, and According to Prakash & Ambekar, (2020) study, blockchain uses a distributed ledger in which identical records of transactions and data are kept across numerous sites. This ensures full transparency and traceability because every network user who has the necessary permissions can view the same data simultaneously. Additionally, because all transactions are time and date stamped records with immutability, fraud and corruption are completely eliminated. According to Lanko et al., (2018) research, blockchain technology would increase payment security, speed up transaction times as cryptography ensures that all payments are secure and that transactions are protected. All transactions require passcodes to be permitted, and all of them are recorded and made public to everyone in the group. Also, according to Wang et al., (2017) study, transactions may even be automated with the use of smart contracts, increasing your efficiency and hastening the process even more. The findings diverged from that of the Hultgren & Pajala, (2018) study, which found that blockchain technology will improve trust, instantaneous collaboration, and procurement. Instead, the Alnahari & Ariaratnam, (2022) study found that smart contracts can systematize trust between organizations and enable effective collaboration by providing tamper-proof storage, workflow and rule automation, and decentralized identity provision. The findings also diverged from research published by Kiu et al., (2022), which claimed that blockchain technology will enhance procurement over the whole supply chain lifecycle.

It is crucial to invest time and resources in training and educating the various stakeholders about blockchain technology applications and how it can make their job easy in terms of delivering the project on time, within the specified budget with better accountability and timeliness since the results in comparison with literature reveal that the respondents are aware of the benefits of blockchain technology applications in the prefabricated construction industry.

5. Conclusions

In various industries, blockchain technology has been used. For instance, the electric industry trades power using smart contracts on the blockchain. Additionally, there is ongoing study into the possible uses of blockchain technology in higher education, including the creation of a worldwide network to store student loans, transcripts of schooling, and other things that may be described in code. In addition, a lot of current research focuses on the use of blockchain in the banking, medical records, land transfer, and food supply chain industries. Furthermore, it is anticipated that blockchain technology would help many sectors and industries, including the prefabricated building industry in the near future, as well as governmental administration (such as passport and identity) and the creation of smarter cities. In conclusion, blockchain technology is currently in its experimental stages and is still relatively new to the construction sector. The advantages and possibilities of blockchain use in the construction sector should not be disregarded, though. Benefits of blockchain technology have been found for the prefabricated building sector, and they include contract management, building information modelling (BIM) systems, data risk management, property management, supply chain management, and funding management. Decentralised, autonomous, peer-to-peer, immutable record, and timestamping are the distinctive characteristics of the blockchain application, which also increase work productivity, save time and money, ensure data security, eliminate errors in information transfer and usage, and promote international collaboration in the construction industry. Despite the benefits, a lot more work has to be done before it can be said that blockchain is an essential component of the building and modular construction process.

References

Adekunle, P., Aigabvboa, C., Thwala, W., Akinradewo, O., & Oke, A. (2022). Challenges confronting construction information management. *Frontiers in Built Environment*, *8*(December). https://doi.org/10.3389/fbuil.2022.1075674

Adekunle, P., Aigbavboa, C., Akinradewo, O., Oke, A., & Aghimien, D. (2022). Construction Information Management: Benefits to the Construction Industry. *Sustainability*, *14*(18), 11366. https://doi.org/10.3390/su141811366

Alnahari, M. S., & Ariaratnam, S. T. (2022). The Application of Blockchain Technology to Smart City Infrastructure. *Smart Cities*, *5*(3), 979–993. https://doi.org/10.3390/smartcities5030049

Azmi, N. Al, Sweis, G., Sweis, R., & Sammour, F. (2022). Exploring Implementation of Blockchain for the Supply Chain Resilience and Sustainability of the Construction Industry in Saudi Arabia. *Sustainability (Switzerland)*, *14*(11). https://doi.org/10.3390/su14116427

Belle, I. (2017). The architecture, engineering and construction industry and blockchain technology. *Proceedings of 2017 National Conference on Digital Technologies in Architectural Education and DADA 2017 International Conference on Digital Architecture*, *September 2017*, 279–284. https://www.researchgate.net/publication/322468019

Figueiredo, K., Hammad, A. W. A., Haddad, A., & Tam, V. W. Y. (2022). Assessing the usability of blockchain for sustainability: Extending key themes to the construction industry. *Journal of Cleaner Production*, *343*(February), 131047. https://doi.org/10.1016/j.jclepro.2022.131047

Hultgren, M., & Pajala, F. (2018). *Blockchain technology in construction industry: Transparency and traceability in supply chain*. 1–55. http://www.diva-portal.org/smash/get/diva2:1229861/FULLTEXT01.pdf

Kim, K., Lee, G., & Kim, S. (2020). A Study on the Application of Blockchain Technology in the Construction Industry. *KSCE Journal of Civil Engineering*, *24*(9), 2561–2571. https://doi.org/10.1007/s12205-020-0188-x

Kiu, M. S., Chia, F. C., & Wong, P. F. (2022). Exploring the potentials of blockchain application in construction industry: a systematic review. *International Journal of Construction Management*, *22*(15), 2931–2940. https://doi.org/10.1080/15623599.2020.1833436

Lanko, A., Vatin, N., & Kaklauskas, A. (2018). Application of RFID combined with blockchain technology in logistics of construction materials. *MATEC Web of Conferences*, *170*, 1–6. https://doi.org/10.1051/matecconf/201817003032

Mohammed, A., Almousa, A., Ghaithan, A., & Hadidi, L. A. (2021). The role of blockchain in improving the processes and workflows in construction projects. *Applied Sciences (Switzerland)*, *11*(19). https://doi.org/10.3390/app11198835

Perera, S., Nanayakkara, S., Rodrigo, M. N. N., Senaratne, S., & Weinand, R. (2020). Blockchain technology: Is it hype or real in the construction industry? *Journal of Industrial Information Integration*, *17*, 100125. https://doi.org/10.1016/j.jii.2020.100125

Prakash, A., & Ambekar, S. (2020). Digital transformation using blockchain technology in the construction industry.

Journal of Information Technology Case and Application Research, *22*(4), 256–278. https://doi.org/10.1080/15228053.2021.1880245

Singh, P. (2020). Blockchain based Security Solutions with IoT Application in Construction Industry. *IOP Conference Series: Earth and Environmental Science*, *614*(1). https://doi.org/10.1088/1755-1315/614/1/012052

Teisserenc, B., & Sepasgozar, S. (2021). Project data categorization, adoption factors, and non-functional requirements for blockchain based digital twins in the construction industry 4.0. *Buildings*, *11*(12), 1–51. https://doi.org/10.3390/buildings11120626

WANG, J., WU, P., WANG, X., & SHOU, W. (2017). The outlook of blockchain technology for construction engineering management. *Frontiers of Engineering Management*, *4*(1), 67. https://doi.org/10.15302/j-fem-2017006

Wang, X., Liu, L., Liu, J., & Huang, X. (2022). Understanding the Determinants of Blockchain Technology Adoption in the Construction Industry. *Buildings*, *12*(10). https://doi.org/10.3390/buildings12101709

Wu, H., Zhang, P., Li, H., Zhong, B., Fung, I. W. H., & Lee, Y. Y. R. (2022). Blockchain Technology in the Construction Industry: Current Status, Challenges, and Future Directions. *Journal of Construction Engineering and Management*, *148*(10). https://doi.org/10.1061/(asce)co.1943-7862.0002380

Yang, R., Wakefield, R., Lyu, S., Jayasuriya, S., Han, F., Yi, X., Yang, X., Amarasinghe, G., & Chen, S. (2020). Public and private blockchain in construction business process and information integration. *Automation in Construction*, *118*(May), 103276. https://doi.org/10.1016/j.autcon.2020.103276

.