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BLOCKCHAIN TECHNOLOGY AND ITS POTENTIAL FOR THE CONSTRUCTION INDUSTRY

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Abstract

Blockchain was introduced as the underlying technology to enable cryptocurrency transactions among untrusted parties. Today, its transformative potential is often compared to that of the World Wide Web, and both practitioners and researchers across all domains are exploring how to utilise blockchain technology to address long-standing problems around data integrity, transparency, and trust. A significant number of research and case study findings indicate many industries are already exploring the diverse benefits of blockchain technology. Analysis of how other industries adopt blockchain could help to understand how to solve similar types of problems in the construction industry. This paper critically analyses the potential to use blockchain in the construction industry. Research findings show that the blockchain technology and its capabilities are mature enough to support many use cases in the construction industry, and the industry's inertia in adopting new technologies seems to be the only hurdle. Two major sectors where blockchain technology could have a greater and immediate impact include the building information modelling and supply chain management.

Keywords

Blockchain; Construction Industry; Smart Contract; Supply Chain Management; Technology Adaptation;

Introduction

The blockchain is an innovative technology first introduced in 2008 through the emergence of Bitcoin (Nakamoto, 2008; Abeyratne and Monfared, 2016). Due to the mainstream attention on Bitcoin, blockchain was first seen as a way to create new digital currencies where people could anonymously transact among untrusted participants transcending geographical boundaries (Wang et al., 2017). However, as time went on, new use cases were explored as industry professionals began to see the significant benefits of blockchain.

The key properties of blockchains include the immutability, consistency, transparency, and disintermediation where data stored on the blockchain cannot be tampered with or deleted (Efanov and Roschin, 2018; Underwood, 2016; Gupta, 2017; Iansiti and Lakhani, 2017). Because blockchains are distributed ledgers, anyone can view the data, which therefore removes the need for trust between transacting parties, as no secrets can be kept on a public blockchain (Guegan, 2017). Permissioned blockchains were introduced to solve the privacy and confidentiality problems in public blockchain networks (Guegan, 2017). The decentralised nature of blockchain overcomes many problems of traditional software due to systems being centralised and controlled by a single entity. These traditional systems are prone to easy tampering and hacking, as well as lack trust and transparency as they are administered by a single entity (Iorio, 2017; Underwood, 2016).

Capabilities of blockchain technology can be extended far beyond cryptocurrencies. It could not only transform existing applications and services, but also lead to many novel use cases such as blockchain-powered elections, power grids, supply chains, property management, and agri-insurance (Rosic, 2017;

Iansiti and Lakhani, 2017). Similarly, blockchain can potentially bring many benefits to the construction industry. In this research, the authors identify several pressing problems experienced in the contemporary construction industry and determine whether the blockchain technology could potentially help in addressing them. Some examples of these problems in the construction industry include, but are not limited to, lack of trust among stakeholders, supply chain continuity, non-payments and delays, fraud, and large amounts of administrative work that can be prone to human errors (Wang et al., 2017).

Research methodology

Even though a decade has passed since the launch of Bitcoin, blockchain is still a rapidly evolving technology, and cryptocurrency is the prominent use case. Blockchain is difficult to understand as it is an amalgamation of several disciplines such as cryptography, mathematics, computer science, finance, economics, and politics. Thus, there are limited applications and case studies in many sectors, including the construction industry. Moreover, due to the limited availability of experts, it is impractical to conduct interviews, questionnaire surveys, or any other data gathering method. Also, due to the infancy of blockchain technology, meaningful primary data sourced from surveys and questionnaires would not be possible due to the general lack of understanding of blockchain amongst the general public. Due to this practical limitation, following four steps were followed to gather qualitative research data from a wide variety of secondary sources such as case studies from other industries:

i) Carry out an in-depth literature review to understand blockchain technology using journal and conference papers, textbooks, technical whitepapers, and reliable Internet sources.

ii) Analyse literature and Internet sources to identify how blockchain is being used in a variety of industries while focusing on other industry use cases and industrial applications which are based on blockchain technologies.

iii) Critically analyse literature and published expert reviews to identify common problems in the construction industry.

iv) Map blockchain solutions in other industries to common problems in the construction industry and identify potential applications of blockchain to help solve these problems.

Scope

This research explores how blockchain as a technology can be used in the construction industry rather than how cryptocurrencies can be applied to the construction industry. The primary scope of this research is to focus on how blockchain can be used to solve common problems encountered in the construction industry through lessons from blockchain solutions implemented in other industries.

Blockchain

Industry 4.0 and the FinTech era are changing the composition of the financial sector and many other sectors rapidly. The most prominent FinTech application is decentralised transaction handling through cryptocurrencies such as Bitcoin, Ripple, Ethereum, LiteCoin, EOS. More than two thousand currencies are available presently (Underwood, 2016; Rodrigo et al., 2018).

The technology underpinning cryptocurrencies is known as blockchain or digitalised distributed ledger (DDL) (Abeyratne and Monfared, 2016; Underwood, 2016; Efanov and Roschin, 2018). The first cryptocurrency, ‘Bitcoin’ was introduced by Satoshi Nakamoto in 2008 in his whitepaper (Nakamoto, 2008), and the first cryptocurrency was implemented in 2009 (Nomura Research Institute, 2016). Blockchain is a secure and transparent technology to share and store data between users through a Peer-to-Peer (P2P) network, without a central point of control, avoiding the middleman and ensuring the trust in a trustless environment (Guegan, 2017; Rodrigo et al., 2018).

In 2013, Buterin (2013) proposed the Ethereum blockchain. Ethereum is not just a cryptocurrency and has the capability to develop applications on top of the blockchain network called decentralised applications or DApps. In 2015, Ethereum made a new programming paradigm with the DApp concept by introducing 'smart contracts' as the first practical distributed processing model on top of a blockchain network (Dannen, 2017).

Blockchain is a mechanism to replicate, share, synchronise, and process data spread across different geographical locations such as multiple sites, countries, or organisations. Accordingly, the main property of blockchain technology is the lack of a central administrator or centralised data storage (Walport, 2016). A blockchain contains records of transactions ordered as a chain of data blocks that are shared with other members of the network. Each transaction is confirmed by the consensus of the members to eliminate fraudulent transactions, e.g., to prevent the double-spending of an asset. Once a transaction is confirmed by the members and accepted by the blockchain, it can never be altered or deleted (Efanov and Roschin, 2018; Underwood, 2016; Gupta, 2017; Iansiti and Lakhani, 2017). While several consensus algorithms with varying properties are used in practice, they share the common characteristic of making it computationally and cost-prohibitive for an attacker to alter the data stored on the blockchain. In terms of data storage, Table 1 explains the problems of traditional data storage that blockchain could potentially solve (Crofts et al., 2018). Applications with less sensitive data can use public blockchain platforms, while private and consortium blockchain platforms are suitable for enterprise-level sensitive data (Rodrigo et al., 2018).

The growing popularity of cryptocurrencies among traders and its impact on multiple domains have led to heightened curiosity to discover other technologies, capabilities, and applications of blockchains. Consequently, several commercial and proof of concept solutions based on blockchains have emerged in domains such as power, supply chain, property, food, health, waste, identity management, elections, and collectibles (Iorio, 2017; Iansiti and Lakhani, 2017; Underwood, 2016).

Table 1: Traditional vs. blockchain data storage

Traditional, Centralised Data Storage	**Blockchain Data Storage**
Prone to hacking due to single point to attack.	Hard to hack due to the decentralised network.
Lack of transparency as the administrator of the network can decide how much information people can view.	The public has full access to the blockchain, meaning that no information can be kept secret. This offers full transparency and eliminates the need for trust.
The central body has full control of the data.	The network is run by users, which reduces the corruption often seen in centralised networks
Prone to tampering of data as there is no way of verifying that data has not been tampered with	Cannot be manipulated or tampered

Technology Concepts Behind Blockchain

A blockchain network consists of several to thousands of peers called nodes. A P2P network forms a distributed and flat topology without a hierarchy, central authority, or the main server where nodes share similar responsibilities and ownership (Kaushik et al., 2017; Weernink et al., 2017). Such a topology provides better resilience, where even if several nodes are compromised by attackers, rest of the nodes in the P2P network can maintain blockchain network in an appropriate state (Nomura Research Institute, 2016). Nodes' main task is to validate the 'transactions/operations' on data and persistently store results of those transactions while preserving data consistency and immutability (Guegan, 2017). Each transaction is digitally signed (Diffie and Hellman (1976), ensuring only the authorised users can update data stored on the blockchain. A set of valid transactions form a 'block', and a chain of interlinked blocks form the 'ledger'. Nodes that form a block is referred to as a 'miner/validator/producer'. As seen

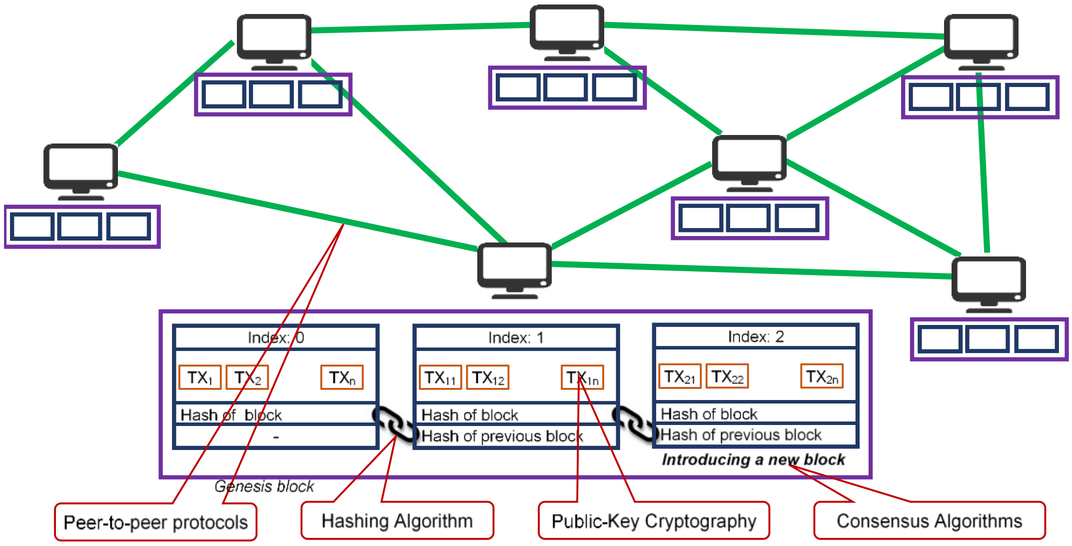

Figure 1: Technologies and concepts behind a blockchain network

in **Error! Reference source not found.**, a miner collects a set of valid transactions (TXs) into a block, links it to the previous block by appending hash of the previous block's data, calculate hash of all data in the block, and then appends it to the ledger (Lewis et al., 2017). A 'hash' value is the digital fingerprint of any data such as text, number, document, or file. Similar to a fingerprint is unique to each human; the hash value is unique to each input dataset (Efanov and Roschin, 2018; Rodrigo et al., 2018).

Blockchains use a consensus algorithm to determine a valid block and which node could create it. For example, in many public blockchains, the first miner that calculates a block with certain cryptographic properties can form a new block. This process is computationally expensive and referred to as 'Proof of Work (PoW)'. Then the block is broadcasted to all other nodes in the blockchain network. Nodes receiving the block further validate it before appending it to their copy of the ledger. Another alternative is 'Proof of Stake (PoS)' where nodes stake assets to become a miner. Then a miner is selected to build a block in each round based on a distributed lottery scheme. If a miner creates an invalid block and gets caught (as other nodes validate a mined block), its stake is removed. Presently, commercial blockchains use over 20 different consensus algorithms with varying scalability, security, and decentralisation properties.

Miners are usually compensated in cryptocurrency for their mining effort; hence, incentivise the participation of many miners making it difficult for a few fraudulent nodes to tamper or modify the data stored on a blockchain. Such attacks become extremely difficult as an attacker needs to modify not only a single block, but all the subsequent blocks as each block is cryptographically linked to the previous block (Nofer et al., 2017). For example, PoW can provide one of the highest levels of security among consensus algorithms, as long as no single miner controls more than 50% hash power of the network (Vranken, 2017). Ultimately, the blockchain network provides a single source of truth.

Notable Properties of Blockchain

Blockchain technology provides a set of unique and enhanced features that increases the trust, usage, and applicability of IT (Information Technology) systems in many sectors (Iorio, 2017; Iansiti and Lakhani, 2017; Underwood, 2016). Blockchain technology has the potential to enhance trust, transparency, auditability, accountability, anonymity, security, robustness, resilience, performance, and equality on Internet-based information systems (Nanayakkara et al., 2019; Rodrigo et al., 2018).

Level of acceptance of any software system depends on both the level of compliance with the Functional Requirements (FRs) and Non-Functional Requirements (NFRs). A Turing-complete blockchain platform can equally satisfy the FRs (Buterin, 2013) without depending on the environment similar to any general-purpose, high-level programming language. Therefore, a blockchain-based software system can equally satisfy all FRs of any business application, just like a traditional software system. That means compliance of NFRs will ultimately increase the level of acceptance of any blockchain-based software system compared to traditional software systems. A significant number of positive features arise from the blockchain properties such as a) functional features such as accuracy, interoperability, non-physicality, self-contentedness, and suitability; b) reliability features such as accessibility, availability (no single point of failure), fault tolerance, robustness, and stability; c) efficient read, write, and execute operations; and d) trust and security features such as accountability, auditability, disintermediation (no single point of trust), fraud resistance, and integrity (Nanayakkara et al., 2019; Rodrigo et al., 2018; Anjum et al., 2017; Buterin, 2016). Developability and maintainability are negative features of blockchain-based systems.

In addition, modern blockchain networks support smart contracts. A ‘smart contract’ is a self-executing contract or set of rules between two or more parties is directly written into the system and exists across the blockchain network (Rudolf, 2017; Silverberg et al., 2016; Nanayakkara et al., 2019). A smart contract can be used to satisfy common contractual conditions such as payment terms and compliance requirements without a central authority or external enforcement while minimising malicious and accidental errors (Rudolf, 2017; Silverberg et al., 2016).

Blockchain Applications

Blockchain is considered as one of the most disruptive technologies applicable to many disciplines. Both blockchain technologies and applications can be classified in three generations as Blockchain 1.0 for the digital currency, Blockchain 2.0 for digital finance, and Blockchain 3.0 for digital society (Swan, 2015; Zhao et al., 2016). Bitcoin is considered as the first blockchain application that was introduced to the financial industry (Mingxiao et al., 2017). In addition to Bitcoin, presently there are over 2600 cryptocurrencies with a total market capitalisation over USD 265 billion (Coin Market Cap, 2019). Ethereum, Ripple, Litecoin, Tether, Monero, and Cardano are some of the other popular cryptocurrencies (Li et al., 2017).

Economic, marketing and financial applications such as stocks, bonds, smart property, and smart-contract-based applications are defined as Blockchain 2.0 by Swan (2015). Further, Turing-complete blockchain platforms or universally computational programming languages enabling the users to develop smart contracts also belong to the era of Blockchain 2.0 (Li et al., 2017; Xu et al., 2018). Smart contracts strengthen mutual trust among blockchain users as the core technology behind Blockchain 2.0 (Lu, 2018). Blockchain 2.0 platforms started with the smart-contract-enabled Ethereum DApps. Some of the other popular platforms include Hyperledger Fabric, Iroha, Sawtooth, EOSIO, R3 Corda, Quorum, Tron, Stellar, NEM, and Neo (Alharby and Moorsel, 2017; Luu et al., 2016).

Blockchain applications beyond cryptocurrency, finance, and markets such as public services, healthcare, gaming, food and agriculture, science, art, culture, and intellectual property belong to the Blockchain 3.0 era (Swan, 2015; Wang et al., 2017). Gaggioli (2018) mentioned that there is a significant number of potential business applications that can be developed in the Blockchain 3.0 era. Examples of Blockchain 3.0 applications related to public services are the BitFury land registry and the Horizon State online voting system. Blockchain applications in supply chain management are OriginChain for food, Everledger for diamonds, and CSIRO’s Data61 blockchain for the beef supply chain management. Healthcare-related applications of blockchain include OmniPHR – a personal health record application, MedRec – a medical records management system, and Konfido – a cross-border electronic health data sharing application. Usizo is a platform where blockchain technology has been applied to manage foreign aid crowdfunding. TravelBlock, Travel Grid, TravelChain, and Aeron are air-ticket and travel planning related blockchain solutions. The music industry uses blockchains such as Ujo, Viberate, and Mycelia for decentralised ownership management. Blockchain in the gaming and collectables industry has many examples, including CryptoKitties, World of Ether, EOS Knights, MegaCryptoPolis, Blockchain Cuties, Mythereum, and MonsterEOS (Crofts et al., 2018; Gaggioli, 2018; Nomura Research Institute, 2016; Rosic, 2017; Underwood, 2016). Some of the contemporary issues faced by the construction industry are also common to other industries, and the authors are already seeing the emergence of blockchain-based solutions to address similar problems in those industries. Potential case studies are discussed next.

Supply chain management

A supply chain is a network of different processes of multiple firms, which are linked as upstream (i.e., suppliers) and downstream (i.e., customers) to deliver products or services to the ultimate consumer (Christopher, 1992). The supply chain is one of the key challenge areas of the construction industry (Hewavitharana et al., 2019; Nanayakkara et al., 2015). Most common supply chain issues are the lack of trust among supply chain members, difficulty in tracking the origin of a product, and difficulty in planning given less transparency in the network. Lack of trust and information across the entire supply chain are common issues in the construction supply chains (Nanayakkara et al., 2013). Therefore, smart contacts based, enhanced trust and immutability features could solve these two key issues to a greater extent (Wang et al., 2017). Moreover, smart contracts and immutability can solve other issues in construction supply chains (Wang et al., 2017) such as difficulty in tracking the origin of a product across a large supply chain (Perera et al., 2012), lack of quality validate (Wang et al., 2017), and difficulty in controlling lengthy supply chain workflow operations (Cox et al., 2006).

Financial services

The financial sector is the first and most successful domain to adopt blockchain (Underwood, 2016). Danuri et al. (2006) mentioned that the construction industry has a significant number of finance-related issues. Ramachandra and Rotimi (2011) mentioned that the construction industry has a chained payment settlement culture, and default settlement durations are much higher than in other industries. Besides the long settlement period, there is a substantial amount of payment delays in the construction industry (Danuri et al., 2006). There is a considerable number of partial payments and non-payments in the construction industry that worsens the financial status of upstream members of the construction supply chain, and sometimes this impact will close down companies (Ansah, 2011). Existing inefficient financial business models and applications are being replaced by highly efficient, blockchain-based financial platforms (Nofer et al., 2017). As an example, Ripple addresses these problems by providing a global, blockchain-based platform for the settlement of transactions across financial institutes (Koch and Pieters, 2017). Another major concern on the traditional financial structure is the middlemen which delay and add additional costs to transactions. Bitcoin was the first cryptocurrency aimed to address this by allowing users to do transactions directly between each other without the need for a middleman or bank (Vranken, 2017). Traditional financial business processes have another drawback where it is hard to transfer value without currencies. Blockchain can define its own digital assets (or digitalised versions of assets) called Tokens. Tokens could be used by any business application to define its own digital assets to perform transactions (Catalini and Gans, 2018). Most financial sector blockchain solutions could be integrated with many information and financial systems in other sectors, including the construction industry, to overcome their financial challenges, reduce costs, and add agility (Zainuddin, 2018).

Compliance and assurance management

Ashworth and Perera (2018) stated that compliance and assurance management is one of the most significant challenging areas for the construction industry. There are many different approaches to ensure compliance and quality assurance. A common technique is to monitor and check an organisation’s practices using an audit process. An ‘audit’ is the internal or external process of examining business records and practices to ensure compliance with specific quality and regulatory standards Karapetrovic and Willborn (2000). Once an audit was completed, a record will be kept for future references and actions will be taken to correct any issues found through the audit process. An audit ensures that the quality and compliance of a product or service are up to standard (O'Dwyer, 2017).

An immutable and distributed blockchain-based system can solve issues related to compliance and assurance management to a great extent in the construction industry (Anjum et al., 2017).

Asset management and maintenance

Proper asset management and maintenance are challenging in any sectors, and even more so in the project-based construction industry (Nanayakkara et al., 2015). The purpose of maintenance is to ensure that a product or service is always running at its intended efficiency and effectiveness. Maintenance is extremely important, especially when it is for a product that is regularly used by the workers and the public, as it ensures safety while using the product or service (Perera et al., 2014). Schedules and records of maintenance are often used to track when an asset requires maintenance, as well as when an asset has received maintenance. Three key issues in asset management and maintenance are accessibility issues of record (Lemieux, 2016), inaccurate records, challenge to execute on-time maintenance schedules (Perera et al., 2013). Lemieux (2016) mentioned the blockchain system could solve issues related to inaccuracy and availability of data, while smart contracts can solve issues related on-time execution of maintenance tasks to a great extent.

Sustainability management

Rodrigo et al. (2019) stated that sustainability management is one of the essential sectors of the modern construction industry. The rise of global warming, climate change, and waste increase the demand for better sustainable operations for almost every domain, including manufacturing, construction, food and agriculture, transportation, and many others. Davidson (2009) mentioned that it is essential to monitor the sustainability of the product or service that they provide in both the private and public sector in any domain. Sustainability monitoring such as monitoring energy use, carbon emission management, and waste management are key focuses for many domains (Davidson, 2009; Ratnasabapathy et al., 2019). Pacheco-Torgal and Jalali (2012) highlighted that the construction industry makes a significant impact on environmental pollution and stress the importance of addressing it. Rodrigo et al. (2019) stated inaccurate record, loss of data, and unavailability of data are among the key challenges in sustainability management and monitoring. Blockchain-based systems can solve these data-related issues to a significant level.

Potential Blockchain Applications for Construction Industry

Blockchain technology can be applied to many areas of the construction industry including construction supply chains, building information modelling, design management, sustainability and waste management, property and land titles, asset management and maintenance, and others. These potential construction applications will be briefly discussed in the next sub-sections.

Construction supply chain management

Blockchain can have many different applications in a construction supply chain. For example, smart contracts could be used to automatically purchase, track, and verify items in a construction supply chain in real-time (Nanayakkara et al., 2019). Furthermore, current procedures in the construction industry heavily rely on contractual agreements. Kinnaird et al. (2017) stated that digital contracts or smart contracts that can be stored and executed securely on a blockchain reduce counter-party risks for suppliers or contractors as they add certainty needed to carry on with a job. Furthermore, blockchain can be used to improve payment settlements, compliance management, material planning, and many other supply chain management operations with better efficiency, trust, and transparency among transacting parties (Nanayakkara et al., 2019).

Building Information Modelling

One of the major potential applications of blockchain in the construction industry is the space of Building Information Modelling (BIM). A major limitation of current BIM models is that they can only provide pre-set information on building components and not live information (Kinnaird et al., 2017). Another issue is that these models often generally stop being updated once the construction is completed due to information is maintained by single or limited parties. Blockchain could be applied to solve these issues by information sharing among present and future information owners to a great extent. Blockchain applications in building information modelling are vast, including integration with the Internet of Things (IoT), Asset Management, Augmented Reality (AR), Virtual Reality (VR), Artificial Intelligence (AI), and many other potential solutions (Heiskanen, 2017).

Design management

In the construction industry, many contractors and consultants come together to design and deliver a one-off project. This can often cause a fragmented approach to design as a different group of contractors and consultants. Usually, each construction discipline is kept separately during the design phase of the project. In recent years, the design management phase has been advanced by BIM to ensure that the design of the building meets the expectations of the client (Wang et al., 2017; Heiskanen, 2017). Blockchain could be utilised to truly enhance the benefits of BIM by allowing all architects and engineers to design on the same BIM model with their respective components with clear ownership (Kinnaird et al., 2017). Moreover, persistent recording on design and construction decisions could be useful in future cases analysis, e.g., to find out who is at fault for designing or building a collapsed bridge.

Sustainability and waste management

Sustainability is one of the highest priorities in the built environment today due to the external demand from governments, customers, and the general public (Pitt et al., 2009). Blockchain technology can be used to properly calculate embodied and operation carbon in the construction industry and assist in optimising carbon management or even carbon trading (Rodrigo et al., 2019). Furthermore, blockchain technology can be used for proper energy management in the built environment (Imbault et al., 2017). The construction industry produces a significant portion of waste worldwide, and a blockchain could be utilised for proper waste management, including waste trading and circular economy (Ratnasabapathy et al., 2019).

Asset management and maintenance

According to the PAS-55 specification of the British Standards Institution (2008), all the necessary data and information related to the built asset needs to be tracked at every stage of the asset life cycle. However, project nature and the involvement of a high number of parties make asset management and maintenance nearly impossible. Blockchain-based, construction asset management systems would allow tracking and access to all the necessary data throughout the asset life cycle. It could provide better asset life cycle while minimising challenges and providing better maintenance performance (Wang et al., 2017).

Conclusion

Blockchain has evolved drastically over the last decade as a generic platform for reducing counterparty risks since its beginnings as the underlying technology for cryptocurrency. There is little research on blockchain adoption in the construction industry at present. Therefore, this study aimed to analyse the current use cases of blockchain in other industries and determine its potential to solve contemporary challenges in the construction industry. The research suggests that blockchain is a persistent, immutable, and secure system that is effective in eliminating the middleman and automating processes due to its prominent disintermediation, transparency, and consistency features. A key finding was that attempts are widely being made to implement blockchain-based solutions in many industries, including food and agriculture, healthcare, entertainment, foreign-aid, advertising, and public services. At the same time, it was noted that both research and commercial attempts are relatively poor in the construction industry. Nevertheless, the authors found that the construction industry could adopt blockchain technology to solve long-standing problems, including trust issues among parties, lack of transparency in the construction supply chain, payment related issues, asset maintenance issues, a large amount of administrative paperwork, compliance issues, collaboration issues especially in design management, and others. Therefore, there is a significant potential for blockchain applications in the construction industry, especially in the areas of supply chain management, building information modelling, asset management, and sustainability.

The authors propose a blockchain maturity model in Figure 2 for the construction industry. The maturity model is based on the present status of research, publications, blockchain platforms, its application development, anticipated developments in core blockchain technologies and adopting maturity model was published by Nguyen et al. (2019). The authors suggest five key stages for blockchain in the construction industry, including ideation, experimentation, pilot, commercialisation, and adoption. The few blockchain research and industrial projects in the construction industry are soon heading to their pilot stage according to their academic, news, and whitepaper publications. With the maturity of blockchain technology, adoption practices, and relevant policy enhancements the construction industry will soon be able to solve several long-standing problems with high efficiency, transparency, agility, and low cost.

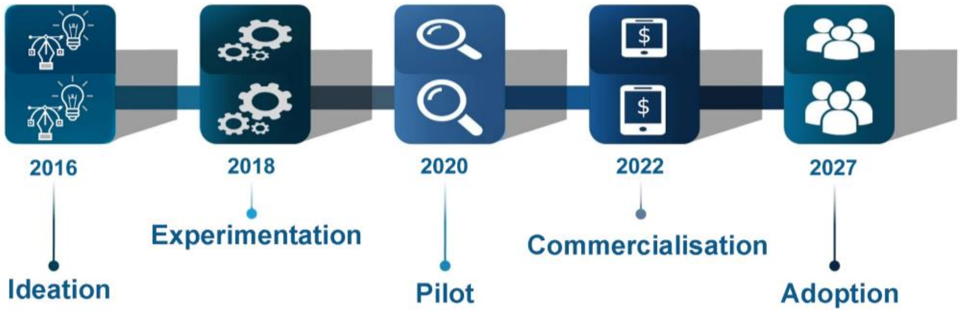

Figure 2: Blockchain maturity in the construction industry

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