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Blockchain in Construction Practice

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Abstract. The construction industry is one of the most important sectors of most economies. However, the sector has been plagued with many challenges, including low productivity, lack of collaboration, inadequate/insecure information sharing and lack of trust between participants. To overcome some of these challenges, blockchain, one of the emerging technologies has been hailed as a solution for sharing and distributing information securely. While blockchain has been widely popularised in the financial fields through well-established cryptocurrencies such as Bitcoins and Ethereum, the same cannot be said of the construction industry. The application of blockchain in the construction sector is yet to be widely documented in academic literature. This study explores the application of blockchain technologies in the construction sector. Specifically, the operational principles, applications, associated benefits, and weaknesses of blockchain in construction practice are examined in this paper. The paper concludes that there is definitely a huge potential in the adoption of blockchain in different construction processes.

Keywords: Blockchain, Distrubuted Ledger Technology, Built Environment, Construction, Innovation.

1 Introduction

The construction industry is one of the main contributors to the UK's prosperity [1]. In 2017, the sector was appraised to be worth approximately £103 billion, contributing up to 6.6% of the country's economy [2]. However, the industry is facing many challenges, including low output, lack of collaboration, inadequate/insecure information sharing and lack of trust between project team members and stakeholders [3]. McKinsey [4] reports that $1.6trillion savings could be achieved globally by improving the performance of the industry alone.

Blockchain is rising as one of the emerging technologies hailed as a solution to improve the performance of the construction industry vis-à-vis building trust, transparency in information exchange and enhancing contract conflict resolution [5]. The construction sector is generally known for distrust and disputes [6]. This being said, payments are one of the major problems, which are commonly tied to contractual entitlements being paid late, not in full or not being paid at all [7]. Additionally, based on many case studies in the industry [8, 9, 10], the mainstream contractual frameworks are believed not to foster collaboration and intraorganizational trust. The use of blockchain technologies and in particular the smart contracts could limit the amount of disputes and enhance collaboration and trust

[11]. The key questions are what are the wider applications of blockchain in construction practice? What are the benefits and barriers of the applications of blockchain in construction practice? In order to attempt these questions it is imperative to critically examine what constitutes blockchain.

2 Overview of Blockchain

A blockchain is a data storage that takes a number of records and organises them in blocks of information. Each block is then 'chained' to the next block using a cryptographic signature [12]. This allows blockchains to be used as a ledger, which can be shared and authorized by anyone with the appropriate permissions.

The key advantage of blockchain is its ability to be applied in various settings and offer solutions that are durable, transparent and secure [13]. Due to decentralization, the database can securely exist even if up to 50% of its network fails or is disengaged [14]. It is guaranteed as blockchain is based on a peer-to-peer system of computers (nodes), which poses identical copies of the database. This ensures transparency and resilience to counterfeit as no single entity has control over it. The structure of blokchains depends on shared information that enables checks through algorithms to uncover any anomalies. To authenticate the transaction/data, a proof-of-work mechanism is used. That is achieved by deterministic currency issuance mechanism to keep numerous network and reward its miners [11]. When a network accepts transmitted transaction, it is received by all nodes, which authenticate it through predefined algorithms regarding its structure and activity within the transaction. While the block is being mined, each node's version is being updated [15].

3 Application in Construction Practice

Blockchains have been applied to solve practical challenges.

Smart contracts and BIM: Smart contracts can be adopted in conventional and BIM-based projects.The agreements between particular individuals can be formulated in the form of computer programs which follow an established schedule and automatically withdraw payments once all the conditions are met. This enables the reduction of documentation and organization of the budget into smaller installments. Breaking large lump payments is not only more sustainable but also divides the schedule into more achievable milestones [16]. In a project developed in 3D software, contracts can be tied to the model. When the physical construction matches its initial design, a fee agreed beforehand is automatically transferred to the contractor. Also, the contract can be divided into multiple tasks and hence limit the risk of layering errors. Once each activity is completed, it is measured using e.g. laser scanners and align to the model. If it is verified as accurately realized, a smart contract is fulfilled and a payment issued [17]. This function improves inspection checks – once recorded, they are available to those performing the checks and hence limit the risk of errors and oversights. Similarly, blockchains could also store information on the buildings structural and maintenance work [18]. Such a system enables all those involved to see

an up-to-date model and its constant progress. Each update creates a unique block of information added to the chain, which makes it transparent and indisputable. This boosts the movement towards interactive on-site project productivity and schedule metrics [19].

BIM model ownership and insurance: Blockchain is said to be the solution for problems raised around model ownership and insurance. BIMCHAIN.io is developing a traceability system which supports legally binding agreements disclosed in a smart contract. Using the technology would limit the risk of copyright theft to a minimum and reduce delays, disputes, and expenses associated with their resolution [20]. All the contributions, changes and validations of the BIM model would be tracked and saved in an invariable environment available to project team members and stakeholders [21].

Smart energy and smart homes: The affordability of residential electricity production (prosumers) systems opens up the possibility for the use of blockchain. The excess energy can be micromanaged using the tool and sold to the grid or neighbours to balance supply and demand at a local level [22]. Such an innovative approach has been tested in the United States, where LO3 Energy is giving a trial to peer-to-peer blockchain network. Houses connected to the system using smart meters can trade electricity between each other to minimise the usage of grid-provided power [23]. A similar experiment has been announced in the UK by Centrica [2].

Smart cities and sharing economy: The definition of smart city is an evolving concept, but it is generally understood as an idealistic city where the quality of life is significantly improved. This can achieved by information and communication technologies (ICT), new services, urban infrastructure. The vision assumes consideration of the issues and seeking solutions from the perspective of the citizens and their engagement in the city management. This is understood as the integration of resources, where individuals interact using technological solutions [24]. The Internet of Things (IoT) and ICT innovations such as blockchain make shared economy much easier and accessible [11].

Smart governance: Enormous savings could be achieved by the implementation of autonomous executing administration to record, store, protect and share information [25]. Also, blockchains are being investigated for use in: automated tax collection, property and land registry and regulatory compliance. Transparency and immutability of blockchains can significantly reduce the time needed for bureaucracy as a result of provision of indisputable and trackable data [26].

Supply chain management: The use of blockchain for supply chain has a great potential to improve its transparency, tracking and reduction of costs of related administrative activities [27]. The supply chain often consists of a vast network of diverse organizations, which manage large quantities of goods, contracts and payments. As the product passes through many locations and organizations, all the data about the product needs to be recorded and updated according to its current stage. The scale and complexity of systems combined with needed manpower leads to high transactional costs and regular errors in paperwork [26]. The use of blockchain technology offers the possibility to associate the transport of a physical item with its digital profile [28]. The essential updates can be added to the digital ledger as items

pass through the supply chain. This is believed to have a positive effect on the trust between stakeholders as it limits the fraud and counterfeit of goods [29]. According to [27], blockchain within the supply chain can be used to document prices, dates, locations, quality, certifications and other relevant information.

Smart asset management: The advancement of BIM technologies and digitalisation has enabled continuous improved project management since its initiation to end of its life cycle. This was followed by the development of so-called "Digital Twin" concept which is a virtual copy of a real-life asset [30]. Digital Twins enhanced by blockchain and Construction Operations Building Information Exchange (COBie) files would not only contain all significant information necessary in the operation and maintenance stages (O&M), but also be traceable and secure. Easy access to immutable record of all actions of those responsible for particular elements or systems would significantly reduce time to resolve disputes and warranty claims [31]. Moreover, blockchain adaptation during O&M can ensure higher quality of services due to inevitable liability [5].

3.1 Benefits of the technology

Blockchains offer a wide range of advantages from improved reliability to security to enhanced collaboration [32].

Directness and transparency: Limitation of intermediaries' involvement fosters transparency and direct relationships with customers [33], and additionally, strengthen corporate reputation through transparent transaction history [34].

Resiliance to failure: Blockchain data is stored across a network, hence no single entity or even an organisation is in control of the encrypted records. Moreover, decentralisation means that even if one or more individuals leave the network, it will continue to function with no loss of data or integrity [14].

Resiliance to counterfeiting and security: The dependency between the blocks is one of the key properties which makes the chain secure. Tempering with a single block consequently causes an individual serial code to change and warns the network; hence blockchain is more secure than other record-keeping systems [35].

Cost benefits: Cost savings can be achieved through the reduction of third parties and their fees. Furthermore, potential benefits stem from easier data collection, consolidation and sharing for management or supervisory purposes, as well as shortened dispute resolution [36]. In addition, decrease of operational costs was stated by 73% of respondents to the 2016 Statista questionnaire on the technology's features [37].

Ensured payment and financial stability: Attachment of smart contracts to particular BIM model elements not only automates and streamlines the payment processes, but also validates if the client is capable of complying with their financial obligations [38]. Furthermore, by associating smart contracts with completion percentage and breaking large lump sums into smaller installments, project cash flow becomes more sustainable and healthier for employers and contractors [16].

Record keeping and accountability: All the parties involved in the network share the same data, which if to be changed, requires a consensus [39]. As reported by

Statista [37] more than half of the respondents to its blockchain-related questionnaire announced significant reduction of issues caused by information loss or inconsistency. Moreover, unalterable record keeping partly solves the accountability issues [5]. All the model modifications, time stamps and contributors are recorded and copyrighted once blockchain is embedded in BIM system [38].

Increased efficiency and speed: Through the reduction of paper-work and automation of processes, blockchain adapters experience quicker settlement of disputes and trading [39]. The settlement time reduction was reported by as much as 69% of blockchain users [37].

Better supply chain management: The possibility to track products, their origin, quantity strengthens the relations between parties and guarantees the ordered services or goods meet the initial quality and sourcing requirements [33]. The extent of supply chain which can be noted in the construction (e.g. Cross rail construction in London involved 700 various suppliers) sector requires enormous effort and resources; hence any way to improve the management processes is at a premium [5].

Better asset management: Storing a "Digital Twin" model in a distributed ledger guarantees its accuracy and uninterrupted access for O&M personnel. Accountability further leads to provision of better services and maintenance [5].

3.2 Barriers to adoption of blockchain in construction practice

Despite the wide range of benefits, the technology is still facing some challenges hindering its wider uptake in the construction [36].

The main challenges focuse on the issues related to regulatory uncertainty, volatility of cryptocurrencies, and lack of trust among users. Besides, lack of maturity and understanding create other issues - as blockchain is a relatively new technological innovation, there is deficiency of terminology and vision of what can be its purpose. The lack of universal standards raises questions on how to ensure quality controls and procedures to be performed on the desired level. It is crucial to clarify the scope of blockchain adaptation beforehand and ensure all the parties have the same expectations [21].

Furthermore, there are the legal implications of smart contracts. There is a fundamental need for legal perspectives, rules and policies, developed and supported by the government [40] to be reinforced in blockchain smart contracts.

Also, cryptocurrency payments are not yet a common practice in the sector. A great majority of construction professionals is not eager to switch from traditional cash payments due to either lack of undestranding of the technology or fear of possible consequences of such a change [40]. Furthermore, according to POST [28], there are currently uncertainties about the scalability and speed of transactions. There are limits that arise from blockchain computer intensive consensus mechanism that are required. As the number of transactions increases, the energy consumption needed to run proof-of-work protocols might have massive impact if implemented on global scale [11]. Some estimates compare the annual electricity consumption of blockchain to that of the entire Austria [28].

Another barrier is the cost of implementation and the need of skilled workforce [41]. Additionally, in order to fully grasp the benefits of blockchain-based business, there must be changes in the organisational structures and culture. As much as blockchain is transparent and hacker impermeable, it also discourages many companies which are not willing to risk disclosure of their data [21]. Furthermore, narrow margins in the construction industry might limit the implementation of blockchain as investments into research and development are limited. The core of the barriers associated with blockchains, and in particular smart contracts creation, are the complexity considerations. Taking into account the complexity of construction agreements, it is hard to imagine how such documents could be enclosed within a program code. The reality is, Smart Contracts do not take into account too complex mitigating circumstances, which are quite common in construction projects. With that in mind, it would be foundamental to consider all possible solutions and design the source code in such manner to ensure it is executed in a way intended. Bug-free codes are extremaly rare even when not developed as a contract framework, what makes it hard to believe it is possible to formulate a defect free and fully reliable smart contract [42].

Lastly, it is important to note that the beneficial features of the network solely depend on the grid integrity [21]. Thus, the main fear of the early adopters has been the crash of the network and all-its related chaos [43].

4 Conclusions

The development of blockchain is definitely one of the most ground-breaking innovations of the century. It offers a wide range of advantages, which include transparency, verifiability, privacy, and security. Decentralized network protects the data against tampering and copyright theft, as well as provides foundations for innovative methods of payments and contracts. Despite presenting many benefits to the construction industry, a majority of professionals are not eager to adopt it just yet. Those who do, use it for handling payments and procurement by so-called smart contracts. More advanced firms further adapt them within BIM systems and attach to BIM models. Nevertheless, its nascent nature may be one of the reasons to its low adoption. With time and further development, the barriers to the adoption of blockchains may become an issue of the past and its benefits may further spur its wider uptake. This will significantly improve the performance of the construction industry.

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