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The Impact of Adopting Smart Contracts and Blockchain in the Construction Industry: A Case of Lusaka, Zambia

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Abstract

Globally, the construction industry is faced with several challenges like inefficiencies, disputes, and a lack of transparency. This paper uses the case of Lusaka, Zambia to investigate the impact of adopting emerging digital technologies in the construction industry, with a particular focus on smart contracts and blockchain technology. Drawing on existing literature and theoretical frameworks, Technology Acceptance Model (TAM), this paper argues that through the adoption of smart contracts and Blockchain technologies, the construction industry in Zambia and the world over could result in many benefits. Lusaka was an ideal case study for validating these hypothesized benefits. The findings of this research identified both benefits and challenges to the adoption of smart contracts and blockchain technologies. The identified benefits include the efficiency in construction processes, an improvement in the supply chain management, mitigation of risks, and a fostering of greater trust among stakeholders within the construction industry. Emerging from the research data were challenges relating to technological illiteracy, absence of regulatory frameworks, and high costs of initial investment. The paper uses qualitative method to analyse data. The paper concludes by emphasizing that the benefits surpass the challenges hence the need for Zambia and other similar developing economies to consider transforming the construction industry processes through adopting blockchain technologies and smart contracts to revolutionizing construction practices.

Keywords

Adopting Smart Contracts, Blockchain, Construction Industry, Lusaka

1. Introduction

Technology Innovation is changing almost every industry with increasing digitization exponential growth of sensible data. (Cenk Budayan, 2023) states that Innovation is critical in achieving higher economic growth, gaining a competitive advantage in an intensively competitive environment. Contract administration in construction projects can be challenging as most construction companies fail to manage their contracts which then leads to many problems and disputes, as construction contracts are well known for being complicated and voluminous. Most construction companies when drafting their contracts believe in mitigating contract related problems through maximizing clause clarity and less terminology which then leads to the contracts being too vague and misinterpreted. (Ernest E Ameyaw, 2023) The construction industry has long been confronted with several challenges that hinder its effective performance such as poor productivity, poor payment practices, cashflow difficulties and contractual disputes. According to (Ishara Rathnayake, 2022) payments issues contribute substantially to various problems relating to subcontractors and suppliers as traditional contracts are one of the seven major barriers to progress of construction projects.

(Ernest E Ameyaw, 2023), the notion of a Smart contract was introduced by Nick Szabo in 1994, who was a legal scholar and a computer scientist.(Xuling YE, 2022),

The introduction of smart contracts known for being legal agreements with a self-executing program that automates actions required by a blockchain (this is a system which records transactions, especially those made in cryptocurrency), (Umesha S Weerapperuma, 2023) using a computer program designed by coders who will draft a contract and being assisted by professional bodies who have contractual knowledge. This will help with the

construction industry to improve efficiency, reduce costs, be more transparent and is a secure way to manage contracts and payments compared to traditional contracts. The smart contracts can be used to design specific logic which is based on the purpose of application and the written code and binding contracts.

Smart contracts according to (Xuling YE, 2022) can be used with Building Information Modeling (BIM) uses intelligent 3D models to plan, design, construct, manage buildings and infrastructure, for payments execution in the design phase. Another smart contract system presented by Xuling was using Decentralized Application (DApp) which is a software application that operates on a blockchain network rather than a centralized server, with a blocked process for securing the payment of construction contracts. Smart contracts benefit the construction projects as they offer a collaborative working environment between clients, contractors, subcontractors, suppliers and consultants, making construction projects more transparent, accountable and collective. (Cenk Budayan, 2023) acknowledges that smart contracts should have six features such as being solely electronic in nature, must have software implementation, must increase certainty, must be conditional in nature, must have self-performance and lastly must be self-sufficient.

The construction industry is a major pillar in the economic development globally, as it contributes to Gross Domestic Product (GDP) and helps in the creation of employment (Al-Syed Construction., 2024). However, there are many challenges that face this already complex and fragmented sector. For example, construction industry is faced with high-cost overruns, delays in scheduling tasks and payments, squabbles, tensions and contractual disputes, as well as a lack of accountability (Iqbal et al., 2024). These challenges are more prominent in developing countries where so many construction practices are still characterized by traditional and informal processes.

For instance, smooth operations of the construction industry in the developing countries are affected by a limited access to finance, and an absence of robust regulatory frameworks, which together commonly affect the construction project success.

Today, construction industry could take advantage of the affordances of emerging digital technologies, like blockchain technologies and smart contracts, since these emerging technologies are capable of solving the challenges currently facing the construction industry at large (Mazlan et al., 2025; Ye et al., 2024; Rathnayake et al., 2022). Blockchain technology is a distributed, immutable ledger technology, and it offers unparalleled transparency, security, and traceability (Wong et al., 2024; Mazlan et al., 2025b; Ok et al., 2025). Smart contracts can self-execute agreements that are stored on a blockchain platform (Nakamoto, 2008), Through smart contracts, contractual obligations are automated and there is a reduction of the mediating agents who are capable of introducing unnecessary disputes (John, 2025 ; Rashid, 2024; Rashid, 2024).

While this research acknowledges the presence of theoretical benefits of blockchain technologies and smart contracts in literature, there are limited studies that present the impact of blockchain technologies and smart contracts on the activities of the contraction industry in the developing countries' contexts. It was on this background that this paper attempts to fill this gap by using the case of Lusaka, to provide an understanding of how emerging technologies such as blockchain and smart contracts influence the activities in the construction industry. The rationale of this case study was that Lusaka, is a rapidly urbanizing capital city and requires an immense infrastructure development, hence her appropriateness as an environment for understanding the real-world effects of blockchain technologies and smart contracts in the construction sector. The paper further answers the following research questions.

1. How does the implementation of Blockchain technologies and smart contracts benefit the construction industry?
2. Why is it challenging to implement the Blockchain technologies and smart contracts in the construction industry?

2. Literature Review

The construction projects are procured using traditional contracts and these are characterized by incentive documentation and information (Ernest E Ameyaw, 2023). The blockchain based smart contracts can help by automating contractual transactions eliminating paper based traditional contracts. Smart contracts are designed to run on blockchain inorder to manage and monitor construction progress including managing cashflow. Blockchain does present a way to solve supply chain issues as funds are held centrally on a blockchain system and authorisation is done only when completion and verification work is finalized. This helps to avoid contractors having debt due to late payments by the owner of the intended construction project as they may extend the payment period such as 120 days payment period with the hope to improve cash flow. Smart contracts can help with reducing both malevolent and accidental errors due to a digital computer code which is linked to digital

currencies (Umesha S Weerapperuma, 2023), The blockchain data is stored in multiple nodes that a single point cannot control since there is a "peer to peer" network where computers on the network are equal. The blockchain nodes where data is entered is called a distributed ledger as it simultaneously maintains all the nodes in the network, this means that in the event there is a cyber-attack the blockchain network can be resilient to the attacks even if the attacker controls several nodes. The built blockchain network has three ways which are public, private and consortium, these help with efficiency, a consensus determination and permission to read. When the term public blockchain network appears it simply means the network is open to anyone who wishes to participate as a member and can access and read transactions.

The smart contracts using blockchain eliminates intermediaries such as banks from the transaction process making procurement straightforward and time saving. Important documents such as drawings, engineers' instructions, payment certificates, claims, variation orders, project plans and task completion tracking can be stored electronically and automated in a decentralized ledger once relevant conditions are met.

Also, when looking at the maintenance aspect in the construction industry the building maintenance system(BMS) with the blockchain network provides a sustainable integrated system which is capable of transparent recording and monitoring of building operations and maintenance so as to reduce the cost of administration (Umesha S Weerapperuma, 2023).

Smart contracts can support complicated requirements that in turn enable developers to build powerful decentralized applications with integrated domain specific functions (Xuling YE, 2022). Smart contracts can improve the drafting and navigating of construction agreements. The smart contract is valuable in managing construction project agreements during disputes as they can automate the consequences of each transaction and maintain a tamper-proof record of the project process.

They also standardize the management of quality information to avoid certain processing violations. According to (Ishara Rathnayake, 2022), smart contracts in the construction industry have been mostly studied in China, followed by Turkey, then both Australia and United States, with limited articles in the African regions. As shown in Figure 1 below, Asia & Pacific region have a high percentage of fifty-four as they have contributed more than half of the articles which demonstrates an enthusiasm by the researchers towards the countries impact in the adoption of smart contracts (Figure 1).

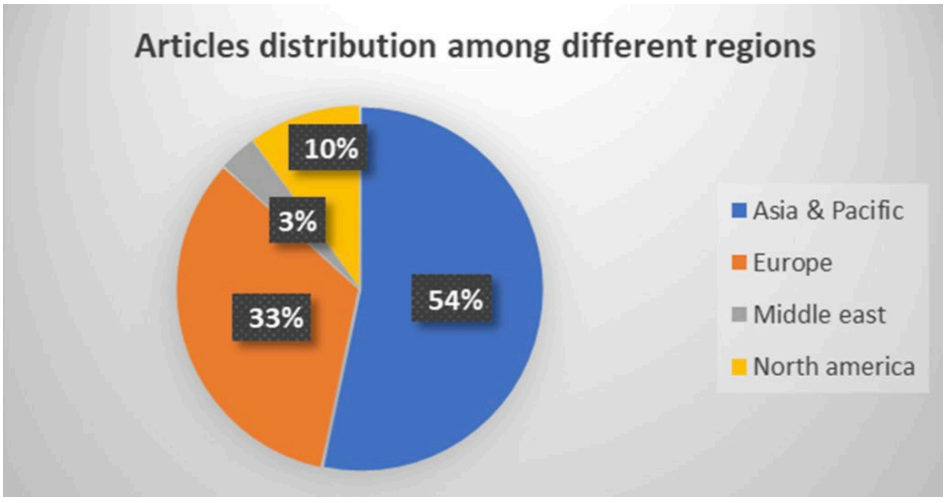

Figure 1. Article distribution from other scholars on smart contracts adoption (Ishara Rathnayake, 2022)

Smart contracts are a way that saves costs, time and can facilitate smooth contract process. (Ishara Rathnayake, 2022) sates that the smart contracts market size was valued at around $145 million in 2020 and is projected to reach $770 million by 2028. The major problem in the construction industry as stated before are payments related issues. The introduction of smart contracts then offers the ability to automate payments to be released on a set date without delay which eliminates late payments. How the innovation of smart contracts work is by having self -implemented features were both parties verify a coded clause, then payments can be released to the exporter's cryptocurrency account. This then brings more highlight to transparency and safety features of the smart contracts as project length, complexity and variability in price. The coded code on the smart contract can be programmed to be automatically actioned when the coded contractual conditions have been fulfilled by both parties.

There is also payment security ensured as the payment may be blocked if the smart contract conditions have not been fulfilled, and no single person can access the blocked money. The blocked amount can only be released if the coded terms and conditions to the related parties are satisfied. (Ernest E Ameyaw, 2023) in his study highlighted that 98% of the participants voted that they would experiment with smart contracts before adopting the practice and 83% would do a trial period prior to adoption. This helps in identifying potential risks, bugs and failures which are addressed in a safe and secure manner to build trust in collaboration of project stakeholders and risk mitigation. The smart contracts provide adopters with a strong competitive advantage as traditional contracts are time consuming, they are susceptible to forgery of the ledgers and other administrative documentation and errors. Smart contracts can address construction project needs as most challenges confronting construction projects are solved.

Smart contracts encompass issues such as identifying theft and data leakage. Measures such as fog computing; novel settlement mechanism can help secure and benefit smart contracts and help gain trust from stakeholders. (Andrew Ebekozien, 2024), smart contracts improve business efficiency and reduction in fraud as there will be reduced anonymity in transactions and mitigate organizational costs and burdens of trusted intermediaries. The elimination in third-party intermediaries enhance the productivity and profitability of construction projects in the construction industry. Smart contracts are capable of automating current manually administered payment principle of a project bank account in public construction projects through eliminating late payments, non-payments and the insolvencies in the construction industry. The smart contracts also include regulation , compliance and project bank accounts. Their adoption depends on the bottom-up efforts from stakeholders in the construction project level (Ernest E Ameyaw, 2023).

The issues related to payments have resulted in cost and time overruns, difficulties in cashflows and business bankruptcy which will cause a delay in construction project completion. Despite introducing smart contracts, the technique and digitalizing the data of contractual application software still depends on ineffective and inefficient human operation work processes. (Ishara Rathnayake, 2022) smart contracts need to be improved with proper compatibility to improve vulnerability issues such as the hack of MT.Gox which incurred a loss of $450 million and $60 million related to decentralized autonomous organizations. The vulnerability in smart contracts are linked with solidity as solidity is an object oriented program language that is supported by Ethereum (which is a blockchain platform that facilitates the creation and execution of smart contracts). According to (Andrew Ebekozien, 2024) regardless of the smart contract status, the defective smart contracts cannot be rectified without reversing the blockchain. This means that the smart contract lacks refund capabilities, inadequate cryptocurrency for fairness purposes and misalignment of incentives which then leads to a great challenge to the adoption of smart contracts. Smart contracts require substantial amount of data from sensors and smart meters meaning more assets are required to activate smart contracts and the deployment of blockchain will be restricted by bandwidth and computational power (Andrew Ebekozien, 2024).The construction industry is highly fragmented and characterized by adversarial, rather than collaborative relationships which this has caused disputes and majority of these disputes are widespread especially in the construction industry and being caused by poor payment practices (Ernest E Ameyaw, 2023).

Joint Contracts Tribunal (JCT) may help smart contracts adoption to be smooth as the smart contract can be streamlined with jurisdictional requirements as well as client requirements. When looking at the ways to trace transactions during the contract process, Origin chain (which is a blockchain) is created to trace products between suppliers of construction material required in a construction project. The traceability details required by the traceability regulations can be utilized between any two parties in the construction supply chain, which can be the client and the main contractor ;the main contractor and subcontractor ;and subcontractor and suppliers (Ishara Rathnayake, 2022). Stakeholders should be assisted in embracing technology innovation as this could enhance organizational value in the construction industry when adopting smart contracts (Andrew Ebekozien, 2024). There must be careful timing for registering smart contracts as operators must ensure trusted entity generates the data received. This can be done through encryption with private keys such as adding “hash” and other cryptography functions to protect data. There must be an implementation of Encourage- Real-Quotation rule to address communication synchronization challenges. Also, just like the German government when implementing smart contracts, they introduced initiatives such as project BEST (Blockchain based decentralization energy market design and management structures) and GDPR (General Data Protection Regulations.

2.1. Understanding Blockchain Technology

Blockchain is a decentralized, distributed, and immutable ledger system that records transactions in a secure and transparent manner (Wong et al., 2024); Afrin & Pathak, 2023); (Ok et al., 2025). Each block contains a timestamped set of transactions and is linked to the previous block, forming a chain. Cryptographic principles

ensure the integrity and security of the data (Khan & Por, 2024; Kumar & Tiwari, 2024). Key features relevant to construction include decentralization where by a single entity controls the network, reducing single points of failure and censorship (Celik et al., 2024). Another feature is Immutability, which means that once recorded, transactions cannot be altered or deleted, creating an unchangeable audit trail (Nweje, 2024); Krishna, 2023). Transparency is another useful feature because it allows all participants to view transactions, fostering trust and accountability (Celik et al., 2024). Security through the cryptographic hashing and consensus mechanisms, there is protection against fraud and manipulation (Afrin & Pathak, 2023).

2.2. Smart Contracts: Automating Agreements

Smart contracts are self-executing agreements where the terms of the agreement are directly written into lines of code (Rashid, 2024). The code and the agreements contained therein exist across a distributed, decentralized blockchain network (Mazlan et al., 2025). When predefined conditions are met, the contract automatically executes, eliminating the need for intermediaries[16] and reducing potential for disputes.[17] In construction, smart contracts could automate payments upon completion of milestones, release of retainage, or trigger penalties for delays (Ye et al., 2024; Mazlan et al., 2025).

2.3. Applications in the Construction Industry

Blockchain and smart contracts have many applications in the different areas of the construction industry. For example, in the Supply Chain Management**, blockchain technologies and smart contracts e**nhanced traceability of materials, assist in the verification of their origin, and automate payments to suppliers upon delivery (Celik et al., 2024). The application of Blockchain technologies and smart contracts for supply chain management deals with the problem of counterfeit materials and improve logistics (Afrin & Pathak, 2023).

Blockchain technologies and smart contracts are also provide a secure platform for making automated payments thereby reducing delays in payments and avoiding unnecessary disputes (Christie et al., 2024). The construction industry is heavily dependent in contracts, which means that an introduction of blockchain technologies and smart contracts could result in a better management of those contracts, leading to a more efficient contractual process, reduction of paperwork, automated dispute resolution mechanisms, and ensuring standard compliance (Rashid, 2024 ; Christie et al., 2024).

Through blockchain technologies and smart contracts, the construction projects are better managed since these technologies have a capability to make real-time tracking of project progress, project performance, and the effective allocation of resources through immutable data records (Ok et al., 2025). More-so, disputes are easily resolved through blockchain technologies and smart contracts because these technologies provide immutable record of project events and transactions, whose evidence can hardly be refuted, thereby simplifying and expediting dispute resolution (Wong et al., 2024; Ok et al., 2025). Blockchain technologies and smart contracts assist in the integration of Building Information Modeling (BIM), where secure and transparent environment for sharing project data are created, data integrity ensured, and collaborative workflows are facilitated (Celik et al., 2024; Brelih & Klinc, 2025).

3. Case of Lusaka, Zambia: Context and Rationale

Lusaka, is the capital city of Zambia, which is currently undergoing a rapid urbanization and vigorously investment Ing in infrastructure development, including residential and commercial buildings as well as in roads (Mwale et al., 2024). Such a massive growth presents both opportunities and challenges for Lusaka's construction industry. Like the many construction sectors in other developing nations, the Zambian construction sector is faced with such problems as payment delays due to contractors' struggle with finances, a situation that negatively impacts cash flow and project progress (Makubalo, 2023). Another challenge regards contractual disputes especially where there are ambiguous contracts and a lack of transparency in record-keeping, a situation that results in disagreements (M'tewa, 2019). Supply chain inefficiencies are also common since there iis no clear tracking of materials, quality verification and reliable logistics management (Afrin & Pathak, 2023) Corruption and a lack of transparency are common challenges in the construction industry due to the current systems which are susceptible to illicit activities and a lack of accountability, as well as fraudulent practices that undermine the project integrity.

Given these challenges, Lusaka provides a compelling case study to explore the impact of blockchain technologies and smart contracts in addressing the afore discussed challenges. The case study provides a platform for demonstrating how transparency, efficiency, and accountability could be realized in the construction industry thereby transforming the local construction landscape, attracting external investors and improving the project delivery.

3. Methodology

The collection of qualitative data from these research participants afforded the researcher to fill the gap in existing literature, which shows that while the use of qualitative methods is a well-established approach , van Dijk (2006) argues that qualitative methods are rarely used in research. Adding to this fact is that data collected through qualitative methods is valuable for the sense-making about phenomena that it affords (Bowen, 2005).

This choice was informed by the convenience and proximity to the researchers who are based in Lusaka, Zambia. Using a single case country enabled the researchers to make an empirical inquiry into a complex phenomenon of solving the energy challenges within its real-life context (Lee & Baskerville 2003). Additionally, Zambia is engaged in massive construction projects, the study will provide knowledge on the research h patterns that ae essential for guiding future research on smart contracts especially in African countries. According to (Ishara Rathnayake, 2022), there are five steps that can be beneficial to researchers to guide in synthesized collected data and reporting the findings, these include formulating research objectives; identifying the research process inclusion and exclusion criteria; conducting data collection; performing quality assessment and lastly conducting the descriptive analysis.

A sample of key stakeholders in the Lusaka construction industry, participated in the research to collect qualitative data. Purposive sampling was used to select key informants with relevant experience and knowledge of project management, supply chain, and technological adoption. Snowball sampling assisted with the further identification of additional participants. The research participants included ten construction companies (contractors, subcontractors), five private developers, five consultants (architects, engineers, quantity surveyors), two material suppliers, one financial institution and a representative of the National Construction Council, a government body. Informed consent was obtained from all participants. Anonymity and confidentiality were assured, and participants had the right to withdraw from the study at any time.

4.1. Data Collection Instruments

Interviews provided a comprehensive understanding of how the construction industry of Zambia operates. Semi-structured, in-depth interviews were conducted with a smaller group of key decision-makers and experts to gather rich qualitative data on their experiences, specific challenges, and expectations regarding Blockchain technologies and smart contract technologies. Document analysis approach was also employed to review existing project contracts, payment schedules, and dispute resolution mechanisms to understand current practices and identify areas for improvement. Focus group discussion further facilitated an open dialogue to enable the gathering of diverse perspectives on specific aspects of blockchain and smart contract implementation. NVivo, computer software tool for analyzing qualitative data was used to analyze the collected data. Thematic analysis enhanced the identification of recurring themes, patterns, and insights from interview transcripts and focus group discussions. NVivo Coding software could was used to assist in organizing and analyzing the collected data.

5. Findings and Discussion

5.1 Benefits of Blockchain Technologies and Smart Contracts

The analysis of the collected data revealed that a successful adoption of smart contracts and blockchain in Lusaka's construction industry could yield several significant positive impacts. For example, the constructors indicated that these technologies could help them to reduce project delays and cost overruns. Furthermore, there will be improved construction operations through automated payments, real-time progress tracking, and improved supply chain efficiency.

Progress and profitability of the construction sectors is usually hindered by unnecessary disputes, which are minimized by the implementation of Blockchain and smart contract technologies as they provide an immutable and transparent record of agreements and transactions, thereby reducing ambiguities and fraudulent claims enhanced trust and collaboration: A transparent and secure platform fosters greater trust among project participants. Adding is the fact that Blockchain and smart contract technologies improved access to finance**.** By providing verifiable project data, blockchain could facilitate easier access to project financing from local and international institutions. More so, a more transparent and efficient construction sector could attract greater investment by foreigners interested in infrastructure projects. Furthermore, reduced corruption, inherent transparency and immutability of blockchain can significantly reduce opportunities for corrupt practices within the project lifecycle. Job creation he demands for new skills in blockchain development, smart contract auditing, and digital project management could lead to new employment opportunities.

5.2 **Challenges of adopting Blockchain technologies and Smart Contracts**

Despite the immense potential, the successful adoption of these technologies in Lusaka will face several challenges, which include a Lack of Awareness and Understanding on how to fully utilize these emerging technologies because many stakeholders indicated that they did not fully grasp the concepts of blockchain and smart contracts. Another challenge relates to the Limited Technological Infrastructure since most participants indicated that they do not have access to reliable internet connectivity. There is also a challenge relating to the absence of Regulatory Frameworks, which stipulates the clear legalities of implementing and using blockchain. Most participants were therefore skeptical due to the uncertainties on these emerging technologies. The participants were also concerned about the Initial Investment Costs, for developing and implementing blockchain solutions, which the research participants felt were too high and prohibitive for smaller construction companies. The most important challenge which emerged from the data was Resistance to Change. Most older research participants could hardly let go of their traditional practices. The discussions with them revealed a reluctance to embrace new technologies and this attitude is hindering the adoption of blockchain technologies and smart contracts.

7. Conclusion

The integration of smart contracts and blockchain technologies has transformative potential for the construction industry, particularly in dynamic and developing economies like Zambia. While the theoretical benefits of enhanced efficiency, transparency, and risk mitigation are compelling, their successful implementation in Lusaka depends on addressing key challenges related to technological literacy, attitude, regulatory clarity, and initial investment.

This study was based on empirical data from a single context of Lusaka, Zambia. Empirical research is crucial that includes multiple cases drawn even from multiple contexts. This research was also limited to narratives and stories of participants who have no lived-experience of working with blockchain technologies and smart contracts. It would benefit the research community if a study is conducted with experience participants in the use of these emerging technologies to facilitate the development of strategies tailored for effective adoption of blockchain technologies and smart contracts. Such lived-experiences could also motivate many in the construction industry of Lusaka and beyond to embrace these innovations, to overcome the persistent challenges and position them as a leader in digital transformation within the African continent, thus paving the way for more sustainable, efficient, and transparent infrastructure development.

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