

Smart Contract Tools for Addressing the Menace of Payment Challenges to Contractors on Construction Projects

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Keywords: Payment Challenges, Smart Contracts, Blockchain.

SUMMARY

Due to complex stakeholder interaction and approval process, the payment process in Ghana's construction industry is most often unduly ineffective and lengthy. Governments of many other countries attempted to address the payment-related issues in the construction industry, through legislation, novel types of payment agreements, conventional information technology solutions, and supply chain management best practices. However, payment challenges remain one of the major issues to address in the construction industry; Ghana is not an exception. Applications of blockchain technology, a reliable and distributed data storage system, and smart contract are becoming more popular as remedies for challenging inter-organizational processes. A smart contract is defined as a self-executing contract or set of rules between two or more parties with the terms of the agreement directly written into lines of code and existing across a distributed, decentralized blockchain network. The suitability of smart contract technology to address payment challenges in the construction industry is examined in this paper. In this paper, the severity of payment challenges, their root causes, and the possibility of smart contracts to address them, were thoroughly examined and discussed. Some data was collected through a questionnaires survey to ascertain quantity surveyors, project managers other construction industry professionals' appreciation of the ability of smart contracts to address payment issues in construction contracts. The results of the survey indicates a strong affirmation of the potential of smart contracts to address the menace of payment challenges in the construction industry in Ghana.

Keywords: Payment Challenges; Ghana; Construction Industry; Blockchain; Smart Contracts

1. INTRODUCTION

The supply systems for the construction sector are often extensive, network-structured, and dynamic, with a vast number of both internal and external suppliers. Owing to multi-pronged stakeholder relationships, the payment procedure in the construction industry has long been deemed inefficient and slow in Ghana. When the payment is not liquid enough, there would be many aftermath problems. Doubts in payments, which causes cash flow problems, have been stated as a reason for business catastrophes and growing disputes (Zaky and Nassar, 2021). The construction industry encounters a lot of different payment issues depending on varying criteria

and reasons. Compared with other industries, the default settlement durations in the construction industry are much higher (Casino, F.,2019).

The construction industry is complicated with issues of compliance, lengthy payment processes, and inefficiencies in finance and payments are the main detrimental effects. In addition to lengthy payment settlement periods and delayed payments, the construction industry frequently experiences partial and nonpayment issues (Ramachandra and Rotimi, 2015).

The impact of payment delays would lead to over-pricing against the risk of delay (Nanayakkara, et al., 2021). These payment inefficiencies result in a considerable rise in the cost of financing to offset the risk, which raises the overall cost of construction. Additionally, failure to pay on time, lack of payment certainty, and reluctance to pay are the three main reasons for contractual conflicts (Ahmadisheykhsarmast and Sonmez, 2018). The low level of transparency in the complex construction industry, specifically, within the supply chain, reduces the level of trust and payment security, ultimately leading to cash flow issues, payment delays, project abandonments, disputes, low quality or compliance issues, and high cost of final products. (Nanayakkara, et al., 2019).

Financial Technologies (FinTech) development and use have recently advanced in the modern world.

The development of cryptocurrencies like Bitcoin, Ethereum, Ripple, EOS, and others is the most notable among them. Blockchain technology which powers cryptocurrencies, was created about a decade ago (Nanayakkara, et al., 2019). With Blockchain technology, transactions that take place in a peer-to-peer network are recorded in a distributed database. It is viewed as a distributed computing paradigm that effectively resolves the trust in a centralized party issue. blockchain technology's applications go far beyond cryptocurrencies (Perera, S et al 2020). It makes it possible to enhance current applications and create new ones like smart contracts, blockchain-based elections, smart power grids, smart property, and others (Nanayakkara, et al., 2019).

Without the aid of a reliable third party, smart contracts enable, execute, and enforce agreements between unreliable parties. Smart contracts are executable codes that operate on top of blockchain technology. Network automation and the capacity to convert paper contracts into digital ones were made possible by smart contracts (Khan, et al, 2021). In contrast to traditional contracts, smart contracts provided automated transactions without the oversight of a central authority, enabling users to codify their agreements and trust relationships (Khan, et al., 2021). This paper, therefore, identifies the most significant payment challenges in the Ghanaian construction industry and determines the causes of these challenges. It then establishes the many benefits of smart contracts and proposes smart contracts as a solution for many payment challenges in the construction industry of Ghana.

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2. ISSUES IN THE CONSTRUCTION INDUSTRY

It is generally known that the construction sector has long struggled with late or non-payments, despite the significant contribution it makes to the national economies of many nations (Rathnayake et al 2022). Payment delays and other payment-related conflicts between the parties in building projects are serious problems for the sector. These problems lead to cost and schedule overruns, cashflow challenges, and company failure. (Perera et al 2021). Also, the most contributing causes of contractual conflicts in the construction industry include missed payment deadlines, a lack of payment guarantee, and refusals and rejections to pay (Clough et al 2015). On the other hand, the construction sector has historically lagged behind in technological advancements. Also, most of the problems could be influenced by stakeholders in the building industry's limited knowledge and comprehension of different technologies. However, compared to other sectors like logistics, automotive, hospitality, and mechanical engineering, the construction industry has a low adoption of modernization-related technology, according to several studies (Li, et al 2015).

Most contractual applications still rely on ineffective and inefficient manual or human operator-based work procedures that take a long time to create, prepare, evaluate, authorize, and ultimately execute, even if contracts and payment processes use automation methods and digitalized data (Lemke, et al 2018). The construction sector therefore need to adopt digitalized processes and cutting-edge technologies that are effective and efficient in terms of cost, quality, and the time in order to alleviate the above highlighted concerns and increase overall production. Smart contracts is one such technology that has been highlighted as having the potential to significantly improve the industry.

3. PAYMENT IN THE CONSTRUCTION INDUSTRY

Typically, in the construction industry, payments are provided in stages based on the value of work completed over a predetermined period or following a predetermined milestone (Nanayakkara, et al., 2021). Most contract forms follow this format. It is clear from a typical construction contract that the contractor has pledged to complete all tasks outlined in it. On the other hand, the employer or client must uphold their end of the bargain by giving consideration when payment is due, which is typically in the form of money. (Ansah, 2011).

“It is very obvious that a healthy and consistent disbursement of money is a critical point in determining contractor performance. To ensure the flow of the work activities under the contract and its eventual successful realization, construction contracts must be drafted” (Eshetu, A., 2020.). The conditions that lay down the primary legal relationship between the parties involved in a project, determining the allocation of risk and consequently, price, drafted in the construction contract are known as the conditions of the contract. The conditions of contract also stipulate payment settlement procedures. Generally, there are periods defined for preparing,

checking, and certifying work done by contractors, and finally making the payment (Nanayakkara, et al., 2021). In Ghana Payment Certificates are issued prior to payment to contractors. There are most frequent payment certificate is the Interim Payment Certificates. Such certificates are prepared according to the agreed conditions of the contract for the project. The client needs the payment certificate as an information to pay the contractor after a certain amount of work has been completed and confirmed. It is usually issued by the contract administrator or manager. Peters, (2019) highlighted the types of payments used in the construction industry under the following categories: Interim or progress payments, stage payments, advance payments, and payments after completion.

3.1 Payment Challenges in the Construction Industry

The construction industry encounters a lot of different payment issues depending on varying criteria and reasons. Compared with other industries, the default settlement durations in the construction industry are much higher (Koc, K., et al 2022). Payments in the construction industry are generally made progressively based on the value of work done during a certain period or on completion of an agreed milestone (Elmualim, A. and Gilder, J., 2014). This was considered as one of the major causes of the default. Since the payment settlement procedures are stipulated in the conditions of the contract, the general periods of preparing, checking, and certifying the bill, and finally making the payments takes valuable time (Nanayakkara, et al., 2021).

According to Nanayakkara, et al. (2021), 1.6% of income is lost in the construction industry due to payment delays. Partial payments and non-payments are also quite common in the construction industry which worsens the situation for contractors and suppliers. The impact of payment delays would lead to over-pricing against the risk of delay (Nanayakkara, et al., 2021). Abeysekera, (2018) found that a loss to a client that equals 0.05% of the contract sum when the interest rate is 5% is created from just a one-week payment delay. The quality and the price of products and services are negatively impacted by low trust and poor payment guarantees among the parties involved (Nanayakkara, et al., 2019). The lengthy payment settlement duration also adds more burden to construction projects as the cost of finance and additional delays create unfavorable impacts.

The low transparency rate in the complex construction industry, specifically, within the supply chain, reduces the level of trust and payment security, ultimately leading to cash flow issues, payment delays, project abandonments, disputes, low quality or compliance issues, and high cost of final products. (Nanayakkara, et al., 2019).

4. SMART CONTRACTS

Cryptographer Nick Szabo first proposed the idea of a "smart contract" as a computerized transaction mechanism in 1994 (Hamledari & Fischer, 2021). A self-executing contract or set

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of rules between two or more parties known as a "smart contract" exists on a distributed, decentralized blockchain network and contains the details of the agreement directly encoded into lines of code (Dixit, et al 2022; Nanayakkara, et al., 2019). Smart contracts are sometimes described as blockchain-based computer programs that may automate a variety of tasks based on certain conditions with little to no human involvement. It can be used to fulfill typical contractual obligations, such as payment periods, compliance demands, liens, and contract conditions, without the need for a central authority or outside enforcement, while minimizing intentional and unintentional mistakes (Nanayakkara, et al., 2019). Healthcare, finance, the hotel industry, and other sectors have benefited from smart contracts unlike the construction industry that struggles with payment defaults and contract conflicts (Rathnayake et al 2022).

4.1 Operation of Smart Contracts

Smart contracts enable a digital transaction to be integrated into the system and then automatically sent to the contract parties. One such digital transaction may be the payment amount (Kirli et al., 2022). Also, by restricting the amount to be paid in this procedure, payment security is also guaranteed, and nobody is able to access the restricted funds (Feng et al, 2019). If the specified requirements and circumstances are met, the blocked money is only released to pertinent parties. Due to the existence of binary logic, which requires that the input and output be the same, and the reliance of contract conditions' functions on programmed scopes, smart contracts are thus important (Feng et al 2019).

In order to streamline the payment process utilizing coded programs, Cardeira has built a payment platform that relies on smart contracts and incorporates many participants (Hewa et al 2021). The contractor cannot take the money under this online payment method until the subcontractors have been paid since once the instructions are followed, the money is instantly released. Since smart contracts are decentralized, the involvement of third parties in a project, like banks, in the payment process may be minimized. Project participants may specifically codify contract provisions at the procurement phase of the project, and the payment amount and due date must be included in smart contracts. Also, until the payment due date, none of the project partners may access this money (Ahmadisheykhsarmast, S., 2020).

Then, once the equipment or material is ordered, the supplier may inform the receiver via smart contracts, and the receiver can inform the supplier when the requested things are delivered. By taking into consideration smart contracts' self-implemented functionality, both parties confirm the coded terms before releasing the money to the exporter's cryptocurrency account (Rathnayake, et al, 2022). A strategy for integrating smart contracts with digital ledger technology, BIM, and IoT was examined by (Li, et al., 2021). Jin also investigated the relationship between BIM and smart contracts and discovered its guiding principles by examining a number of use cases. This research placed a strong focus on smart contracts' technical features (Wang, H., et al 2023).

Contracts are enforceable agreements that inevitably have legal and contractual repercussions. If a smart contract replicates enforceable contractual arrangements, the jurisdictional legal requirements that apply to a conventional contract will essentially apply to smart contracts. However, considering the legally binding nature of smart contracts, the rapid proliferation of information and communication technologies in smart contracts has raised questions concerning legal constraints (Durovic, M. and Lech, F., 2019). A "contract" is viewed as a binding agreement that may be enforced in court. In order to ascertain enforceability, state courts often examine whether common law requirements like offer, acceptance, and consideration are satisfied. So then legal frameworks must be improved to incorporate blockchain and smart contract components.

This demonstrates that governments, especially those in developed countries, favor the use of smart contracts. Despite attempts to make the process more cooperative, construction is still a competitive industry, and problems between parties to contracts still happen often. The unbiased and effective decision-making process of a smart contract may help to reduce such contractual disputes between parties. A dispute, however, could ultimately lead to Alternative Dispute Resolution (ADR) processes or even legal action (Tezel, A et al 2021). The right to ADR and legal appeal is provided under standard form construction contracts like the JCT and NEC. The ability to adopt more cooperative dispute resolution methods, being subject to the same legal rights of appeal, and being able to circumvent such regulations will all have a substantial influence on smart contracts operations. Nevertheless, other ADR rules, such as adjudication, seem to provide more possibilities for integration into smart contracts due to the more clearly stated mechanisms involved. The rules for adjudicating building disputes must adhere to a strict timeframe and decision-making process (Zekos, G.I., 2022). Hence, it is expected that smart contracts will be linked to clear legal rules and regulations to make them more enforceable even if the usage of smart contracts has major legal repercussions.

5. RESEARCH IN GHANA ON SMART CONTRACTS AND PAYMENT CHALLENGES.

In the study used quantitative research strategy was used. A well-structured questionnaire was created to gather primary data from Ghanaian construction industry professionals. The respondents determined the severity and causes of the identified payment difficulties in the Ghanaian construction sector. They also stated their opinion on the potential of smart contracts to address payment-related challenges. They were however engaged to ensure they understood the concept of smart contracts before they are requested to complete the questionnaire. In sampling respondents, purposive sampling techniques were used to choose respondents who had knowledge and expertise to respond to the questionnaires. A total of 120 construction professionals in Ghana were selected from this approach to respond to the study questionnaires but 75 responses were retrieved. This represents a 62.5% response rate which is usual with such surveys.

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5.1 Results

A total of 75 construction professionals in Ghana with over one year of working experience participated in the study with 52 (69.3%) of them being males and 23 (30.7%), being females. Approximately a quarter (25.3%) of the participants were quantity surveyors. Other professionals include Project managers (18.7%), Architects (17.3%), Services Engineers (14.7%) and procurement Officers (24%). All these professions were either working for contractors, consultants or clients and were greatly involved in administration of contracts. The majority (61.2%) of the respondents have undertaken more than 10 projects used as reference for completing the survey with everyone undertaking at least 1 project. The Majority (62.6%) of respondents have more than 5 years of working experience. This gives a background information on the respondents, and it is reflective of the representation of the information provided by them. Since the study is more focused on payment challenges in the construction industry of Ghana, all the respondents in the survey in one way or the other, involved in payments issues under various contracts. They are therefore well positioned provide the right and accurate responses to questions involving payment challenges in the construction industry of Ghana.

5.2 Severity of the Various Payment Challenges

Reponses from respondents with respect to various payment challenges are outlined in the Table 4.1 below. A mean score of 3.50 and above represents a severe payment challenge in the industry. It was realized from the output of the results as shown in Table 4.1 that, the most severe payment challenge in the industry is payment delays since it had the highest of the mean (3.95) among the challenges.

Table 1 Payment Challenges in the Ghanaian Construction Industry

Payment Challenges	Total Observation	Mean	RII	Rank
Payment delays	75	3.95	0.79	1st
Long payment cycle	75	3.73	0.75	2nd
Non-payments	75	3.65	0.73	3rd
High cost of finance	75	3.63	0.73	4th
Cost overrun	75	3.63	0.73	5th
Partial payments	75	3.51	0.70	6th
Cash flow difficulties	75	3.36	0.67	7th
Payment disputes	75	3.35	0.67	8th
Payment hold	75	3.28	0.66	9th
Insecure payments	75	3.20	0.64	10th
Retention	75	2.99	0.60	11th

Cronbach's alpha = 0.886

This re-emphasizes the issues identified earlier in literature that, payment delay is one of the major issues in the construction industry, if not the biggest. A considerable amount of income is lost due to payment delays (Danuri et al., 2006). The literature also outlined the lengthy default payment cycle in the industry as one of the critical payment challenges. The long payment cycle adds more burden to construction projects as the cost of finance and additional delays create unfavorable impacts on stakeholders. Non-payments and partial payments are also common in the construction industry. This worsens the situation for construction workers. Remedies to these challenges are essential to the industry and the national economy. Smart contract technology is therefore proposed as a solution to many of the challenges and the perceptions of the industry on this technology is discussed in subsequent sections.

5.3 Underlining Causes of the Payment Challenges

In a bid to resolve the payment challenges in the construction industry of Ghana, it became necessary to identify those factors that act as the underlining cause of these payment challenges. This was necessary to identify the most significant causes so that efforts to enhance the implementation of smart contract technology could be tailored to tackle the most significant causes of payment challenges.

Most causes identified in Table 4.2 were ranked as significant (above mean score of 3.5) factors to payment challenges in the construction industry. The most significant cause was identified to be the Payment culture of the industry (work first and get paid later). This was keenly followed by time overrun of projects caused by poor planning and the attitude of the payer (dishonest/unethical conduct) as they ranked second and third respectively. These three causes were agreed to as important factors that must be overcome by the construction industry to eliminate the payment challenges in the construction industry. They can be referred to as the critical obstacles.

It was found that lack of trust among members and legislative procedures (Contract Act) were last based on the ranking system. Although they were not viewed as very significant causes, their mean scores are 3.48 and 3.33 respectively. This means that they (lack of trust among members and legislative procedures (Contract Act)) cannot be ignored in resolving the payment challenges as they are also closely linked to the third ranked factor.

Payment challenges in the construction industry will be lessened if it is possible to eliminate or reduce these underlying causes. The majority of the root causes are peculiar to the construction sector and are difficult to eradicate with the use of typical information systems. However, these underlying problems can be addressed through the high level of transparency, trust, accountability, and automation with less human interaction associated with the characteristics of a smart contract technology. With a Cronbach's alpha coefficient of 0.922, table 4.2 the responses are consistent and largely reliable (George & Mallery, 2016).

Table 2 Causes of Payment Challenges in the Construction Industry

Causes of Payment Challenges	Total Observatio n	Mean	RII	Rank
Payment culture of the industry (work first and get paid later)	75	4.08	0.82	1st
Time overrun of projects caused by poor planning	75	3.99	0.80	2nd
The attitude of the payer (dishonest/unethical conduct)	75	3.96	0.79	3rd
Work done exceeding allocated budget	75	3.95	0.79	4th
Disputes over the quality of work	75	3.89	0.78	5th
Easy entry of players with little/no capital backing	75	3.87	0.77	6th
Rework of errors during construction	75	3.84	0.77	7th
Over-reliance on client/payer	75	3.80	0.76	8th
Entrance with low capital	75	3.77	0.75	9th
Lack of knowledge and experience in the field	75	3.76	0.75	10th
Structure of the industry (Involvement of many commercial parties)	75	3.75	0.75	11th
Requirement and design changes	75	3.75	0.75	12th
Disputes regarding payment claims	75	3.73	0.75	13th
Delay in certification	75	3.73	0.75	14th
Complications from contractual conditions	75	3.72	0.74	15th
Improper supervision and financial control	75	3.71	0.74	16th
The standard form of contracts used (right to payment and non-payment)	75	3.55	0.71	17th
Project delays because of supply chain issues	75	3.49	0.70	18th
Lack of trust among members	75	3.48	0.70	19th
Legislative procedures (Contract Act)	75	3.33	0.67	20th
Cronbach's alpha = 0.922				

5.4 Potential for Smart Contract to Resolve Payment Challenges

In attempt to identify the potential of smart contracts to resolve payment challenges in the construction industry of Ghana, the participants were introduced to the various properties of a smart contracts since the entire concept is not popular with a huge proportion of construction professionals in Ghana. The respondents than scored the potential of the various properties of the smart contract to eliminate payment challenges in the industry. The results are presented as follows.

- Approximately half (49.3%) of the participants agreed to the fact that a shared and open ledger between contracting parties is a good idea. Though the concept is not a new, it was not clear why the rest were neutral.
- With respect to the characteristics of visibility, transparency and traceability into everyone's (connected to the smart contract) supply chains, 68.0% of the participants

agreed that this property of smart contract can help eliminate some payment challenges in the construction industry. Eighteen percent had a neutral position about it.

- Majority (69.3%) of the respondents were of the view that increased trust and reduced human influence in contract processes were properties of smart contracts that can help eliminate some causes of payment challenges.
- The potential for smart contracts to eliminate intermediaries such as banks from transaction processes in the construction industry can reduce the causes of payment challenges. This was alluded to by 66.7% of the respondents.
- When introduced to the overall concept and process of smart contracts, approximately three out of four participants (72.0%) alluded to the fact that smart contracts can help eliminate many payment challenges in the Ghanaian construction industry.
- Nearly 74.7% of the respondents affirmed that smart contract solutions must be embraced by the construction industry in order to overcome many transactional challenges with payment.

5.5 Potential efficiency of Smart Contract to Resolve the Identified Payment Challenges

The ability of smart contracts to resolve the various payment challenges earlier identified was assessed here. In this aspect of the survey, there is an attempt to ascertain the level to which smart contracts technology can resolve the payment challenges. The challenges are ranked by the order of the which can best be resolved.

Table 3 Smart Contract Resolutions to the Identified Payment Challenges

Payment Challenges	Total Observation	Mean	RII	Rank
Long payment cycle	75	3.92	0.78	1st
Payment delays	75	3.91	0.78	2nd
Non-payments	75	3.88	0.78	3rd
Insecure payments	75	3.88	0.78	4th
Payment disputes	75	3.77	0.75	5th
Payment holds	75	3.76	0.75	6th
Cash flow difficulties	75	3.68	0.74	7th
Partial payments	75	3.68	0.74	8th
High cost of finance	75	3.67	0.73	9th
Retention	75	3.67	0.73	10th
Cost overrun	75	3.59	0.72	11th

Cronbach's alpha = 0.933

With a mean score of 3.50 and above representing a significant payment challenge resolution by smart contract technology, it was realized from the output of the results as shown in Table 3

that, all the payment challenge in the industry represented in published literature in the table can be resolved by smart contract technology.

As illustrated in Table 3, smart contract technologies could assist in overcoming payment challenges, such as insecure payments, retention, payment hold, payment disputes, cash flow difficulties, non-payments, long payment cycles, partial payments, and high cost of finance, to a great extent. This denotes a significant positive impact on many of the challenges identified in published literature.

Long payment cycles, payment delays and non-payments are ranked as the first three most important payment issues in the industry, respectively, by the participants. However, respondents affirm that smart contract technology has a high potential to resolve these problems. Though not all respondents alluded to this affirmation, which means smart contract technology cannot completely eradicate payment challenges in the sector, the findings imply the technology can address the problem to a very high extent. Smart contract technology therefore have a substantially high potential to address payment challenges in the construction industry

6. CONCLUSION

This study is focused on how the key decentralized properties of smart contracts technology such as immutability, integrity, transparency, accountability and efficiency can help resolve payment challenges associated with the construction industry, specifically Ghana. It was identified that the critical obstacles or major caused of payment challenges such as ‘industry's payment culture’, ‘inadequate planning’, payer's attitude (dishonest/unethical behavior) among others can be effectively reduced using the smart contract technology.

In comparison other systems, smart contracts technology has a substantial positive potential in providing solutions that result in overcoming payment challenges in the construction industry. Smart contracts also speed up the approval and payment process, reduce the number of payments that are held back, and create a private payment environment. It is therefore relevant that the technology is embraced in order to resolve the challenges.

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Smart Contract Tools for Addressing the Menace of Payment Challenges to Contractors on Construction Projects (12019)

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