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The Use of Smart Contracts to Assist in Mitigating Payment Inefficiencies

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Abstract

Most projects are not being delivered on time because of disputes arising from payment inefficiencies. Unfair payment practices and inefficiencies exist within the construction industry, delays occur on projects, disputes arise between stakeholders; cost overruns occur, and overall project performance is poor. A construction contract provides a guideline for a project and forms the basis for control of procedures during construction. Smart contracts in turn, provide an opportunity to ensure that the guidelines set out in the construction contract are followed and adhered to. Using blockchain technology, smart contracts limit the amount of subjectivity relative to claims and disputes, payment, quality, risk, and time, ensuring that the parameters set and agreed upon in the formulation of the contract are maintained through the project life cycle.

Against this background, the study investigated the problem of poor payment practices and the use of an automated smart contract system to reduce payment inefficiencies and create optimisation within the construction industry. The study adopted a quantitative approach, the aim being to evolve a framework of interventions to address the challenges relative to payment inefficiencies, including the use of smart contracts.

Key findings include: the five key contributors to payment delays are extended waiting time for approval, deficiencies in coordination, delayed decision making, variation orders, and delayed information flow; there is a lack of knowledge relative to smart contracts and blockchain technology; a lack of adoption of Industry 4.0 technologies, and there is major interest regarding smart contracts.

Conclusions include: an up to date as-built model to track progress on projects speeds up payment approval, and minimises scope changes and rework; the greatest contributor to payment delays relates to stakeholders agreeing to progress; the implementation of smart contract systems to manage disputes, hinges on clients', contractors', and contractors' knowledge and understanding of construction contracts.

Recommendations include: a paradigm shift with respect to payment on projects; delayed payments on projects should be monitored; education of project stakeholders regarding smart contracts, and smart contracts should be implemented on projects to enable automated payment once certain conditions, variables, and principles have been met.

Keywords: Automation, Blockchain, Construction, Payment delays, Smart contracts.

1. Introduction

Compared to many other industries, the construction industry, plays a vital role in South Africa's economy and is a key contributor to economic growth (Windapo & Cattell, 2013). The industry is labour intensive providing employment opportunities for large sections of the nation's work force.

The South African construction industry is known for being unique with characteristics that contribute to payment problems. The industry is renowned for low capital backing; however, it relies heavily on cash flow to sustain operations, especially regarding small contracting firms and sub-contractors. Ramachandra and Rotimi (2015) contend that firms or individuals with little capital base and very limited experience can set up construction businesses. Omopariola and Windapo (2019) emphasise that developing and maintaining a healthy and competitive construction industry stems from smooth cash flow guarantees, which ensure the efficient delivery of construction projects.

The construction contract can assist in the management of a project and should provide security and peace of mind for all parties involved. However, many projects are not being delivered on time, disputes

arise, and this negatively affects the construction industry. The reason is due to a lack of understanding and experience of construction contracts and their formulation and implementation during the project life cycle. According to Arditi and Chotibhongs (2005), the problems in the construction industry begin when payment of the exact amount due by the date shown on the statement is not received. Arditi and Chotibhongs (2005) further lament that disagreements then lead to arguments as relationships break down, attempts to shift the blame, and conflict ensue, and litigation follows. Ultimately, projects exceed initial time estimates, costs escalate, and delays are experienced.

The study aims to determine whether smart contracts using block chain technology can assist in mitigating payment inefficiencies and excludes studies that focus on specific smart contract systems, and which can be best implemented.

2. Review of the literature

2.1 Factors contributing to payment delays

Ramachandra & Rotimi (2015) reference Ye & Rahman (2010) who listed the top five causes of payment delays, namely poor financial management, ineffective utilisation of funds, lack of capital to finance projects, failure to source money from banks in times of reduced sales, delay in releasing retention monies to contractors, and delay in evaluation and certification of interim and final payments. Ramachandra & Rotimi, (2015) document that payment inefficiencies relate to inadequate processes and are largely attitudinal and could be refined to ensure smooth cash flow through the supply chain between contractors, principals, and subcontractors.

Further causes arise when contractors and the professional team fail to agree with onsite valuations of work, which disagreements result in conflict between clients and contractors, which in turn leads to conflicts dispute resolution, ultimately contributing to delayed payments (Ansah, 2011). These late payments have an immediate effect on cash flow which is key to contractors' and subcontractors' survival. A delay concerning payments often drive contractors to source additional funding through overdraft facilities, trade credit, and other means to meet cash flow demands. It should be noted that often these payment delays are often deliberate. Given that in recent years between 70 - 75% of the value of work is undertaken by subcontractors, such payment delays cripple subcontractors who rely on the cash flow to pay suppliers, staff, and operate (Ramachandra & Rotimi, 2015).

2.2 Poor performance on projects due to payment delays

Omopariola and Windapo (2018) and Omopariola and Windapo (2019), and prior thereto, Motawa & Kaka (2009), have investigated how payment systems and related impact projects and performance. They determined that current payment systems in use include interim payment, advance payment, stage payment, milestone payment, and payment on completion. Omopariola and Windapo (2019) point out that there is an underlying principle that governs these systems, and that is that clients make payments to contractors and stakeholders in different ways and at different times of the project. Ansah (2011) explains that when contractors fail to receive interim, and / or other payments on time or in accordance with the stipulated terms of the contract or the proper amount, these payment delays affect the performance of the contractor.

2.3 Disputes between stakeholders regarding payment inefficiencies.

Omopariola and Windapo (2019) state that "the delivery of successful quality projects and the ability to meet client requirements and resolve disputes between stakeholders is often affected by inappropriate payment systems in the construction industry." Other researchers such as Danuri, Munnaim, Rahman, & Hanid (2006) agree with Omopariola and Windapo (2019) and state that the main subject of disputes among construction stakeholders that lead to financial problems are payment related. Omopariola and Windapo (2019) contend that clients' choice of payment systems is not necessarily suitable to the project environment.

Ansah (2011) further contends that there are not many favourable outcomes or remedies for the affected party. The contractor can either initiate legal action for the recovery of money owed including the interest payable to them, or initiate arbitration proceedings to claim for damages incurred by their business. If the client continues to refuse to pay the contractor after numerous interim payments have been authorised by the contract administrator, the contractor may treat non-payment as a repudiation of the contract, and therefore the contractor can legally treat this repudiation as an offer to rescind the contract (Ansah, 2011).

Ansah (2011) concludes that clauses that address delayed payment must be included in contracts. These could be in the form of additional charges on overdue payments and the establishment of a payment department.

2.4 The concept of smart contracts

Smart contracts utilise protocols and user interfaces to facilitate all the steps in the contracting process. Lamb (2018) describes a smart contract as a contract using computer protocols to formalise elements of a relationship to automatically execute the terms encoded therein once the pre-defined conditions are met. The need for acceleration and automation of key processes is critical to the industry in terms of moving forward, and Altay & Motawa (2020) highlight how this can be achieved using smart contracts using blockchain technology.

A key feature of smart contracts is that transactions are performed without intermediaries. A blockchain consists of units of data pertaining to specific transactions arranged in an ordered list (Lamb, 2018), that allows the automation of transactions within a contract once certain predetermined project variables and principles are met (Altay & Motawa, 2020). Smart contracts enable greater traceability and provide an opportunity for an increase in processing efficiency.

2.4 How smart contracts have emerged as a potential solution to payment inefficiencies

Although there have been mechanisms put in to practice within standard forms of construction contracts, there is still an overwhelming issue of delayed payments within the construction industry (Omopariola and Windapo, 2019). Construction projects are a unique type of project in that multiple professional groups work alongside each other to achieve project success. This poses a problem regarding coordination. Automation through digitalisation in construction can assist in addressing coordination deficiencies to reduce disputes between stakeholders on projects (Altay & Motawa, 2020). According to Altay and Motawa (2020), digital construction aims to increase collaboration among project stakeholders. Furthermore, Altay and Motawa, (2020) describe how the simulation feature in smart contracts reduces coordination deficiencies.

The industry has attempted to resolve the problem of payment delays and progress has been made. Adapting to advancements in technology is a limiting factor when trying to mitigate payment inefficiencies, there is technology available to assist. Smart contracts, if implemented correctly should have the potentially to solve or reduce important issues regarding payment delays and make a meaningful contribution to overall project performance (Altay & Motawa, 2020).

3. Research

3.1 Research Method and Sample Stratum

The quantitative method was adopted for the study, which entailed an online questionnaire survey. The sample included 65 potential respondents who were registered with statutory councils and members of employer associations in the Nelson Mandela Bay Metropole, and in the case of individuals, from 18 to over 65 years of age, and having worked in the construction industry for more than one calendar year. The respondents included architects, engineers, construction project managers, engineers, general contractors, project control consultants, quantity surveyors, and subcontractors. 33 Responses were included in the data analysis, which entailed the computation of frequencies, and a measure of central tendency in the form of a mean score (MS), which equates to a 50.8% response rate. The questionnaire consisted of forty-four questions – forty-three closed-ended, and one open-ended. Thirty-five of the close-ended were Likert scale type questions and eight were demographic related questions.

3.2 Results

Table 1 indicates the extent to which nine factors contribute towards payment delays during construction projects in terms of percentage responses to a scale of 1 (minor) to 5 (major) and mean scores (MSs) ranging between 1.00 and 5.00. It should be noted that all the MS's are above the midpoint score of 3.00, which indicates that in general these factors contribute to payment delays during construction projects to more of a major, as opposed to a minor extent.

It is notable that 6 / 9 (66.7%) factors have MSs > 3.40 ≤ 4.20, which indicates they contribute between some extent to a near minor / near minor extent. Extended waiting time for approval is ranked first followed

by deficiencies in coordination, delayed decision making, variation orders, delayed information flow, and lack of communication. 3 / 9 (33.3%) of factors have MSs > 2.60 ≤ 3.40, which indicates the contribution is between a near minor extent to some extent / some extent - non-utilisation of professional construction / contractual management is followed by inaccurate estimates, and poor site management. These findings indicate that the causes are multi-stakeholder in terms of origin, and several can be mitigated by smart contracts.

Table 1. Extent to which nine factors contribute to payment delays during construction projects.

Factor	Response (%)						MS	Rank
		Minor……..Major						
	Un-sure	1	2	3	4	5		
Extended waiting time for approval	0.0	0.0	9.1	15.2	39.4	36.4	4.03	1
Deficiencies in coordination	3.0	3.1	3.1	15.6	46.9	31.3	4.00	2
Delayed decision making	0.0	3.0	9.1	15.2	36.4	36.4	3.94	3
Variation orders	0.0	3.0	15.2	18.2	30.3	33.3	3.76	4
Delayed information flow	0.0	3.0	9.1	18.2	48.5	21.2	3.76	5
Lack of communication	0.0	12.1	18.2	15.2	24.2	30.3	3.42	6
Non-utilisation of professional construction / contractual management	6.1	6.5	19.4	25.8	25.8	22.6	3.39	7
Inaccurate estimates	0.0	9.1	18.2	18.2	39.4	15.2	3.33	8
Poor site management	3.0	9.4	18.8	37.5	28.1	6.3	3.03	9

Table 2 indicates the frequency at which phenomena occur on projects in terms of percentage responses to a scale of never to always, and MSs ranging between 1.00 and 5.00. It is notable that 6 / 10 (60.0%) of MSs are above the midpoint score of 3.00, which indicates that in general the phenomena occur frequently, as opposed to infrequently. The mean score is 3.26, the regularity that payment delays and/ or disputes on projects occur can be deemed to be from sometimes too often.

It is notable that 5 / 10 (50.0) % of MSs are > 3.40 ≤ 4.20, which indicates that the frequency is between sometimes to often / often. A further 3 / 9 (33.3%) phenomena have MSs > 2.60 ≤ 3.40, which indicates the frequency is between rarely to sometimes / sometimes. The remaining phenomenon's MS is > 2.60 ≤ 3.40, which indicates the frequency is between never to rarely / rarely. To summarise, payment delays and / or disputes are occurring on projects and the frequency is related to time overruns, scope changes, mismanagement of funds, withholding of funds and disputes between stakeholders which is resulting in non-conforming work and rework, vandalism of projects, and cost overruns.

Table 2. Frequency phenomena occur.

Phenomenon	Response (%)						MS	Rank
	Unsure	Never	Rarely	Sometimes	Often	Always		
Payment related disputes arise between stakeholders	9.1	0.0	13.3	16.7	46.7	23.3	3.80	1
Withholding of payments result in disputes on projects	3.0	6.3	6.3	25.0	43.8	18.8	3.62	2
Payments delays and / or disputes result in time overruns	6.1	0.0	16.1	25.8	38.7	19.4	3.61	3
Payment delays occur on projects that our firm is involved in	0.0	3.0	21.2	24.2	27.3	24.2	3.48	4
Mismanagement of finances result in payment delays	3.0	6.3	12.5	21.9	46.9	12.5	3.47	5
Late payments cause project cost overruns	3.0	6.3	18.8	28.1	37.5	9.4	3.25	6
Rework	6.1	6.5	22.6	38.7	29.0	3.2	3.00	7
Quality of work is sacrificed because of late payment and / or non-payment	6.1	12.9	19.4	32.3	29.0	6.5	2.97	8
Payment delays result in scope changes	0.0	6.1	24.2	45.5	18.2	6.1	2.94	9

Construction projects are vandalised and / or damaged because of payment delays and / or disputes	9.1	20.0	36.7	33.3	0.0	10.0	2.43	10

Table 3 presents the impact of late payments on project performance in terms of percentage responses to a scale of 1 (minor) to 5 (major), and a MS ranging between 1.00 and 5.00. It is notable that 6 / 7 (85.7%) MSs are above the midpoint of 3.00, which indicates that in general the impact is more major as opposed to minor. 4 / 7 (57.1%) MSs are > 3.40 ≤ 4.20, which indicates that the impact is between an impact to a near major / near major impact. A further 2 / 7 (28.6%) MSs are > 2.60 ≤ 3.40, which indicates the impact is between near minor to an impact / impact. The remaining MS is > 1.80 ≤ 2.60, which indicates the frequency is between minor to near minor / near minor. These findings indicate that there is a link between late payments and poor project performance. Poor productivity and time overruns predominate, which presents several problems for the stakeholders in terms of escalation, compensation for increased preliminaries costs, as many other costs, which are time related and calculated accordingly. These, cost overruns and quality-related issues impact negatively on profit margins, and many affect the reputation of the parties involved.

Table 3. Impact of late payments on performance.

Aspect / Impact	Response (%)						MS	Rank
	Un-sure	Minor……..Major 1	2	3	4	5		
Productivity	6.1	0.0	3.2	22.6	71.0	3.2	3.74	1
Time overruns	0.0	3.0	12.1	12.1	57.6	15.2	3.70	2
Cost overruns	6.1	6.5	3.2	32.3	45.2	12.9	3.55	3
Reduced profit margin	3.0	12.5	9.4	15.6	50.0	12.5	3.41	4
Quality	3.0	6.3	15.6	28.1	40.6	9.4	3.31	5
Tarnishing of reputation of parties involved in the project	3.0	6.3	25.0	28.1	31.3	9.4	3.12	6
Health and safety	3.0	18.8	43.8	25.0	12.5	0.0	2.31	7

Table 4 indicates whether respondents understand what a smart contract is or not. Almost half (48.5%) responded 'No' and notably, 21.2% were 'Unsure'. Only 30.3% responded 'Yes', and of those who responded yes only 60% answered correctly when asked to provide a definition for a smart contract.

Table 4. Respondents understand **s**mart contracts.

Response	Frequency	%
Yes	10	30.3
No	16	48.5
Unsure	7	21.2
Total	33	100.0

Table 5 indicates the extent to which smart contracts could assist in reducing payment delays by means of seven paths during construction projects in terms of percentage responses to a scale of 1 (minor) to 5 (major), and MSs ranging between 1.00 and 5.00. It is notable that all the MSs are > 3.00, which indicates smart contracts could assist to a major, as opposed to a minor extent. Only 1 / 7 (14.3%) MSs is > 4.20 ≤ 5.00, which indicates that the extent is between near major to major / major – eradicating corruption. The remaining 6 / 7 (85.7%) MSs are > 3.40 ≤ 4.20, which indicates smart contracts could between some extent to a near major / near major extent assist in reducing payment delays. Clearly smart contracts are perceived to have the potential assist in reducing payment delays.

Table 5. Extent to which **s**mart contracts could assist in reducing payment delays by means of seven paths.

Path	Response (%)						MS	Rank
	Un-sure	Minor……..Major 1	2	3	4	5		
Eradicating corruption	12.1	0.0	0.0	10.3	48.3	41.4	4.31	1

Minimising malicious or accidental errors in payments	12.1	0.0	6.9	6.9	55.2	31.0	4.10	2
Using blockchain technology to assist in payment automation	18.2	0.0	3.7	11.1	63.0	22.2	4.04	3
Providing greater efficiency within the construction industry	15.2	0.0	3.6	17.9	57.1	21.4	3.96	4
Increasing project performance and productivity	12.1	0.0	6.9	24.1	51.7	17.2	3.79	5
Decreasing stakeholder disputes	12.1	0.0	3.5	31.0	55.2	10.3	3.72	6
Decreasing cost overruns	12.1	3.5	13.8	20.7	51.7	10.3	3.52	7

Table 6 indicates that only 27.3% of the respondents opined that smart contracts could be implemented in the South African construction industry. However, it is notable that 45.45% felt that smart contracts could not be implemented. 27.27% of the respondents were unsure which indicates that either there are barriers to entry of the smart contract system or more information is required to answer this question effectively.

Table 6. Possibility of implementation of smart contracts in the South African construction industry.

Response	Frequency	%
Yes	9	27.3
No	15	45.5
Unsure	9	27.3
Total	33	100.0

4. Discussion

The findings revealed that there are five key areas contributing to payment delays. These factors are extended waiting time for approval, deficiencies in coordination, delayed decision making, variation orders, and delayed information flow. Given these findings, payment inefficiencies and delays can be deemed to relate to inadequate processes and are largely attitudinal.

In terms of payment inefficiencies contributing to disputes between stakeholders, the top three factors include: the frequency payment-related disputes arise between stakeholders; withholding of payments result in disputes on projects, and the frequency that payments delays and / or disputes resulted in time overruns. Omopariola and Windapo (2019) state that the delivery of successful quality projects and the ability to meet client requirements and resolve disputes between stakeholders is often affected by inappropriate payment systems in the construction industry. It is also notable from the literature that the main subject of disputes among construction stakeholders are payment-related. Furthermore, the project environment needs to align with the client's choice of payment systems (Omopariola and Windapo, 2019).

The findings reveal that the majority of respondents are either unsure or do not know what a smart contract is. The majority of respondents indicated that smart contracts could assist in payment automation and provide greater efficiency in the construction industry. They also perceive that smart contracts have a role to play in terms of eradicating corruption. Another key consideration is that the respondents perceive that smart contracts can improve project performance and productivity, while decreasing cost and time overruns as well as minimising malicious or accidental errors in payments.

It is evident from the study that the use of smart contracts has the potential to eradicate corruption, minimise malicious or accidental errors in payments, and to assist in payment automation. It is evident from the literature that there is a great need for transparency and optimisation of payments in the construction industry. Adapting to advancements in technology is a limiting factor when trying to mitigate payment inefficiencies. Possible disputes that may occur among the stakeholders in the project can be reduced as transaction approvals in the blockchain system require joint action, which automatically promotes collaboration among parties.

5. Conclusions

This study aimed to investigate the problem of poor payment practices and the use of an automated smart contract system to reduce inefficiency and create optimisation within the South African construction industry. This was done through identifying the factors that contribute to payment delays during construction projects while examining why payment disputes arise between stakeholders on projects. In conjunction with this literature examining the extent to which non-payment and / or late payments can

influence project performance and cost overruns was reviewed. The extent to which smart contracts can be utilised to assist in reducing payment delays was reviewed and evaluated.

Conclusions include: having an up to date 'as-built' model to track progress on projects speeds up payment approval and minimises scope changes and rework. The greatest delays towards payment relate to stakeholders agreeing with respect to progress, which is a result of contractors not submitting the correct information to substantiate progress. In terms of payment disputes between stakeholders and the implementation of smart contract systems to manage these disputes, contractors', clients', and consultants' knowledge and understanding of construction contracts is important. Educating stakeholders with respect to any contracting system is key. However, incorporating a smart contract system where automation can occur after certain predetermined parameters are met will create greater efficiency and decrease cost and time overruns. The successful implementation of smart contracts in the South African construction industry has the potential to solve or reduce payment issues and delays and result in greater overall project performance. The literature also reveals that for this to be implemented there needs to be incentives for stakeholders to implement the blockchain enabled payment and project management systems. Furthermore, the question arises as to whether the public sector in the form of government and state-owned enterprises will embrace this approach, or not. The mitigation of corruption due to the nature of smart contracts and blockchain technology constitutes the incentive, if the public sector is committed to combatting corruption.

6. Recommendations

There should be no doubt that any construction project will experience delays in coordination and information flow, which in turn result in scope changes and ultimately, stakeholder frustrations. There should be more awareness and attention given to stakeholders withholding payments. There should be more attention given to the stakeholders who experience the effects of late payments, which effects have a detrimental effect on project performance, and result in non-conforming work. Although there have been mechanisms included in standard forms of construction contracts, there is still the overwhelming issue of delayed payments within the construction industry. Automation through digital construction can assist in coordinating deficiencies to reduce disputes between stakeholders on projects.

There is a lack of knowledge relative to smart contracts and blockchain technology, followed by non-implementation, and a lack of adoption towards new technology and willingness to change towards industry 4.0 technology. What is crucial is that an acceptable smart contract model for payment automation and progress confirmation is selected. All parties need to agree with respect to the system to be implemented, and that these models are applicable for the type and nature of a particular project.

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