

تحديات ومعوقات تنفيذ العقود الذكية في صناعة البناء والتشييد

في المملكة العربية السعودية بالمنطقة الشرقية بمدينة الدمام

إعداد الطالب/

- | | |
|-----------|-----------------------------|
| 222000841 | 1. عبد اللطيف بن سعد آل سيف |
| 222001987 | 2. خالد بن أحمد الأحمري |
| 222000880 | 3. الزبير بن يوسف العثمان |

إشراف/

- د. وليد عبد الجواد سليمان الصديق
د. الفيصّل عبد الحميد محمد حسن

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Midocean University

College of Management

Department of project management



Challenges and Barriers to the Implementation of Smart Contracts in the Construction Industry in the Kingdom of Saudi Arabia in the Eastern Province of Dammam City

Prepared by:

- | | |
|---------------------------------|-----------|
| 1. Abdullatif Saad Alsaif | 222000841 |
| 2. Khalid Ahmed Qahhas Alahmari | 222001987 |
| 3. Azzubair Youssef Alothman | 222000880 |

Supervised by:

Dr. Walid Abdul Jawad Soliman Siddiq

Dr. Alfaisal Abdel Hamid Mohamed Hassan

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الخلاصة

تتمتع العقود الذكية بالقدرة على المساعدة في معالجة مجموعة متنوعة من العقبات والعوائق المهمة في قطاع أعمال البناء والمقاولات، مثل النزاعات المتعلقة بالعقود وقضايا المدفوعات، كما قد تعمل على تسهيل وتبني واعتماد عملية نمذجة معلومات البناء (BIM).

هذا ويُعزى الاعتماد الضعيف على تقنية دفتر الأستاذ الموزع (distributed ledger technology) ، والتي تعتبر أساس تقنية البيانات المتسلسلة (blockchain) ، في قطاع البناء والمقاولات في الوطن العربي ، إلى جملة من العوائق والعقبات ، وذلك على الرغم من إزدياد شعبية استخدام التقنية الذكية في جميع أنحاء العالم. ففي الوطن العربي لا يوجد العدد الكافي من الخبراء المدركين لأهمية العقود الذكية وقدرتها في جعل قطاع البناء والمقاولات أكثر نجاعة وتعاونية وشفافية في هذا العصر الرقمي.

الغرض من هذه الدراسة هو لتقييم فوائد وعيوب استخدام العقود الذكية في مجال صناعة البناء والتشييد. ولتحقيق أهدافها ، تبنت هذه الدراسة في غالبها الأساليب الكمية مرفوقة بالاستبيانات ، حيث استخدم الباحث المخططات البيانية التوضيحية لتبسيط التحديات والمعوقات التي تحول دون اعتماد وتبني العقود الذكية من منظور المتجاوبين معها . وتبعا للنتائج المتمخضة ، برزت هناك خمس فئات رئيسة يمكن توزيع التحديات عليها وهي: إنترنت الأشياء ، وأمن الأنظمة الموزعة ، والتمويل والاقتصاد ، وموثوقية البيانات ، وأصحاب المصلحة. هذا فقد أفرز الاستبيان عدد (21) معيارا لقياس التحديات ، بما في ذلك تحسين عملية توزيع المخاطر، وتقليل مدة المعاملات وتكلفتها، وسهولة الفهم للعديد من أصحاب المصلحة. وقد أسفر الاستطلاع علاوة على ذلك، عن عدد (19) مما يمكن إعتباره عوائق وعقبات، بما في ذلك منحنى التعلم، وارتفاع تكاليف التدريب والتعليم، ومخاوف الأمن السيبراني.

وأشارت النتائج أيضا إلى وجود خمس مجموعات يمكن توزيع الحواجز والعوائق عليها وهي: إنترنت الأشياء ، وأمن الأنظمة الموزعة ، والتمويل والاقتصاد ، وموثوقية البيانات ، وأصحاب المصلحة.

الكلمات الرئيسية: العقد الذكي ، نمذجة معلومات البناء ، صناعة البناء والمقاولات ، التحديات ، العوائق.

Abstract

Smart contracts have the ability to help address a variety of important obstacles in the construction business, such as contract conflicts and payment issues, and may facilitate the adoption of Building Information Modeling (BIM). The poor adoption of distributed ledger technology, which is at the foundation of blockchain technology, in the construction sector in the Arab world is due to a variety of impediments, despite the fact that the usage of smart technology is growing in popularity across the globe. In the Arab world, there aren't enough experts who are aware of how smart contract technology can make the construction sector more efficient, collaborative, and transparent in the digital era. The purpose of this study is to evaluate the benefits and drawbacks of using smart contracts in the construction industry. To accomplish its goals, this study mostly used the quantitative method with a questionnaire. The researcher used the illustrative diagram to simplify the challenges and obstacles to the adoption of smart contracts from the respondents' perspective. According to the results, there are five key categories into which the challenges can be divided: Internet of Things, Security for Distributed Systems, Finance and Economics, Data Reliability, and Stakeholders. The questionnaire yields 21 challenge criteria, including better risk allocation, decreased transaction time and cost, and ease of understanding by multiple stakeholders. Moreover, the survey yields 19 barrier considerations, including learning curve, high training and education costs, and cybersecurity concerns. The findings also indicated that there are five categories into which the barriers can be divided: Internet of Things, Security for Distributed Systems, Finance and Economics, Data Reliability, and Stakeholders.

Keywords: Smart Contract; Building Information Modelling; Construction Industry; Challenges; Barriers.

Chapter 1. Introduction

The global economy heavily relies on the construction industry, which contributed approximately 6% of the world's GDP in 2018. It is predicted to grow to about 14.7% of the total by 2030. Nevertheless, this industry has been criticized for years due to low productivity, subpar performance, and slow innovation. With increasing digitization and exponential rise of valuable data, Information and Communication Technology (ICT) advances are now transforming virtually every business. Due to the implementation of ICTs to increase production and efficiency, other sectors such as automotive, aerospace, and aviation have seen significant advancements. On the other hand, the Architecture, Engineering, and Construction (AEC) sector, on the other hand, lags behind in this trend of digital innovation. The development of smart contracts is being looked at more and more as a component of the digital transformation of the construction sector (Ye, et al. 2022).

Building Information Modeling (BIM) adoption may be facilitated by smart contracts, which have the challenge to assist in addressing a number of significant concerns in the construction sector, including contract conflicts and payment problems. The construction business often has contract disagreements. Contradictions, errors, or incorrect terminology in construction contracts may make implementation challenging. Paper-based contracts are still widely used, making it challenging to track changes and document implementation. The lack of a solid basis for disagreements and claims fosters erroneous behavior and poor compliance with agreements on the part of clients or contractors. When employing smart contracts, consistency may be established, and all changes are securely recorded and readily apparent. Another problem that is getting worse is financing. In order to receive payments on schedule and maintain a steady flow of income, construction projects must be effectively finished. Challenges such as non-payment, delayed payment, and improper payment are to blame for conflicts, increased costs, poorer results, and delays in construction. Recent advancements in smart contract innovation make it easy to manage transactions in a reliable and safe manner. The difficulty in adopting BIM is a problem with IT developments. Unavoidable barriers to implementing and employing BIM more efficiently include the risks related to information security and intellectual property ownership. In fact, by using another party's BIM model, one party may unknowingly breach

that company's intellectual property rights. Therefore, the possession of electronic information in BIM becomes a problem that won't go away and that could be fixed through the implementation of smart contracts in construction projects. In the meanwhile, information security may also be guaranteed since BIM allows for the tracking of any modifications. It's usual to refer to or discuss smart contracts as a component of the blockchain. On the blockchain, smart contracts are seen as a link, element, layer, feature, or 'one of the most crucial features.' The smart contract, however, has a distinct meaning, connotation, and value to the construction sector as a driver for pertinent automation and a vital innovation for digital transformation. This application of smart contracts is still in its infancy. In its early stages, an invention may face a number of problems, such as difficulties evaluating its effectiveness administrative and technical obstacles to further growth. As a result, it is very important to outline the benefits and point out the challenges in the creation of smart contracts from their inception to their full maturity (Ye, et al. 2022).

1.1 Problem Statement

People often think that the construction industry is reluctant to use new innovations. The fact that smart contracts could protect against late payments could be a big reason for adopting. Even though the use of smart technology is becoming more popular around the world, the low adoption of distributed ledger technology, which is at the core of blockchain technology, in the construction sector in the Arab world is due to a number of barriers. There aren't enough experts in the Arab region who know how smart contract technology can allow the construction industry to become more productive, cooperative, and transparent in the digital age. This is because smart contract technology can record, enable, and improve digital security, as well as open up new areas of application and help the construction industry make a smooth transition to the digital age.

1.2 Objectives

The purpose of this study is to evaluate the possibilities and obstacles associated with the deployment of smart contracts in the construction industry. This study also aims to serve as a pioneering investigation into the adoption of smart contracts in Saudi Arabia's construction industry by answering the primary research question of what advantages,

uses, difficulties, and challenge future applications smart contracts can offer to solve construction industry problems in Saudi Arabia. Furthermore, the research aims to outline the advantages, uses, difficulties, and future challenge that smart contracts may bring to address the issues in the Saudi Arabian construction business. Additionally, the purpose of this research is to assess the use and deployment of smart contracts in the building and infrastructure industries.

1.3 Methodology

This study largely relies on a quantitative technique with a comparative casual design to attain its objectives. Using this research technique, the researcher is able to explore the barriers connected with smart contract adoption in the Saudi Arabian construction industry. The questionnaire begins with a summary of the research, its aims, and the advantages of the findings. The participants will then confirm that their participation was voluntary and that their data will be treated with the utmost discretion and will not be shared with any third parties. With this questionnaire, the data and information essential to characterize the study problem will be acquired. The survey will be available through Google Form Link online. The researcher contacts the study population using social media sites such as Facebook and WhatsApp groups, and even direct interviews, and they delete duplicate or incomplete questions.

Chapter 2. Literature Review

Two of the biggest problems facing the construction industry are late payments and disputes between partners. Disputes might include things like failure of the company, cost overruns and time delays, cash flow problems, and payment holding. Inability of project participants to comply with due dates for payments, a shortage of payment assurance, and unwillingness to pay, according to the conclusions of a government of a New South Wales government study into the bankruptcy of the building sector, are the main reasons for contractual disputes in the business. To solve these problems and offer a secure payment environment, the industry must deploy innovative technologies. Despite its resistance, the construction industry may be compelled to embrace new technology as a result of the rapid technological development in the sector in order to achieve revolutionary alterations (Arslan, Tuncan, Birgonul, & Dikmen, 2006).

Blockchain and smart contracts are two such innovations that have significantly impacted a number of sectors, including the banking and healthcare industries. A blockchain can be characterized as a distributed public ledger that stores all transaction data exchanged within the system's stakeholders. Therefore, it provides a safe and synchronized record of transactions to all parties participating in a business network. A data transaction can only be completed with the agreement of all system users. Every transaction sequence is recorded in the blockchain ledger from beginning to finish, creating definite, verifiable, and irreversible records of every transaction ever done. There are several industries where blockchain technology may be used. One of the primary utilizations of blockchain innovation is the smart contract, which is crucial for the digitization of conventional paper contracts (Crosby, Nachiappan, Pattanayak, Verma, & Kalyanamaran, 2016).

The goal of a smart contract is to recreate legally enforceable contracts using computer code that is executed on the blockchain public system. Smart contracts are a kind of computerized transaction protocol. In the program, clauses, and instructions might be programmed. Smart contracts are self-enforcing because they run when the contractual criteria specified in the code are satisfied. Moreover, smart contracts provide the

embedding of digital transaction data, such as payment amounts, and the automated transmission of data between the contract parties following the completion of the instructions (Crosby et al., 2016).

Smart contracts prohibit the quantity to be purchased so that no one party may access the funds. The payment amount won't be transferred to the accounts of the parties unless the conditions are met. Due to its binary logic, which makes sure that inputs and outputs are equal, and that the fulfillment of contract requirements relies on defined scope, smart contracts are crucial. Blockchain is a decentralized innovation, therefore it does away with the requirement for additional middlemen like banks, notaries, and exchanges. Because of smart contracts' inherited characteristics and dispersed qualities, it also lessens payment fraud. Being distributed implies that every party on the network validates each contract's output. Since other users on the network will notice and mark the effort as unreliable, one person cannot make the contract release the money. In other words, every participant in this system must confirm any transaction before it can be completed. Smart contracts also reduce transaction costs and raise party confidence in contracts. As well as this, smart contracts and blockchain technologies are impermeable, once a smart contract is made, it cannot be changed. Hence, it is almost impossible to alter the code or smart contract. Transactions involving digital data in smart contracts, such as purchases, are impractical without the use of cryptocurrency, a digital or virtual currency designed to be used as a means of exchange. Cryptography controls the introduction of new cryptocurrency kinds and ensures secure and verified transactions (Rutink, 2018).

By combining the strengths of blockchain with smart contracts, a secure payment environment might be created. This essay discusses the significant advantages of blockchain and smart contract technologies for the building sector as well as how these technologies may be used to address industry-wide insolvencies. In the building sector, there are several agreements between stakeholders. The contracts that have been formed may take on several forms, such as those between an employer and an employee, an employee and a subcontractor, an employee and a supplier, etc. As a result, this sector of the economy is primarily contractually oriented, making smart contract technology highly desirable to resolve contractual disputes and payment issues (Cardeira, 2017).

Little academic research regarding smart contract uses in the construction sector is available since smart contracts are cutting-edge technology. According to Perico (2018), the building information modeling (BIM), timelining, liens, and insurance sections of the construction sector might all benefit from the use of blockchain technology. Cardeira (2017) has pointed out that the system can automatically pay progress interims because of the combination of smart contracts and Building Information Modeling (BIM). Cardeira (2018) introduced a smart contract-based payment system for use in contracts with several parties in which the instructions for payments between parties are programmed in the program. With the designed online payment system, as long as the employer and contractor follow the instructions, the payment will automatically be issued. As a result, the contractor cannot withdraw money until the subcontractors have been paid. The suggested idea in this article discusses how the procurement phase and interim payments of a smart contract in the construction sector may be implemented. Smart contracts might provide several advantages for the construction sector, including lowering exchange and transaction costs, offering ongoing as-built cost data, as well as voiding third parties, lowering administrative costs associated with tracking down payments, preventing parties from missing payment due dates, minimizing contractual disputes, and boosting performance and confidence, etc. (Mason, 2017).

2.1 Construction Industry in Saudi Arabia

The entire amount of building contracts issued in Saudi Arabia in 2017 was reportedly over USD 24 billion, according to Deloitte (2017). Although the start of some of them has been delayed or postponed because of the recent declines in oil prices and the government program of financial reforms, this does not change the fact that Saudi Arabia's construction market is one of the main drivers for domestic economic growth and development. Saudi construction companies are the most significant and costliest clients in several economic sectors, including those related to supplies, equipment, and logistical support. However, in addition to implementing performance evaluation tool, there is an obvious a need to increase the performance and output of Saudi construction contractors. Several large-scale projects seem to be delivered with obvious flaws, either in specifications or functioning, despite the vast values of contracts given to construction firms (Deloitte and Touche, 2017).

According to Kwame, Baiden, and Badu (2016), Construction companies in emerging countries often lack the ability to compete with global firms. One of the factors that negatively affect local contractors' performance in many economies is the use of outdated technology, equipment, and training programs for staff and workers.

2.2 Smart and traditional contracts

The traditional contract, often known as a paper contract, is made to demonstrate the parties' obligations to carry out a specific action. These agreements frequently entail discussions between the parties, writing procedures, and the assistance of lawyers. Smart contracts, which establish the obligations of the parties, are created by codifying the traditional contract in a digital context. Smart contracts are increasingly favored over traditional paper contracts for fulfilling payment obligations due to their various benefits. Smart contracts are digitized and rely on code, eliminating the need for physical presence when drafting payment terms. In fact, virtual presence of the parties involved is adequate. Additionally, a digital signature serves the same purpose as a wet signature in signing and authenticating contract provisions. The absence of a middleman in a smart contract system significantly decreases overhead expenses and transaction costs. Also, the notary and administrative costs related to the pursuit of payment are reduced. Additionally, cryptocurrencies like Ethereum have transaction costs ranging from zero to four dollars, which are much lower compared to the fees charged by banks (Crosby et al., 2016).

The blockchain-stored smart contract terms that have been encoded. Contract clauses are only accessible by the parties to the agreement, making it difficult to change the code or alter the terms of the agreement. So, the establishment of a safe and private environment via smart contracts leads to a decrease in contract fraud. There is no room for misunderstanding in smart contracts because they function exactly as described in the contract's code. Moreover, because the smart contract is recorded in the blockchain, a distributed ledger, every piece of information, such as the transaction quantity, the justifications for the payment, and the date of the payment, is stored in a node of the blockchain, minimizing confusion and disagreements. Using smart contract, payment conflicts in the construction sector might be significantly reduced. It is a useful solution for

automating certain construction project performance factors and saving money and time. During the purchasing phase, the project's payment procedure often has cost and schedule overruns. Another financial issue that partners in a project encounter is late progress payments. The solution for reducing payment issues in the construction business by using smart contracts is proposed in the next chapter (Ahmadisheykhsarmast ,2018).

2.3 Applications of smart contracts in the construction industry

When many contracts are signed, the procurement process is one of the drawn-out phases of a construction project. There should either be confidence between the parties, or third parties—such as banks, notaries, middlemen, etc.—should build that trust, given the challenge that buyers and sellers have never conducted business together. Using a letter of credit (LoC) document, third parties, including banks, can aid in fostering trust among parties. The bank utilizes a letter of credit (LoC) to guarantee that the seller will be paid if the delivery requirements are satisfied and the buyer gets the items (Reilich, 2018).

The principal participants in a LoC are the applicant or buyer, beneficiary or selling, issuing bank, and advising bank. An illustration from the purchasing phase of the construction industry is used to explain the procurement procedure and the requirement for LOC. As seen in Figure 1, the X party (applicant) want to import the machinery, whereas the Y party (beneficiary) is an exporter of it. In the beginning, the parties set up a contract, and the conditions of that contract are stipulated in the LoC document. The X party approaches the issuing bank with a LoC request while Y is present. The LoC document is created by the issuing bank and delivered to the advising bank in line with the predetermined terms. The amount of the transaction must be paid by the issuing bank on the designated day. The letter of credit instrument's validity is attested by the advising bank, which also informs the Y party of its contents. Y party tells the bank that provided advice that the letter of credit's conditions have been met as soon as X party gets the machinery. The letter of credit is subsequently delivered to the issuing bank, which verifies that all conditions outlined in the instrument have been satisfied. The payment is paid to the Y party via the advised bank. The issuing bank accepts the X party's payment and provides the X party with the delivery paperwork (Eker, 2018).

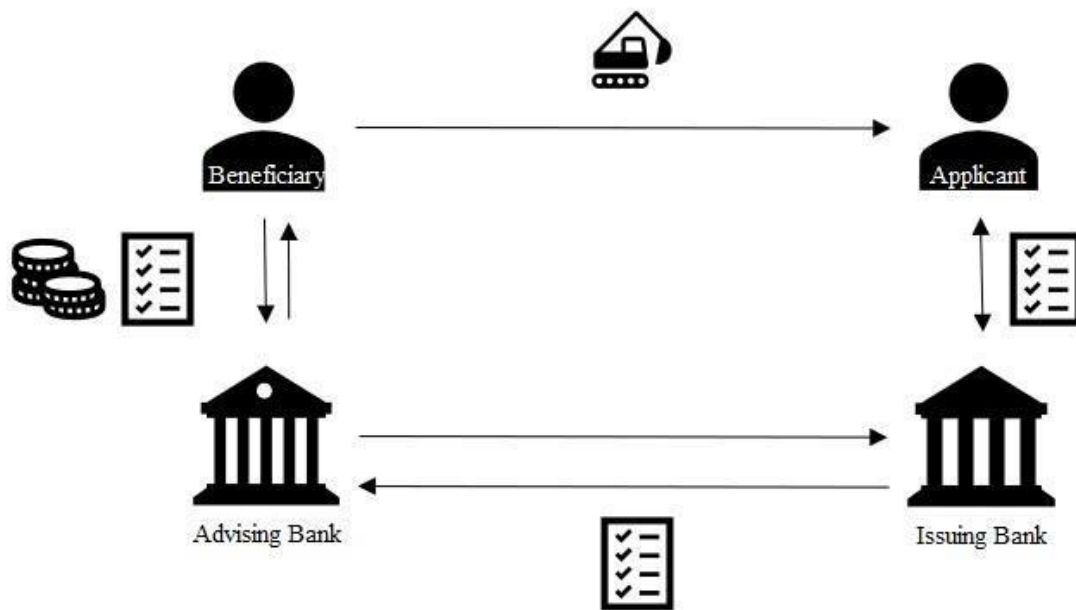


Figure 1: Letter of Credit Document Process

Although the LoC lowers the payment risks involved in a transaction, it does have some drawbacks, such as costly bank fees that can amount to 4% of the total cost of the purchased goods and a drawn-out process. Because smart contracts are decentralized, it is possible to remove third parties like banks from a transaction process. By utilizing smart contracts in the procurement stage of a project, the contracting parties are able to code contract terms like the amount and payment due date. The amount that is owed for items like materials and machinery is contained in the smart contract. Additionally, the system could be configured to display the payment due date. Due to the transparency of smart contracts, both parties to a contract may be certain that the outstanding payment for a good will be stopped in the system so that no one is able to view it before that payment is made. The exporter may inform the importer once the merchandise has been ordered away via the smart contract. Additionally, the importer may let the exporter know when the necessary goods arrive. When both parties verify the system's specifications, the payment amount will be automatically transferred using the smart contract's self-executing functionality to the exporter's bitcoin account. Using smart contracts during the purchase may provide the following benefits. Since there is no middleman, such as a bank, there is no requirement for providing a letter of credit. The astronomical costs related to

management and arbitration fees are significantly reduced as a result. Quick approvals and payments, a decrease in payment withholding, and the provision of a private payment environment are further advantages of adopting smart contracts in the construction procurement process (Cardeira, 2015).

Delay in progress payments is one of the main problems with building project payment arrangements. Late and refused progress payments cause cash flow issues, which prevent the contractor and subcontractors from finishing the job and ultimately result in bankruptcy. The predicted progress payment quantity and payment due date, which can be entered into the smart contract, may be determined using the project cash flow diagram. The software implements this concept by delaying the next month's planned payment until the scheduled payment date. The system could calculate the real payment value from cash flow when interim payments were due, allowing the contractor to submit a payment request. The employer verifies the accuracy of the actual amount while a smart contract verifies the contractor's demand for advance payment, and then the actual progress payment is put into the contractor's bitcoin account. By using the suggested automated intermediate payment system, timely interim payments mitigate cash flow issues and reduce conflict in addition to reassuring the contractor that there is a budget to complete the task (Cardeira, 2015).

A smart contract is a kind of digital agreement that quickly manages a user's digital assets while outlining the user's rights and obligations. The reaction to the message received, as well as data storage and the ability to transmit messages or send them outside, are two of the most significant reasons why the implementation is automated and goes beyond the standard computer method where he is one of the contract participants. An address-specific sequence of code on a blockchain is referred to as a smart contract. Includes a list of state variables and functions that may be used. These functions will be run when transactions are made to them. The transactions comprise input requirements that are necessary for the contract's operations. The execution of the system's purpose and the use of logic are the two factors that have the most impact on how variables in nodes change state. Contracts may be created in a variety of top-level languages, including Solidity and Python (Kosba, 2016).

Contracts are converted to byte code using smart contract language compiler optimizations (such as Serpent and Solidity). After being assembled, the contracts are sent to the Blockchain network, which generates the contracts' unique addresses. Ethereum: Ethereum is a programmable, open Blockchain platform. Using the platform, which uses its own digital currency known as called ETH, users may develop a broad variety of apps, services, or contracts. The success and dependability of the smart contract must be increased by key factors and components like time. the Virtual Machine for Ethereum the Ethereum Virtual Machine (EVM) is in a time-sensitive position where smart contracts are being implemented. Moreover, the whole Ethereum network's nodes switch on in (EVM). It functions as a box filled with sand and offers an isolated environment for implementation. The same installations are used by every node in the Blockchain network because smart contracts provide redundancy in execution. Even if this massive repetition is not an efficient implementation strategy, the consensus in the network must be preserved in the absence of a centralized authority or reliable third party (Gencer, 2019).

Another crucial use is smart contracts, which have an odd name and some ambiguity since it isn't really a contract and some people don't think it has to be followed or approved. Law and order may be employed to enforce a contract's terms, but a smart contract works in the other way. A smart contract is a collection of self-executing instructions and directives that are not maintained by anybody. To transfer transactions to other accounts on a blockchain in the context of a smart contract, only software is able to do so without any intervention from a central authority, broker, or another third party. Tools for smart contracts rely on dependable security servers. The smart contract concept aims to realize the initial idea of the parties interacting with a dependable and secure virtual computer and implementing programs that include data and information. As miners may presently perform a wide range of duties in a variety of fields, including banking, smart contracts are seen as a component of the code (Kosba, 2016).

Chapter 3. Methodology

The employment of technology and its various applications are rapidly increasing worldwide within the construction industry. However, in comparison to other industries such as finance and automotive, the construction industry exhibits a slower inclination towards technological advancement, possibly attributed to the nature of the industry (Mason et J., 2018). For optimum utilization, the incorporation of a smart contract is crucial (Reiff et M., 2020). The aim of this investigation is to expose the challenge of adapting smart contracts within the construction sector of Saudi Arabia, as well as identifying any challenge hindrances. This chapter will outline the study design and data collection methods utilized in this research.

3.1 Research approach and design

The quantitative approach with a questionnaire was heavily relied upon in this study to accomplish the research's goals. By using this study methodology, the researcher was able to explain the challenge implementation of smart contracts in construction sector in Saudi Arabia and the challenge barriers that can hinder it, as well as suggest possible solutions to overcome these obstacles. The participants were assured that their participation was optional and that the data they gave would be handled in the strictest confidence and would not to be shared with any other parties. The questionnaire consists of 32 questions about challenges and barriers of the smart contracts in Saudi Arabia's construction industry.

3.2 Data collection tool

A variety of data sources were used during the study's research. The current study's theoretical and applied elements are built upon one another. Theoretically, for the current investigation, the researcher drew from pertinent scientific studies. Practically, data are gathered, assessed, and tested using a descriptive and analytical technique.

There are two categories of data collection techniques:

1. Primary source: a questionnaire was created specifically to gather primary data about all the study variables and the demographics of the research sample based on prior empirical studies and the research aims.

2. Secondary source: To comprehend the theoretical underpinnings of the study and create its model and hypotheses, books, journals, and these were used.

As the main source of data for this study, the researchers used a survey. No in-depth research has been done in this field because the study's topic is novel. To best answer this study issue, the researchers believed that primary data should be generated and gathered. A web-based survey served as the study's main method of data collecting. A self-administered questionnaire was selected in this instance. This was owing to the fact that it required less effort and time to administer, as well as less money and effort to gather enormous amounts of data. The questionnaires are simple to construct because of the online dissemination strategy and plenty of web-based. With the aid of web-based technologies, researchers can design their own questionnaires online and use social media to connect with the necessary respondents. Online surveys have a number of benefits, including better geographic accessibility and improved respondent grouping versatility. Primary data includes questionnaires as well as the survey that was done, which was sent out to gather information directly from survey respondents.

Secondary data are readily available to contemporary researchers and were produced by other researchers using materials for their own objectives. Secondary data can be used to supplement and improve primary data. However, no secondary research was undertaken for the thesis because there hasn't been any research on the subject of how workplace factors affect employees' digital transformation.

Only closed-ended questions were used in the creation of the questionnaire due to their advantages. The data and information required to describe the research issue were gathered using this questionnaire. The survey was made accessible online interviews. One of the most crucial data gathering techniques in the social sciences, the quantitative survey method, was utilized in the study to get primary data. The survey used a Likert scale, on which respondents indicated their degree of agreement with a statement, often in 5 points:

1. Strongly agree
2. Agree
3. Neither agree nor disagree

4. Disagree
5. Strongly disagree

3.3 Influence factors on Smart Contracts in construction projects:

As shown in Table 1, the first phase involves evaluating the relevant literature from various academic publications linked to the consequences of Smart Contracts in construction projects. This is followed by summarizing the most common impacts that be may be present in Saudi construction projects after eliminating the repeated impacts based on previous lateral reviews.

Table 1. Displays the barriers and challenges of smart contracts in construction projects.

Country	Reference	Barriers	Challenges
Malaysia	(Bolhassan et al. 2022).	• There is a lack of legal precedent and infrastructure. • Vulnerable to human coding errors that could result in a catastrophic failure of the system. • Because smart contracts are irreversible, they are unsuitable for long-term initiatives that are subject to changes or variables. • There is a risk of cybersecurity issues in contract administration due to the confidential nature of contract information. • Cryptocurrencies have not been utilized in the construction industry, and little is known about their stability.	• Responsibilities are determined during the formulation of the contract, and there is a more equitable distribution of risk in a multidimensional party because obligations are self-executed. • Lessen the need for parties' responsibilities to be interpreted. • Contract administration and management are more efficient thanks to digitization when contract obligations are automated. • Shorten the duration and expense of paying contractors. • Due to automation in payment processing, the contractor's cash flow will be improved.

Country	Reference	Challenges
Turkey	(Koc and Gurgun 2020)	1. Simple for different stakeholders to understand. 2. An easy-to-read style; 3. A decrease in client hazards. 3. A decrease in contractor hazards. 4. Reduction of subcontractor risk. 5. A decrease in supplier risks. 6. Responsibility and risk allocation are both clear. 7. Reduction of disputes, claims, and conflicts. 8. Capacity for adjusting to building contracts. 9. Easier interactions between clients and contractors. 10. Easier interactions between contractors and subcontractors. 11. Improved efficiency in interactions with suppliers. 12. Improved stakeholder interaction. 13. Quickening the procurement procedures. 14. Improving the quality of the procurement process. 15. Cost-saving measures in the purchasing process. 16. Clients' willingness to use smart contracts. 17. The readiness of contractors to use smart contracts.

Country	Reference	Barriers	Challenges
Egypt.	(Zaky and Nassar 2021)	1. The volatility of crypto currency. 2. The immutable nature of the Smart Contract. 3. The requirement for a bank to complete the transaction. 4. The need to establish faith in such technologies.	1. Getting rid of third-party trust. 2. Who may partake in a transaction that is encrypted and controlled. 3. minimizing transaction costs and times. 4. A contract that can be executed automatically. 5. A move toward the digitalization of the construction industry

Country	Reference	Barriers	Challenges
UK.	(Altay and Motawa 2020)	1. Smart contracts do not allow for the modification of transactions. 2. Long-Term Trade Relations The capacity of smart contracts to conduct transactions autonomously is regarded as a defining characteristic. 3. Execution Options, the fact that the command system is founded on the "yes" or "no" principle means that if 95% of the task is completed within the allotted time, the option "no" is selected and no payment is made. 4. Fraud and Financial Security There are still system flaws, and as a result, there have been instances of hijacking in certain industries. 5. The fact that the entire project budget is stored in the system makes the Hacking and Fund Security issue even more urgent.	1. The greatest benefit of smart contracts will be in resolving payment issues. 2. increases stakeholder collaboration and confidence 3. Human intervention is unnecessary for the surveillance and execution procedure 4. The amount paid for transaction fees in smart contracts is significantly less than the amount paid to the bank for transaction fees in conventional contracts. 5. Smart Contracts contribute to a reduction in the duration and expense of an undertaking. 6. Traditional contracts may contain drafting errors, but Smart Contracts eradicate such errors. 7. Smart Contracts prevent different parties from interpreting a contract differently. 8. Smart Contracts can reduce human error and do not require human intervention. 9. Smart Contracts utilize digital archiving and backup features. 10. Using cryptography, the data on each Smart Contract block is encrypted. 11. The undertaking is reasonably protected from challenge attacks.

		6. There is no legal binding currently available for smart contracts.	12. Smart Contracts ensure the timely payment of project stakeholders and suppliers other than the client by guaranteeing the project's funds. 13. Smart contracts' immediate payment execution will alleviate companies' cash flow issues.
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Country	Reference	Barriers	Challenges
China & KSA	(Zheng et al. 2020)	1. Readability 2. Functional concerns 3. Contract correctness 4. Dynamic flow regulation 5. reputable oracle 6. Transaction-ordering dependence Efficiency of execution 7. Privacy and Safety Fraud	1. Recover code source 2. Human legible code 3. Human comprehensible execution 4. Re-entrancy 5. Block randomness 6. Overcharging 7. Bytecode examination 8. Code source analysis 9. A study based on machine learning 10. Analysis based on graphs 11. Path-searching Environment for Execution 12. involving a third entity 13. Decentralized 14. Sequential execution 15. Definition of contract 16. Execution serialization 17. Examination of the contract 18. Privacy Security 19. Ponzi scam 20. Honeytrap

Country	Reference	Barriers	Challenges
Global (China, Singapore, Canada and Australia)	(Lo and Le 2019)	1. It is difficult to ensure the security of smart contracts. 2. There is an absence of potent instruments (such as a debugger or testing framework). 3. Current programming languages are limited in a number of ways. 4. The limitations of the Ethereum virtual machine that executes smart contracts are numerous. 5. It is difficult to manage performance issues. 6. There are limited online learning resources and community support. 7. During smart contract development, it is challenging to debug. 8. Optimization of gas usage is always difficult, particularly for complex applications. 9. It is difficult to locate qualified developers who can identify smart contract code vulnerabilities. 10. Reviewing the code of smart contracts is a lengthy process. 11. It is difficult to contemplate all possible scenarios and edge circumstances. 12. Unseen vulnerabilities in compilers and virtual machines. 13. No mature testing frameworks like Java or other languages. 14. No instruments to measure the efficacy of the test suite for smart contracts. 15. Testing must be performed asynchronously. 16. If testing is conducted on testnets or the mainnet, gases are consumed. 17. Lack of valuable testing guidance, such as best practices, tutorials, etc.	1. More general-purpose libraries. 2. More robust error recording and reporting capabilities. 3. Standardized interfaces. 4. Enhanced security verification of data type validation. 5. A more secure and convenient method for calling external functions. 6. A more robust memory management system. 7. Increase the number of available global and local variables. 8. Better support in troubleshooting 9. Increase the pace of binary code execution. 10. Relax the array capacity restriction. 11. Support additional traditional languages.

Country	Reference	challenges
Germany	(Ye, Zeng, and König 2022).	1. Contract and payment as follow: a. Advanced fundamental logic design. b. Compound smart contracts deployment. c. Integration with BIM. d. Regulation change. e. Inconsistency of legal systems. f. Difficulties in defining unforeseen conditions. 2. Administration, Design, Site management as follow: a. Define possible application scenarios. b. Explore domain-specific requirements. 3. Information management, Quality management as follow: a. Integration of other ICTs (IoT, BIM, AI) b. Lack of standardization in protocol design c. Lack of a driving force. 4. Supply chain and logistics, Facility management as follow: a. Development of Decentralized Autonomous Organization (DAOs) b. Integration of other ICTs (IoT, BIM, AI) c. Explore domain-specific requirements

3.4 The Smart Contract impacts on construction project performance.

In Table 2 below, this study summarizes the most common impacts of Smart Contracts that are available in Saudi construction projects after deleting the repeated impacts based on previous lateral review. The study conducted many workshops with experts (Table 4) to validate the proposed impacts. They were presented with the results after analysis and asked to provide their insights on them.

Table 2. Summarizes the Smart Contracts impacts on construction projects.

challenges	Challenges
• It is difficult to ensure the security of smart contracts. • There is an absence of potent instruments (such as a debugger or testing framework). • Current programming languages are limited in a number of ways. • The limitations of the Ethereum virtual machine that executes smart contracts are numerous. • It is difficult to manage performance issues. • There are limited online learning resources and community support. • During smart contract development, it is challenging to debug. • Optimization of gas usage is always difficult, particularly for complex applications. • It is difficult to locate qualified developers who can identify smart contract code vulnerabilities. • Reviewing the code of smart contracts is a lengthy process. • It is difficult to contemplate all possible scenarios and edge circumstances. • Unseen vulnerabilities in compilers and virtual machines. • No mature testing frameworks like Java or other languages. • No instruments to measure the efficacy of the test suite for smart contracts. • Testing must be performed asynchronously. • Gases are consumed when testing on testnets or the mainnet. • Lack of valuable testing guidance, such as best practices, tutorials, etc.	• Simple to comprehend for all stakeholders. • Simple format for reading • Risk reduction for clients • Risk reduction for contractors • Reduction in subcontractor risk • Risk reduction for suppliers • Clarity in attribution of responsibilities and risks • Reduction of conflict, claims, and disputes • Adaptability to building contract terms • Improved client-contractor relationship processes. • Relationships between contractors and subcontractors are more streamlined. • Relationships with suppliers that run more efficiently. • Enhanced stakeholder interaction • accelerating the procurement procedure • Quality enhancement of the procurement procedure • Cost savings in the procurement procedure • inclination of the client to implement smart contracts • inclination of contractors to embrace smart contracts

Finally, 12 expert interviews with senior professionals, Saudi Council of Engineers members, and academics in the field of construction engineering and management are undertaken to validate the suggested implications. They were given the findings of the analysis and asked to share their thoughts on them. Vice presidents, directors, partners, litigators, consultants, attorneys, and counsels, among others, were among those interviewed. Furthermore, they should have at least 15 years of expertise in the field of construction and project contracting (table 3).

Table 3. Summary of expert's number and position.

ID	Position	Total No. administrators	Role
P1	VP	1	Engineering & projects Dept.
P2	Contracting Management Experts	1	Professor
P3	Directors	2	Projects and Engineering Directors
P4	Managers	3	Program Managers
P5	Section heads	2	Contracting and Civil Section Heads
P6	Contracting Experts	1	Contractors and Consultant
P7	Financial Experts	1	Client and Contractors
P8	IT Experts	1	(System, Programmers)

Chapter 4. Discussion

The data interpretation and analysis are the focus of this chapter. By disseminating the survey technique to the sample population, the survey instrument is used in the research to gather the necessary data. Moving forward in this chapter, the findings of the survey are reviewed. Then the results derived from these survey's findings will be evaluated and discussed. The researcher also uses appropriate statistical procedures for data analysis, such as the descriptive statistical approach with frequency, mean and standard deviation. The chapter also provides an analysis of the challenges and barriers related to the implementation of smart contract in construction projects in Saudi Arabia (Zheng et al. 2020).

4.1 Study Sample

The researcher targeted the construction sector in Saudi Arabia as it is an important factor that the survey's respondents should have an experience about the main topic of the survey. A total of 50 respondents has participated in the survey. There is a variety of positions in the construction sector of the survey's respondents such as vice presidents, directors, managers, section heads, contractors and consultants, contracting experts, financial experts, IT experts, and project managers. The distribution of sample members according to work position is shown in Figure 2.

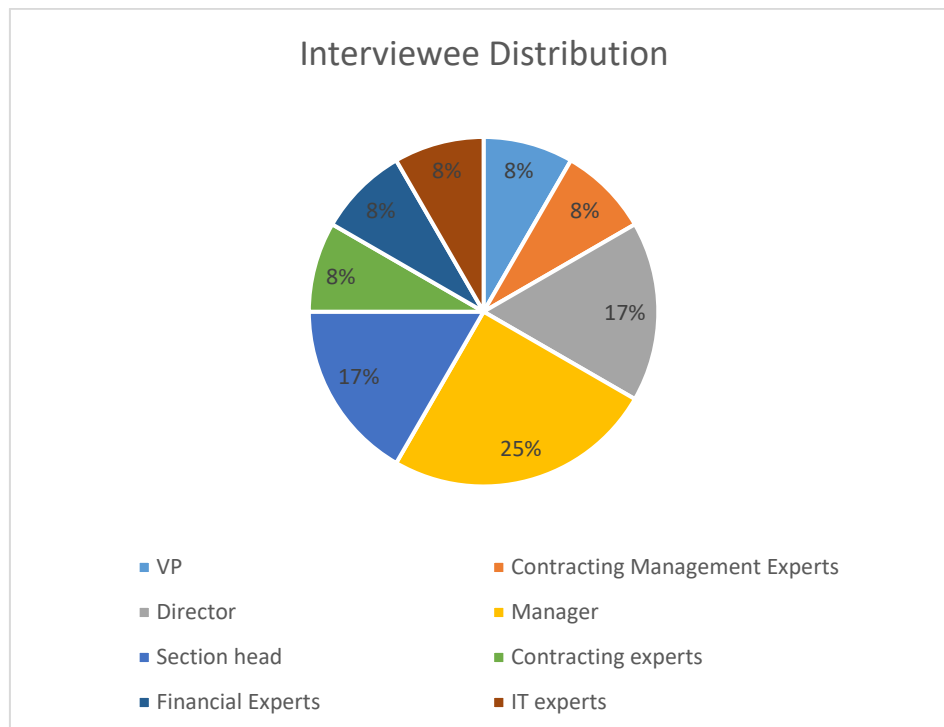


Figure 2: Frequency distribution of the study sample according to work position.

After identifying the major barriers and challenge which impacted smart contract, we had a total of 12 interviewee candidates (more details provided in the Participant Recruitment section above). This was done to simplify complex contractual issues and to highlight areas of barriers and challenges concerns for developers, construction contractors, and construction industry professionals throughout Saudi Arabia. The mentioned barriers and challenges of smart contract in the construction industry that were approved by expert's interviews were used to develop a list of Categories to form the basis of smart contracts and the availability for use in construction projects. Table (4) presents the final list of major criteria, challenges and challenges that are unique to the Saudi Construction industry. Other causes were either deleted or paraphrased because they were either repeated or not considered major causes in KSA.

Table (4) final list of Major criteria of challenges and challenges

Categories	Challenges	Barriers
Internet of Things	- Reducing time consumed. - Automated P2P business interactions. - Decreased expenses for central server administration. - KPI can be monitored etc. which mean can control too. - Integration of BIM, Digital	- Lack of standardization in protocol design. - Difficulty for applying the integration with various ICTs (IoT, BIM, AI). - Complex underlying design. - Blockchain could cause limitations of modifications. - Smart contracts do not offer the opportunity to change transactions.
Security for Distributed Systems	- Enabling to Share attack list accurately, quickly and reliably. - Verify the trustfulness of cloud service providers by Verifying the trustfulness of cloud service providers - Avoid users from using broker by distribute Service-Level-Agreements for Clouds	- The entire construction projects fund is stored in the system make hacking as well as finance security issues much more urgent. - Need third party for coding.
Finance + Economics	- Reducing administrative and service costs, - Reducing financial risks - Increasing financial services' effectiveness. - Providing in best budget allocation. - lowering costs for consumers. - Trusted third parties.	- Compound smart contracts deployment inconsistency of legal systems. - Changes in prices. - Challenges in identifying unforeseen circumstances. - Lack of sufficient of compensation for progress (work performed). - Have not been practiced in construction payment. - There is not much knowledge on the stability of the cryptocurrency.
Data Reliability	- Detecting illegal data tampering embed provenance data into blockchain transactions so that any data modifications are traceable. - Enhancing data dependability.	- Lack of experts' availability to identify security holes in smart contract coding. - Lack of a driving force.

	• Accessibility of Data, drawing specifications by store the meta-data information of data origin, derivation and transformation in this manner, any malicious falsifications of data can be captured	
Stakeholders	• Transparency for them. • Enable stakeholders' involvement. • Enhancement of communication for all parties. • Eliminating disputes room for parties	• Smart contracts are unchanging, so, it is not appropriate for long-term projects where they will be subject to modifications or variations. • Changes in regulations. • Approvals of high authorities of applying contracts. • Awareness of smart contracts.

4.2 Descriptive Statistics

The present section employs the use of descriptive statistics to assess the sentiments of research participants towards the subscales of the survey questionnaire. The descriptive statistics utilized are detailed in the tables presented below. The mean and standard deviation for the participants' responses were computed utilizing the Likert scale for each dependent variable, namely the challenges of smart contract implementation, and barriers of smart contract implementation. Based on Joseph and Rosemary's (2019) research, the calculation and reporting of Cronbach's Alpha coefficient for internal consistency reliability is essential when implementing Likert-type scales for any scales or subscales that a study utilizes. It is crucial to analyze the data using these summated scales or subscales rather than individual items. Failure to do so may result in low reliability of items at best and unknown at worst; thus, Cronbach's Alpha coefficient cannot provide dependable estimates for single items.

4.2.1 Cronbach's Alpha

The estimated reliability of a scale is typically impacted by the quantity of items utilized. A low score, below 0.5, may arise from inadequate questioning or insufficient interconnectedness among items. Conversely, a high alpha score, exceeding 0.90, may indicate the presence of excess instruments. It is also important to note that the formula for Cronbach's Alpha is as follows:

$$\alpha = \frac{(K)}{(K-1)} \times \frac{Sy^2 - \text{Sum } Si^2}{Sy^2}$$

Where:

α = Cronbach's Alpha

K = the number of items in the scale

S_i = the sum of the item scores for each item

S = the sum of the total scores for all items

As per the findings of Adeniran Adetayo (2019), the range that can be deemed acceptable varies from 0.70 to 0.90, or higher, depending on the nature of the research undertaken. In light of the Cronbach's Alpha values, any figure of 0.7 or higher signifies that all the variable indices and dimensions manifest internal consistency that is acceptable. Upon analyzing the reliability and consistency of the research, it has come to light that the reliability test, in the case of the survey quality satisfaction regarding Smart Contracts barriers and challenges encompassing thirty-four factors, stands at 0.83, thus meaning that it is greater than the acceptable range of 0.7. Therefore, based on this assessment, the reliability and internal consistency of the research are deemed satisfactory.

4.2.2 Challenges of smart contract implementation

Table 5 highlights the descriptive statistics (mean, standard deviation, and percentages) for the challenges of smart contract implementation for each factor. Figure 3 shows a bar chart that determines the mean of challenges of smart contract implementation.

Table 5: Mean and Standard Deviation for the Challenges of smart contract implementation

Statistics to the challenges of smart contract Implementation				
n	Phrase	Mean	Std. Deviation	Percentage %
1	Internet of things is a important technology than can facilitate smart contacts.	4.26	1.29	85.20
2	Smart contracts offer exceptional levels of security in the construction industry by virtue of their advanced technology.	4.06	1.17	81.20
3	Smart contracts have proven to create significant improvements in the realm of Finance and Economics.	3.98	1.16	79.60
4	Smart contracts have been shown to play a pivotal role in enhancing data reliability.	4.2	1.17	84.00
5	Smart contracts offer efficient management of stakeholders by automating various aspects of contract execution and enforcement.	4.12	1.19	82.40

6	The Internet of Things (IoT) has the challenge to significantly diminish the amount of time consumed in executing smart contracts.	4.06	1.14	81.20
7	The Internet of Things has ushered in a new era of technological advancements. This innovative platform has the capacity to automate peer-to-peer business interactions, providing an efficient and seamless experience to all stakeholders involved.	4.06	1.19	81.20
8	The integration of the Internet of Things (IoT) has resulted in a reduction of costs associated with central server administration in the implementation of smart contracts.	3.88	1.14	77.60
9	The integration of the Internet of Things (IoT) into smart contracts represents a powerful method of control and monitoring.	4.06	1.17	81.20
10	Smart contracts have the remarkable ability to integrate Building Information Modeling (BIM), Artificial Intelligence (AI), and Internet of Things (IoT).	4.2	1.13	84.00
11	Smart contracts security is an essential aspect of modern-day technological advancements. In this regard, the ability to accurately, quickly, and reliably share an attack list is crucial.	4.2	1.11	84.00
12	Smart contracts play an integral role in ensuring the security and reliability of cloud service providers.	3.98	1.09	79.60
13	Smart contract security allows users to bypass the use of brokers and instead distribute surface-level agreement cloud.	3.9	1.15	78.00
14	Smart contracts have the ability to significantly decrease administrative service costs, providing a valuable solution for businesses seeking to streamline their processes.	4.12	1.16	82.40
15	Smart contracts significantly enhance the operational efficiency of various services.	3.96	1.17	79.20
16	Smart contracts offer optimal solutions for budget allocation.	4.18	1.13	83.60
17	Smart contracts have effectively reduced costs for consumers.	3.96	1.11	79.20
18	Smart contracts ensure reliable data by detecting any tampering of provenance data embedded in blockchain transactions. This allows for traceability of any modifications made to the data and prevents the illegal embedding of information.	4.1	1.12	82.00
19	Smart contracts enhance data dependability by providing reliable data.	4.14	1.18	82.80
20	Smart contracts facilitate accessibility and reliability of data by storing the meta-data information of data origin, derivation, and transformation. This ensures that any malicious falsifications of data can be easily detected and captured.	4.02	1.10	80.40

21	Smart contracts have the capacity to enhance transparency for stakeholders, thereby fostering greater trust and accountability in business transactions.	4.06	1.22	81.20
22	Smart contracts are an increasingly prominent tool that facilitates the involvement of stakeholders.	4.06	1.08	81.20
23	Smart contracts have the ability to improve communication between all parties involved.	4.08	1.18	81.60
24	Smart contracts offer a solution that effectively mitigates the possibility of disputes arising for all parties involved.	4.02	1.01	80.40

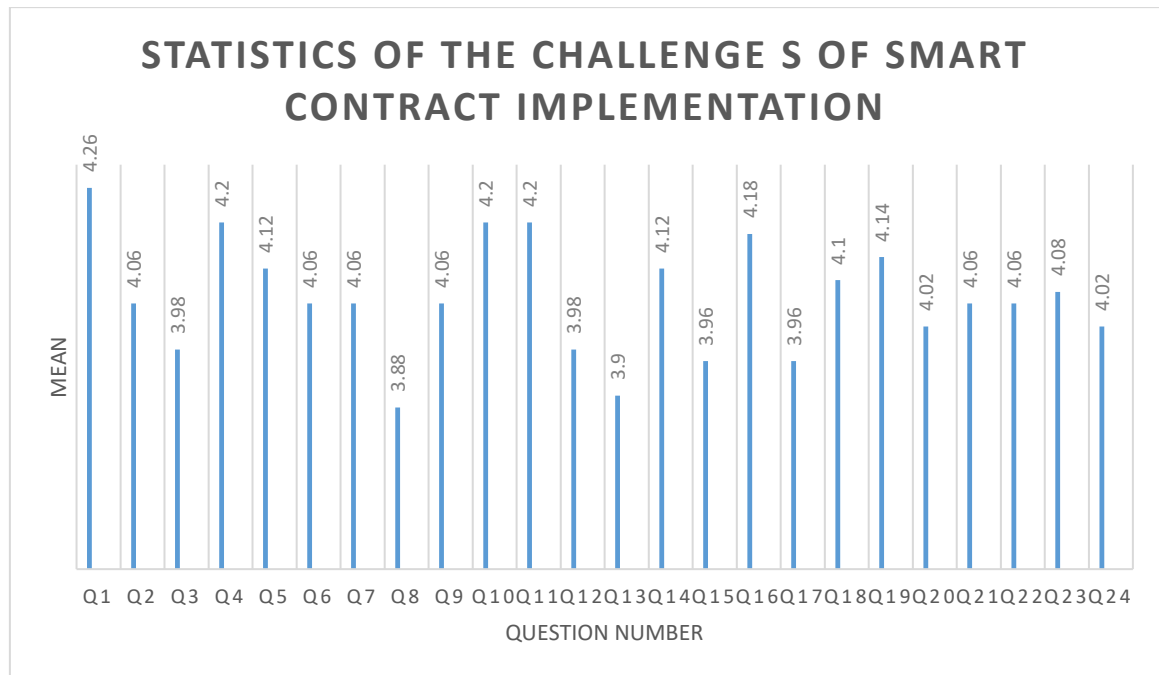


Figure 3: Bar chart for Total Mean Results of the Challenges of smart contract implementation

The previous table and figure show the following:

- The highest mean value is (4.26) and the lowest is (3.88).
- Based on value allocation of the descriptive analysis, respondents agree with that all of the above factors have a challenge impact on smart contract implementation in Saudi Arabia as the mean of most factors ranges from (3.88 to 4.26) which mean it is agree.

4.2.3 Barriers to smart contract implementation

Table 6 highlights the descriptive statistics (mean, standard deviation, and percentages) for the barriers to smart contract implementation for each factor. Figure 4 shows a bar chart that determines the mean of barriers to smart contract implementation.

Table 6: Mean and Standard Deviation for the Barriers to smart contract implementation

Statistics to the barriers of smart contract Implementation				
n	Phrase	Mean	Std. Deviation	Percentage %
25	There is a lack of standardization in protocol design the smart contracts.	3.88	1.14	77.60
26	Difficulty for applying the integration with various ICTs (IoT, BIM, AI).	3.72	1.18	74.40
27	There is a complex underlying design.	3.82	0.95	76.40
28	Blockchain could cause limitations of modifications.	3.82	1.32	76.40
29	Smart contracts do not offer the opportunity to change transactions.	3.54	1.31	70.80
30	The entire construction projects fund is stored in the system make hacking as well as finance security issues much more urgent.	3.72	1.23	74.40
31	Smart contracts need third party for coding	3.72	1.39	74.40
32	Compound smart contracts deployment inconsistency of legal systems.	3.62	1.26	72.40
33	Smart contracts cannot change prices after activation.	3.68	1.27	73.60
34	Smart contracts have Challenges in identifying unforeseen circumstances.	3.86	1.13	77.20
35	Lack of sufficient of compensation for progress (work performed).	3.62	1.32	72.40
36	Smart contracts payments processing has not been a commonly practiced aspect in the realm of construction projects.	4	1.20	80.00
37	There is not much knowledge on the stability of the cryptocurrency.	3.78	1.30	75.60
38	Lack of experts' availability to identify security holes in smart contract coding.	4.04	1.13	80.80
39	Smart contracts currently suffer from a lack of a driving force.	4.02	1.14	80.40
40	Smart contracts are inherently immutable, signifying that they cannot be altered in any way once they are implemented. This makes them less suitable for long-term projects that may require adjustments or variations over time.	4.04	1.18	80.80
41	Smart contracts are immutable entities and remain unaffected by changes in regulations.	3.84	1.35	76.80
42	In order to apply smart contracts, the approval of esteemed authorities is a prerequisite.	4.26	1.04	85.20
43	There is a lack of awareness of smart contracts.	4.02	1.21	80.40

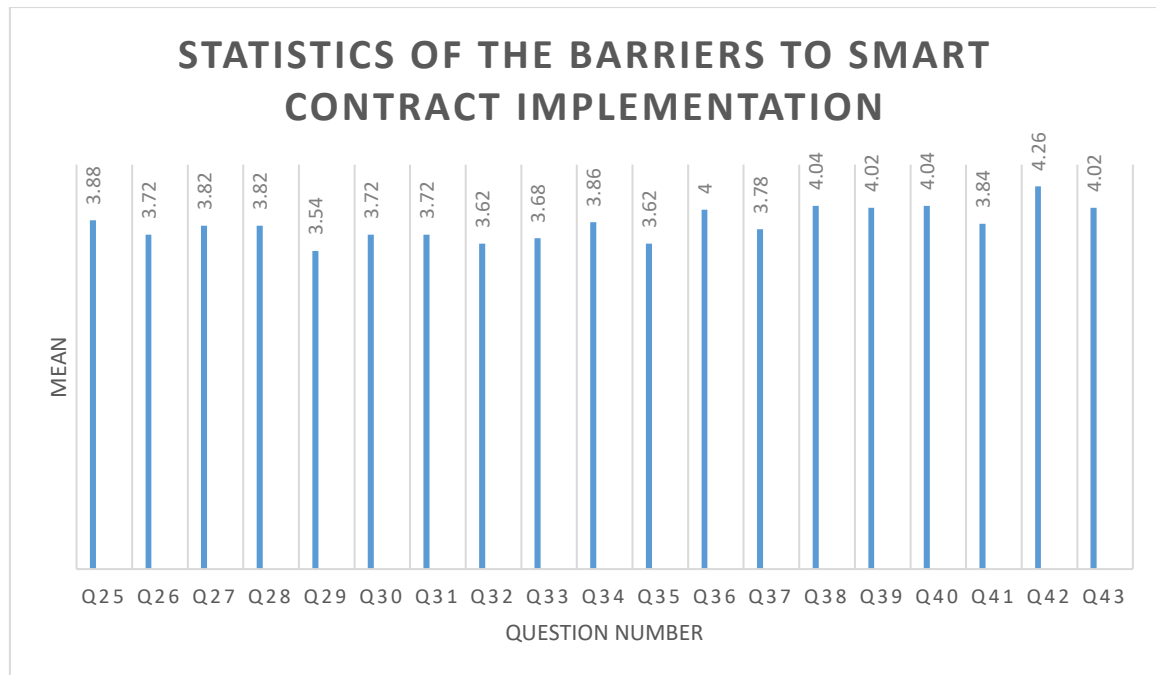


Figure 4: Bar chart for Total Mean Results of the Barriers to smart contract implementation

The previous table and figure show the following:

- The highest mean value is (4.26) and the lowest is (3.54).
- Based on value allocation of the descriptive analysis, respondents agree with that all of the above factors are considered as barriers to smart contract implementation in Saudi Arabia as the mean of most factors ranges from (3.54 to 4.26).

4.2.4 Diagram of the Challenge and Barriers of Smart contract implementation.

In this step of identifying main and secondary causes, the researcher relied mainly on a distributed questionnaire in which he asked some respondents about their opinions on previously determined challenges and barriers to the implementation of smart contracts in the construction industry in Saudi Arabia. The responses analyzed in the previous section shown in this chapter determine these challenges and barriers. The researcher classified them into main categories after interviewing 12 experts, as mentioned in Table 4, based on the common characteristics between these factors and the most aspects encountered in the related literature. As a result, this study offers an illustrative model to aid the decision-maker in defining the challenge and barriers that impact smart contracts in the construction industries in Saudi Arabia. This model, shown in Figure 5, illustrates the challenge and barriers that impact smart contracts in construction industry contracts within Saudi Arabia.

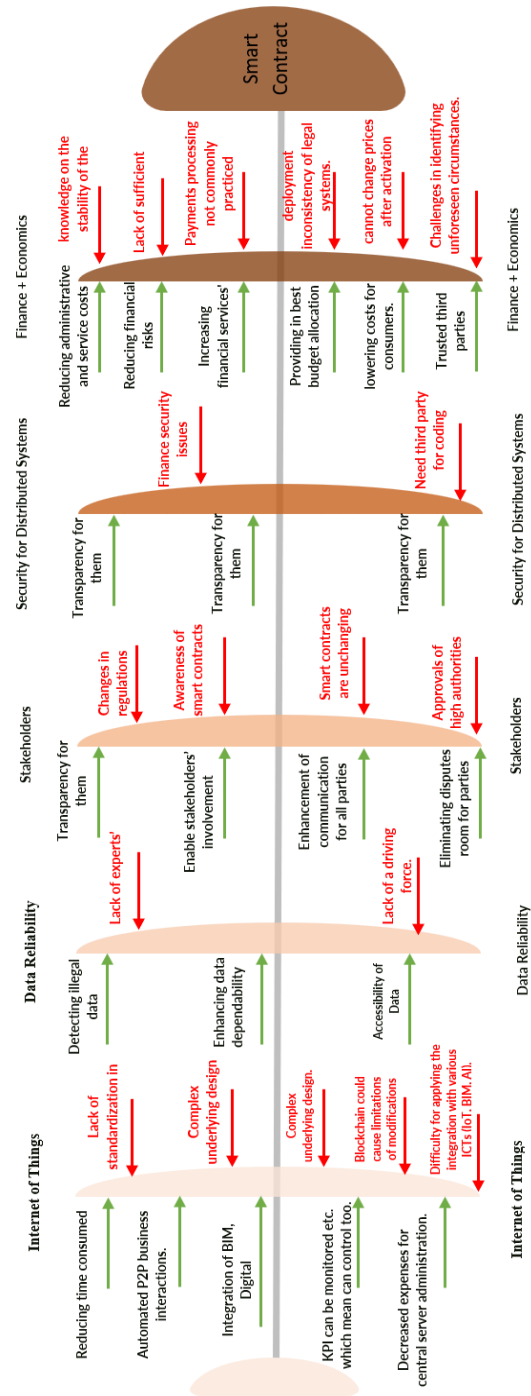


Figure 5: Illustrates Diagram for the challenge and barriers that impact smart contracts in construction industry contracts within Saudi Arabia.

Chapter 5. Results

Through the analysis of interview and survey data, we could find that:

The barriers to smart contract implementation are categorized into six main categories, namely Internet of Things, Data Reliability, Stakeholders, Security for Distributed Systems, and Finance + Economics. The total number of secondary causes in this study reaches 19 barrier factors as shown below:

#	Barriers Main Categories	Smart Contract Barriers
1	Internet of Things	1. Lack of standardization in protocol design. 2. Difficulty for applying the integration with various ICTs (IoT, BIM, AI). 3. Complex underlying design. 4. Blockchain could cause limitations of modifications. 5. Smart contracts do not offer the opportunity to change transactions.
2	Data Reliability	6. Lack of experts' availability to identify security holes in smart contract coding. 7. Lack of a driving force.
3	Stakeholders	8. Smart contracts are unchanging, so, it is not appropriate for long-term projects where they will be subject to modifications or variations. 9. Changes in regulations. 10. Approvals of high authorities of applying contracts. 11. Awareness of smart contracts.
4	Security for Distributed Systems	12. The entire construction projects fund is stored in the system make hacking as well as finance security issues much more urgent. 13. Need third party for coding.
5	Finance + Economics	14. There is not much knowledge on the stability of the cryptocurrency. 15. Smart contracts payments processing has not been a commonly practiced aspect in the realm of construction projects. 16. Lack of sufficient of compensation for progress (work performed). 17. Compound smart contracts deployment inconsistency of legal systems. 18. Smart contracts cannot change prices after activation. 19. Smart contracts have Challenges in identifying unforeseen circumstances.

The barriers to smart contract implementation are categorized into six main categories, namely Internet of Things, Data Reliability, Stakeholders, Security for Distributed Systems, and Finance + Economics. The total number of secondary causes in this study reaches 21 challenge factors as shown below.

#	Challenge Main Categories	Smart Contract Challenge
1	Internet of Things	1. Reducing time consumed. 2. Automated P2P business interactions. 3. Decreased expenses for central server administration. 4. KPI can be monitored etc. which mean can control too. 5. Integration of BIM, Digital
2	Data Reliability	6. Detecting illegal data tampering embed provenance data into blockchain transactions so that any data modifications are traceable. 7. Enhancing data dependability. 8. Accessibility of Data, drawing specifications by store the meta-data information of data origin, derivation and transformation in this manner, any malicious falsifications of data can be captured
3	Stakeholders	9. Transparency for them. 10. Enable stakeholders' involvement. 11. Enhancement of communication for all parties. 12. Eliminating disputes room for parties
4	Security for Distributed Systems	13. Enabling to Share attack list accurately, quickly and reliably. 14. Verify the trustfulness of cloud service providers by Verifying the trustfulness of cloud service providers 15. Avoid users from using broker by distribute Service-Level-Agreements for Clouds
5	Finance + Economics	16. Reducing administrative and service costs, 17. Reducing financial risks 18. Increasing financial services' effectiveness. 19. Providing in best budget allocation. 20. lowering costs for consumers. 21. Trusted third parties.

Chapter 6. Conclusion

This study's objective is to assess the advantages and disadvantages of the use of smart contracts in the construction sector. By responding to the main research question of what benefits, uses, challenges, and possible applications that smart contracts may provide to address construction industry problems in Saudi Arabia, this study also aims to serve as an innovative study into the widespread use of smart contracts in that country's construction industry. This study largely relied on the quantitative method using a questionnaire to achieve its objectives. Through the use of Google Form Link, the survey was made available online. Duplicate or incomplete surveys were then removed. After determining the challenges and barriers to the implementation of smart contract from the respondents' point of view, the researcher applied the illustrative diagram to simplify the challenges and obstacles to the adoption of smart contracts from the respondents' perspective. The findings showed that the challenges are classified into five main categories which are Internet of Things, Security for Distributed Systems, Finance + Economics, Data Reliability, and Stakeholders. The questionnaire yields 21 challenge criteria, including better risk allocation, Decreased transaction time and cost, and Ease of understanding by multiple stakeholders. Moreover, the survey yields 19 barrier considerations, including learning curve, high training and education costs, and cybersecurity concerns. The findings also indicated that there are five categories into which the barriers can be divided: Internet of Things, Security for Distributed Systems, Finance + Economics, Data Reliability, and Stakeholders.

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Questionnaire:

Complexity Rate Assessment Modeling for Challenges and Barriers to the Implementation of Smart Contracts in the Construction Industry in the Kingdom of Saudi Arabia in the Eastern Province of Dammam City.

Dear Participant,

This questionnaire is a crucial component of a study aimed at analyzing the challenges and barriers associated with the implementation of smart contracts in the construction industry of Saudi Arabia in the Eastern Province of Dammam City. The purpose of this research is to aid decision makers and contract specialists, particularly in the Kingdom of Saudi Arabia in the Eastern Province of Dammam City, in light of the ongoing digital transformations taking place across the country. By participating in this study, you can help identify key challenges and benefits that companies may encounter when adopting this technology, ultimately contributing to the advancement of the construction industry in Saudi Arabia.

Finally, we would like to thank you for your kind cooperation.

Prepared by:

- | | |
|--|------------------|
| 1. Abdullatif Saad Alsaif | 222000841 |
| 2. Khalid Ahmed Qahhas Alahmari | 222001987 |
| 3. Azzubair Youssef Alothman | 222000880 |

Supervised by:

Dr. Walid Abdul Jawad Soliman Siddiq

Dr. Alfaisal Abdel Hamid Mohamed Hassan

Part 1: Company and Professional Profile:			
Company Name:			
Projects' Type:	☐ Residential projects	☐ Infra structure projects	☐ Industrial projects
	☐ Other (please specify):		
Respondent's Name (Optional):			
Position/Job Title:			
Years of experience in construction:			
Respondent's email:			
Respondent's Mobile (Optional):			

Part 2: Evaluation of Closely Challenges and Barriers in Saudi's construction contracts:
Please assess the use and deployment of smart contracts in the building and infrastructure industries. Based on your experience as a contract's construction professional, please specify the significance of each factor, which implies your opinion on whether it has to be part of the procedure set to be designed for claims procedure in construction projects in Saudi Arabia Kindly give each factor the most closely Barriers (in your opinion), where: 1. Strongly agree 2. Agree 3. Neither agree nor disagree 4. Disagree 5. Strongly disagree

The most closely Challenges and Barriers in Saudi construction projects		(Please add [√] as appropriate)				
		1	2	3	4	5
1	Internet of things is a important technology than can facilitate smart contacts.					
2	Smart contracts offer exceptional levels of security in the construction industry by virtue of their advanced technology.					
3	Smart contracts have proven to create significant improvements in the realm of Finance and Economics.					
4	Smart contracts have been shown to play a pivotal role in enhancing data reliability.					
5	Smart contracts offer efficient management of stakeholders by automating various aspects of contract execution and enforcement.					
6	The Internet of Things (IoT) has the challenge to significantly diminish the amount of time consumed in executing smart contracts.					
7	The Internet of Things has ushered in a new era of technological advancements. This innovative platform has the capacity to automate peer-to-peer business interactions, providing an efficient and seamless experience to all stakeholders involved.					
8	The integration of the Internet of Things (IoT) has resulted in a reduction of costs associated with central server administration in the implementation of smart contracts.					
9	The integration of the Internet of Things (IoT) into smart contracts represents a powerful method of control and monitoring.					
10	Smart contracts have the remarkable ability to integrate Building Information Modeling (BIM), Artificial Intelligence (AI), and Internet of Things (IoT).					
11	Smart contracts security is an essential aspect of modern-day technological advancements. In this regard, the ability to accurately, quickly, and reliably share an attack list is crucial.					
12	Smart contracts play an integral role in ensuring the security and reliability of cloud service providers.					
13	Smart contract security allows users to bypass the use of brokers and instead distribute surface-level agreement cloud.					
14	Smart contracts have the ability to significantly decrease administrative service costs, providing a valuable solution for businesses seeking to streamline their processes.					
15	Smart contracts significantly enhance the operational efficiency of various services.					

The most closely Challenges and Barriers in Saudi construction projects		(Please add [√] as appropriate)				
		1	2	3	4	5
16	Smart contracts offer optimal solutions for budget allocation.					
17	Smart contracts have effectively reduced costs for consumers.					
18	Smart contracts ensure reliable data by detecting any tampering of provenance data embedded in blockchain transactions. This allows for traceability of any modifications made to the data and prevents the illegal embedding of information.					
19	Smart contracts enhance data dependability by providing reliable data.					
20	Smart contracts facilitate accessibility and reliability of data by storing the meta-data information of data origin, derivation, and transformation. This ensures that any malicious falsifications of data can be easily detected and captured.					
21	Smart contracts have the capacity to enhance transparency for stakeholders, thereby fostering greater trust and accountability in business transactions.					
22	Smart contracts are an increasingly prominent tool that facilitates the involvement of stakeholders.					
23	Smart contracts have the ability to improve communication between all parties involved.					
24	Smart contracts offer a solution that effectively mitigates the possibility of disputes arising for all parties involved.					
25	There is a lack of standardization in protocol design the smart contracts.					
26	Difficulty for applying the integration with various ICTs (IoT, BIM, AI).					
27	There is a complex underlying design.					
28	Blockchain could cause limitations of modifications.					
29	Smart contracts do not offer the opportunity to change transactions.					
30	The entire construction projects fund is stored in the system make hacking as well as finance security issues much more urgent.					
31	Smart contracts need third party for coding					
32	Compound smart contracts deployment inconsistency of legal systems.					
33	Smart contracts cannot change prices after activation.					

The most closely Challenges and Barriers in Saudi construction projects		(Please add [√] as appropriate)				
		1	2	3	4	5
34	Smart contracts have Challenges in identifying unforeseen circumstances.					
35	Lack of sufficient of compensation for progress (work performed).					
36	Smart contracts payments processing has not been a commonly practiced aspect in the realm of construction projects.					
37	There is not much knowledge on the stability of the cryptocurrency.					
38	Lack of experts' availability to identify security holes in smart contract coding.					
39	Smart contracts currently suffer from a lack of a driving force.					
40	Smart contracts are inherently immutable, signifying that they cannot be altered in any way once they are implemented. This makes them less suitable for long-term projects that may require adjustments or variations over time.					
41	Smart contracts are immutable entities and remain unaffected by changes in regulations.					
42	In order to apply smart contracts, the approval of esteemed authorities is a prerequisite.					
43	There is a lack of awareness of smart contracts.					