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A CRITICAL SUCCESS FACTORS MODEL FOR ADOPTING AND IMPLEMENTING SMART CONTRACTS

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ABSTRACT

Recently, smart contracts (SCs) have flourished and have become a mainstream research topic because smart contracts drive the new wave of innovation in business processes. SCs transform real-world contract terms into digital promises of the virtual world. But, the adoption of SCs' technologies in various industries and services is a challenging task. Therefore, this study articulated twenty-one critical success factors for SCs adoption in different applications based on the previous researches and classified them into three categories. These factors are analyzed for each stage of the SCs' lifecycle using the Hierarchical Decision-Making Trial and Evaluation Laboratory (Hierarchical-DEMATEL) technique. At the early stage of SC creation, mature technology, and complexity are the top critical success factors. Then, at the deployment stage, the infrastructural facility and the correctness and immutability of the contract represent the success cornerstones. Finally, having the appropriate infrastructural facility is vital to execute SCs successfully. Based on these results, the authors proposed a smart contract adoption success model based on the implementation life cycle of SCs. The proposed success model was validated by creating a smart contract platform for Egypt's subsidized social housing land program. As a result, the framework managed the project successfully through its early life stages.

Keywords: *Subsidy programs, Critical Success Factors (CSF), Hierarchical DEMATEL, Smart Contract Lifecycle.*

1. INTRODUCTION

Nowadays, Smart Contracts (SCs) have the potential to revolutionize many industries. The smart contracts that appeared over twenty years ago were first proposed in the 1990s by Nick Szabo [1], a cryptographer. SCs are self-executing contracts that utilize blockchain technology to digitally enforce, verify, or facilitate performance or negotiation [2]. A smart contract will automatically execute contract clauses written in computer programs when predefined conditions are met. In contrast, a trusted third party must complete conventional contracts centralized, resulting in long execution times and extra costs. The life cycle of smart contracts consists of four consecutive phases: creation, deployment, execution, and completion of smart contracts [1].

Smart contracts are being deployed across various sectors [3]. They have been applied in the financial sector, public sector, supply chain management, automobile, real estate, insurance, and healthcare industries [4]. The general goals of smart contract design include minimizing the need for trusted intermediaries, satisfying common contractual requirements (such as payment terms), and aligning expectations [5], [6]. However, despite the increasingly professional and academic perceived valuation of the smart contracts technology, there are few successful adoptions of its technology. Since smart contracts adoption is in its nascent stage and, thus, requires not only an assessment of factors influencing its adoption but also determining the impact of those factors at each stage of the adoption lifecycle. Accordingly, the main objective of this study is to identify and classify the factors that influence the adaption of smart contracts in their different stages and determine the relationship between the identified success factors. Where determining critical success factors for smart contracts makes a valuable contribution to both academic literature and practice by highlighting what factors should be considered in each stage of the SCs' lifecycle that will drive the successful adoption of smart contracts.

The work presented in this paper addresses two main research proposals:

- Determining the impact and the relationships of the success factors for each stage.
- Developing a structured success model for adopting smart contracts through each stage of its life cycle.

This paper is organized into six sections: section two presents an overview of some of the related literature and highlights the success factors of smart contracts. Next, the critical success factors of smart contracts are introduced in section three. Then, the proposed success model is constructed in section four. Using a case study, the proposed model is validated in section five. Finally, the study is concluded in section six.

2. RELATED WORK

With the rapid development in recent times, smart contract technology has become a hot spot research topic and has attracted the widespread attention of researchers and academics. Therefore, recently, the literature proposed a diversity of SCs applications ranging from retail energy trading [6], [7] to supply chain collaboration [8]. In addition, some studies reviewed the SCs' construction and execution schemes and their related success factors [9] in the UK construction sector [5], supply chains [10], Internet of Things [11], financial technology (FinTech) innovation [12], privacy protection [13], and developing challenges [14].

Moreover, the literature shows lesser attention to SCs challenges from a broader perspective without focusing on one application. For example, Gupta et al. investigated the open issues and challenges of various Artificial Intelligence (AI) techniques and tools used for SC privacy protection [13]; Zou et al. identified the major challenges developers face during smart contract development [14]. Baharmand & Comes identify various adoption barriers of blockchain-based smart contracts in supply chains [10]. Schmitt et al. analyzed the opportunities and challenges for firms when smart contracts are available as integrated functions of IOT [11]. Ye et al. carry out a systematic review to present the potential application of smart contracts in construction and explore their benefits and challenges [15]. Finally, Duran & Griffin examined the risks associated with smart contracts, a disruptive FinTech innovation. Therefore, they assessed the future threat of smart contracts on the integrity of the global financial system [12].

All the previous studies mentioned above answer questions relating to various aspects of smart contract technology and its integration with other fields. The field of research about smart contract technology integration in other fields has a relatively brief history, but critical success factors and challenges of smart contracts have received lesser attention. Therefore, having a bird-eye view of the CSFs of smart contracts is crucial for the technology practitioners and the decision-makers to assess the viability needed to develop, deploy and execute SCs.

Currently, the progress and development of SCs are still in their infancy; therefore, little is known about adopting smart contracts in organizations. As a result, this paper makes several important contributions:

- First, this paper presents a systematic literature review to identify the critical success factors (CSFs) of smart contracts adoption in applications to identify and classify the factors that influence the adaption of smart contracts in different stages
- Second, based on the identified CSFs, it proposes a framework for smart contract adoption.
- Third, it uses the novel hierarchical DEMATEL technique to prioritize critical success factors and determine their relations.
- Fourth, it presents for smart contracts adaptors an insightful analysis of the impact depth and width of each success factor on the success of this adoption.

Based on the best of our knowledge, none of the previous research papers has provided such a smart success factors review nor provided such practical lifecycle classification. Moreover, no other research papers utilized the novel hierarchical DEMATEL to prioritize the success factors and uncover their relationships in any technology other than blockchain [16].

3. SUCCESS FACTORS IDENTIFICATION

To address the first research proposal, a systematic protocol is designed to identify the critical factors of smart contracts that influence the adoption of smart contracts and evaluate these factors using experts' opinions as shown in the research methodology in Figure 1. Furthermore, the opinions of these experts were scored using the recent hierarchical Decision-Making Trial and Evaluation Laboratory (DEMATEL) technique to

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prioritize critical success factors and extract the interlinked relationships among those factors [17]. First, the literature is surveyed to identify the possible smart contract adoption success factor (SCASF). Then, the primary search term used is placed between the logical AND and OR operators and can be as ("Challenges" OR "Critical success factors" OR "Factors" OR "Successful implementation factors ") AND ("smart contract" OR "Blockchain" OR "Distributed" OR "Decentralized") to ensure a broad set of results. A total of one-hundred and sixty-six studies were detected using generic search terms.

Table 1: Key Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
Published from 2018 to 2022	Published not in the English language
In the field of smart contracts	Not relevant to success factors or challenges
Presented empirical data	Review papers or non-technical papers
Peer-reviewed	Grey literature (white papers, editorial comments, book reviews)

After applying inclusion and exclusion criteria, as shown in **Error! Reference source not found.**, the study pool was reduced to eleven relevant studies—the detailed review of those eleven studies extracted twenty-one critical success factors. Then, three smart contract experts are surveyed to validate and rank those factors. The DEMATEL methodology was considered to collect the experts' opinions to uncover the relationships among the success factors. However, DEMATEL is not suitable for addressing such complex multi-level problems. Therefore, the newly developed hierarchical DEMATEL is chosen for the experts' opinions survey analysis.

Still, smart contract adoption is in its nascent stage and thus requires an assessment of factors influencing its adoption. Therefore, the success factors that affect the spreading of a smart contract are identified through a literature review. SCASFs are summarized into three significant categories: technological, organizational, and environmental [5], [11]. These success factors occur throughout a smart contract lifecycle, from creation to deployment, execution, and completion [1], [4]. The first step in implementing smart contracts is contract creation, where users have to code their contracts before deploying them on a blockchain platform. Finally, SCs are ready to be executed when predefined conditions are met, and the updated states are packed and broadcast to each BlockChain node [1].

Therefore, this study examines success factors that affect the adaption of smart contracts in each stage. Where the success or failure of a smart contract implementation can be significantly impacted by these factors. There is a larger danger of failure or less than ideal results if the important criteria for SC success are not identified.

Therefore, the proposed framework consists of two levels. As shown in **Error! Reference source not found.**, level one represents the three categories of success factors affecting smart contracts in each stage: technological, organizational, and environmental. As shown in **Error! Reference source not found.**, **Error! Reference source not found.**, and **Error! Reference source not found.**, level two shows the success factors of each category.

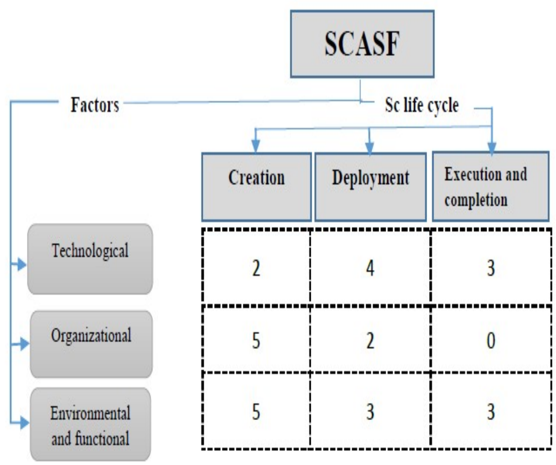

Figure 2: The categories of SC success factors

The first category focuses on how technological features can affect the adoption of smart contract technologies in different applications. The technological context includes five factors: infrastructural facility, complexity, compatibility, scalability, and technology maturity, as shown in **Error! Reference source not found.**.

First, the proper infrastructural facilities of hardware and software are crucial for the successful deployment and execution of SCs [18], [19]. On the other hand, complexity, which Rogers defines as " the degree to which an innovation is perceived as somewhat difficult to understand and use" [5], [20], affects the creation and deployment of SCs. Also, the compatibility of the SCs' technology describes the level it meets the technical standards and requirements of existing IT infrastructure [5]. A

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higher level of compatibility means faster and cheaper deployment on the relevant platforms [21].

The scalability of a platform is determined by its throughput in terms of the number of transactions per second. Ethereum 1.0 requires every node to store the entire state of every account balance, contract code, storage, etc. Although this strategy enhances Ethereum's security, it dramatically limits its ability to process more transactions behind a single-node capability [22]. The scalability of a platform is related to the validation process of newly generated blocks and its consensus mechanism during the execution phase [23], [24]. SCs and their underlying technological concept, the blockchain, have not yet reached the desired degree of maturity. Therefore, adopting SCs presents a risk for early adopters that should not be underestimated [11].

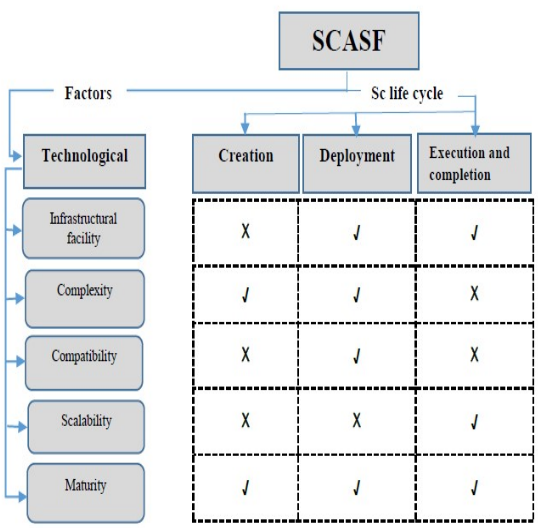

Figure 3: The technological factors

Organizational context refers to inherent characteristics and resources that can either facilitate or impede the adoption of smart contracts. Five sub-factors have become apparent in this context: top management support, organizational culture, organization slack, adequate resource, and lack of experience and knowledge, as shown in **Error! Reference source not found.**.

For example, top management support reduces the salience of the forces working against the change and helps overcome internal resistance during the creation stage. Furthermore, the support of top management can also influence the adoption process of smart contracts by stimulating change by communicating and reinforcing the values and vision of the firm [5]. On the other hand, organizational culture is considered a management philosophy to manage and improve work performance and influence thoughts, emotions, and communication.

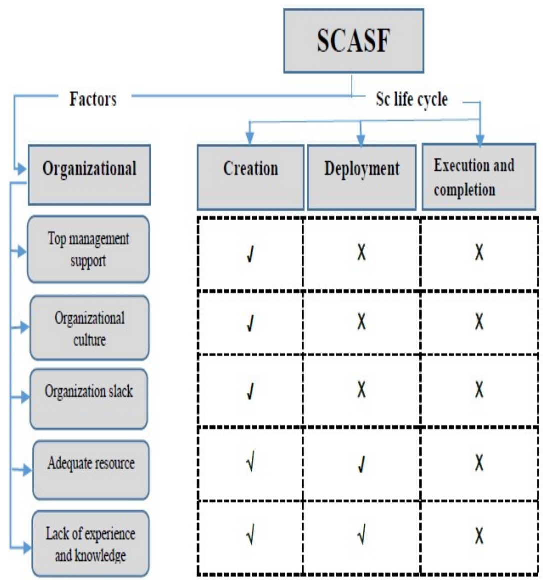

Figure 4: The organizational factors

Furthermore, organizational culture affects how firms respond to external pressures and make strategic business decisions [25]. Therefore, organizational culture influences the adaption of smart contracts in the stage of creation. Additionally, organization slack refers to the availability of uncommitted resources. Therefore, it is among the most frequently discussed factors within the organizational context [11] that influence the adaption of smart contracts in the stage of creation.

Moreover, the availability of adequate resources during the development of smart contracts is considered an acritical success factor that influences the adaption of smart contracts in the stage of creation and deployment [14]. Also, the lack of experience and knowledge of smart contracts emerging technologies imposes a crucial factor for the success of the adoption in the creation and deployment stage of smart contracts.

The environmental and application contexts are related to the business operating domain. Therefore, ten sub-factors became apparent in this context, as shown in **Error! Reference source not found.**First, like various blockchain-based technologies, smart contracts are not yet comprehensively regulated [10]. Second, the lack of laws and policies may limit the ability of relevant government agencies to provide aid and

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enact rules and regulations [26] during the creation stage. Third, competitive pressure within an industry incentivizes a firm to implement innovative technologies. Fourth, smart contracts have the potential to disintermediate markets and fundamentally change market structures. Especially in liberalized markets with limited or no governmental leverage, smart contracts and blockchains could create significant pressure for adoption [11].

There are many functional issues with incumbent smart contract platforms during creation, such as reentrancy (the interrupted function can be safely recalled). Malicious users could use this vulnerability to commit digital theft. Block randomness, or the generation of pseudo-random integers in a block timestamp or nonce, may be necessary for some smart contract applications, such as lotteries and betting pools. Nevertheless, some malicious miners might create blocks to alter the results of the pseudo-random generator [1].

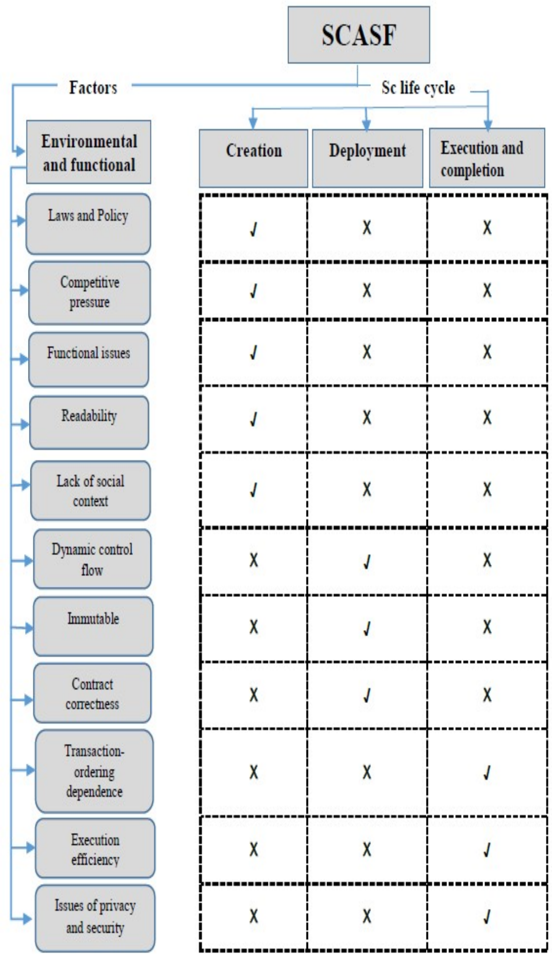

Figure 5: The environmental factors

At the creation stage, since most smart contracts are written in coding languages like Java, Go, Kotlin, and Solidity, SCs raise concerns regarding the readability of code. Therefore, programs in different periods have different codes that should be readable in each form, which remains a big challenge [14]. Also, at the creation stage, smart contracts raise another issue of the lack of social context, which means that blockchain and smart contracts are not widespread in all sectors.

At the deployment stage, smart contracts raise issues of dynamic control flow, immutable, and contract correctness. Although the deployed smart contracts are immutable, the control flow of smart contracts is not guaranteed to be immutable. In particular, a smart contract can interact with other contracts (e.g., transferring funds to the contract or creating a new contract). Therefore, smart contracts control flow must be carefully designed when developing the contract [1]. Furthermore, contract correctness presents a challenge since it is nearly impossible to make any revisions once smart contracts have been deployed on blockchains. Therefore, it is vital to evaluate the correctness of smart contracts before formal deployment [1], [4].

Finally, smart contracts raise transaction ordering dependence, execution efficiency, and privacy and security issues at the execution and completion stage. Transaction-ordering dependence occurs when several dependent transactions invoke the same contract and are included in one block [27]. For instance, users transmit transactions to use a smart contract's functions while miners collect those transactions into blocks. However, because of the unpredictability of the split blockchain branches, the order of transactions is not deterministic. Another related factor is execution efficiency, showing that miners serially execute smart contracts. In other words, a miner won't execute another contract until the current contract is finished. The system's performance is fundamentally constrained by execution serialization. However, because numerous smart contracts exchange data, concurrently executing smart contracts is difficult [1].

Additionally, privacy and security issues since most current smart contracts and blockchain platforms lack privacy-preserving mechanisms, especially for transactional privacy. In particular, the transaction records are disseminated throughout the whole blockchain network. As a result, everyone in the networks can see every transaction. Additionally, SCs have inherent software vulnerabilities that make them susceptible to malicious attacks. Smart contracts also run on top of blockchain systems which suffer from system vulnerability [1].

4. SUCCESS FACTORS' RANKING & INTERRELATIONSHIPS

Despite recent interest in using a smart contract, there are few efforts to explore the critical success factors of adopting smart contracts. Therefore, this paper's novelty lies in categorizing these success factors according to the life cycle phases of SCs. The proposed smart contract model is a complex system with many success factors, multiple types of influences, and hierarchies, as shown in the previous section. Therefore, the hierarchical DEMATEL technique was utilized to collect the experts' ranking of the factors described in the previous section to identify the relationship among the obtained factors. The questionnaire was sent to fourteen experts, and only two experts responded to this questionnaire. The analysis of the experts' ranking of each factor for each SC's lifecycle phase is described in the subsequent subsection.

4.1 Creation stage

At the creation stage, the involved parties, with the help of lawyers or counselors, negotiate the contracts' obligations, rights, and prohibitions to draft an initial contractual agreement. Software engineers convert this agreement in natural languages into a smart contract written in computer languages, including declarative and logic-based rule languages [1]. Twelve of the mentioned factors affect SCs at this stage, as shown in **Error! Reference source not found.**.

The hierarchal DEMATEL is applied to determine the prominence and ranking of each factor, as listed in Table 2. As a result, when the value of (R - D) is positive, the success factor is a net causer. However, when the value of (R - D) is negative, the success factor behaves as a net receiver [28]. Alfa (∝), the average value of (T), the total relationship matrix, is 0.0821. Therefore, the elements of (T) with a higher value than 0.0821 are considered significant relationships among the factors. The grey arrows in Figure 6 represent significant relations between the net causers and the net receivers among the top eight factors. The experts ranked the technological context as critical for successful SCs adoption. Therefore, complexity and maturity are the top two factors needed for SCs adoption during the creation phase. Moreover, the readability, functional issues, and lack of social context are highly ranked from the environment and functional contexts. Regarding the organizational context, only top management support and lack of experience are considered significant factors and net receivers of the other factors, as shown in Figure 6 and Table 2.

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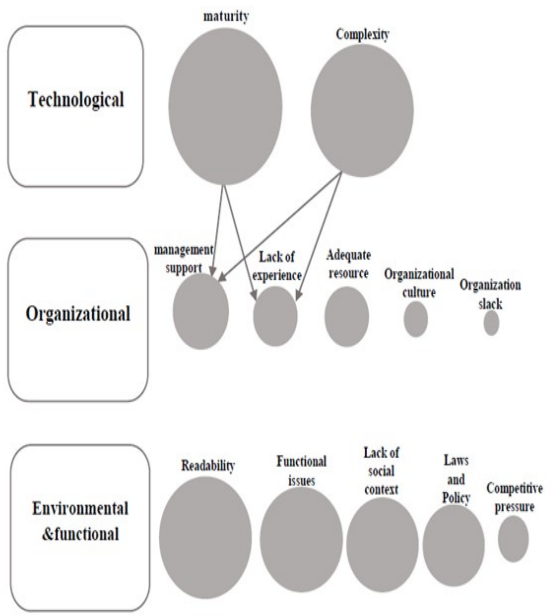

Figure 6: The SCASF of the creation stage

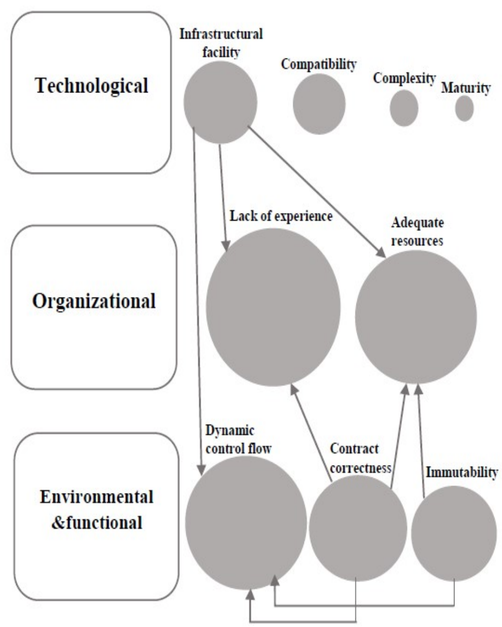

Figure 7: The SCASF of the deployment stage

4.2 Deployment stage

After creation, the validated SCs are deployed on blockchain platforms. Contracts stored on the blockchains cannot be modified due to the immutability of the blockchains. Therefore, any revision requires the creation of a new contract. Furthermore, once smart contracts are deployed on blockchains, all the parties can access the contracts through the blockchains. Therefore, smart contracts need to be checked carefully to avoid potential bugs. Furthermore, smart contract developers must be aware of the contract's interaction patterns to mitigate potential losses due to malicious behaviors [1]. Nine of the mentioned factors affect SCs at the deployment stage, as shown in **Error! Reference source not found.**.

The value ∝ of the deployment stage is 0.1489. Therefore, the elements of (T) with a higher value than 0.1489 are considered significant relationships among the factors. The grey arrows in **Error! Reference source not found.** represent significant relations between the net causers and the net receivers among the six top prominences factors.

Based on the value of (r-d) shown in **Error! Reference source not found.**, the lack of experience, adequate resources, and dynamic control flow is the top prominent net receivers-factors. At the same time, infrastructural facility, immutable, and contract correctness are net causers' top prominences. Therefore, lack of experience and knowledge is the top factor for SCs deployment despite their lower ranking during the creation phase. Dynamic control flow and contract correctness are highly ranked in the environment and application context. Among the technological context, the only infrastructural facility is considered the top significant factor for smart contract adoption. Despite that high ranking of technology maturity and technology complexity during the creation phase, they do not have the prominences during the deployment.

4.3 Execution and completion stage

The contractual clauses are monitored and assessed after the deployment of smart contracts. Once the contractual conditions reach, the contractual functions are automatically executed. Furthermore, the novel states that all parties involved are updated after the smart contract has been executed. Accordingly, the transactions during the execution of the smart contracts and the updated states are stored in blockchains [1]. There are six factors clustered into two dimensions during this stage: technological and functional, as shown in Figure 8.

The hierarchal DEMATEL was applied, as shown in Table 4, to determine the prominence and ranking of each factor. Therefore, the infrastructural facility is the factor with the top prominence score, and the net causer for functional factors is ranked as net-receivers. Infrastructural facilities continue to represent a critical factor in the deployment and execution stages. The value ∝ is 0.3602. Therefore, the elements of (T) with a higher value than 0.3602 are considered significant relationships among the factors. The grey arrows in Figure 8 represent significant relations between the net causers and the net receivers among the four top prominences factors.

This study was intended to identify significant factors that influence the adoption of smart contracts in each phase of SCs. through using the Hierarchical-DEMATEL technique, technological context is found to be the most significant factor in the creation and execution stage, and organizational context is the most significant factor in the deployment stage. Compared to previous studies Badi et al. reveal that environmental factors have been considered to be the most significant factors that influence the adoption of smart contracts in the UK construction sector [5]. Schmitt et al. analyzed the opportunities and challenges for firms when smart contracts are available as integrated functions of IoT. The findings revealed that the combination of the two technological concepts promises significant opportunities, however, some technical and environmental challenges need to be overcome [11].

5. SMART CONTRACT SUCCESS FRAMEWORK

Despite the prominent future of SCs and based on our best knowledge, no structured SCs implementation success model has been proposed yet. However, such models were proposed for the majority of the current technologies, e.g., Enterprise Resources Planning [29], Business Intelligence [30], and BlockChain [31]–[33], and previous research has demonstrated a framework for identifying the success factors of Blockchains [16]. Such success models are crucial for the technology practitioners and the C-level decision-makers to assess the viability of the investment needed to develop, deploy and execute SCs.

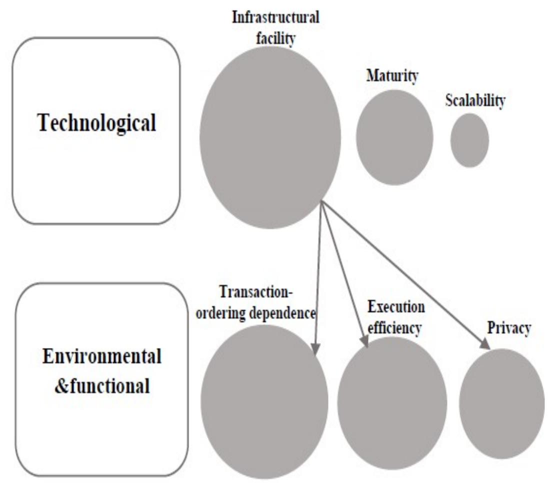

Figure 8: The SCASF of the execution stage

Thus, to address the second important research proposal, this work contributes to rendering a smart contract adoption success model based on the implementation life cycle by using the interrelationships presented in the previous section, as shown in Figure 9.

Before starting the smart contract creation, a checklist of four items must be validated.

- Is the proposed smart contract technology matured?
- Can the complexity associated with this technology be handled?
- Can the stack holders easily understand/read the contract structure?
- Can the proposed contract handle the needed functional needs?

The contract will be created if the proposed smart contract projected passes the above checklist. During the deployment phase, the following indicators should be evaluated frequently to ensure successful deployment:

- The availability of an experienced team
- The availability of technological resources
- The dynamics of the flow among the stockholders
- The immutability of the contract
- The correctness of the contract

The careful monitoring of the abovementioned indicators should result in successful project deployment. However, During the contract execution phase, three different indicators should be closely monitored:

- The efficiency of the execution
- The availability of the needed facility
- The transaction ordering

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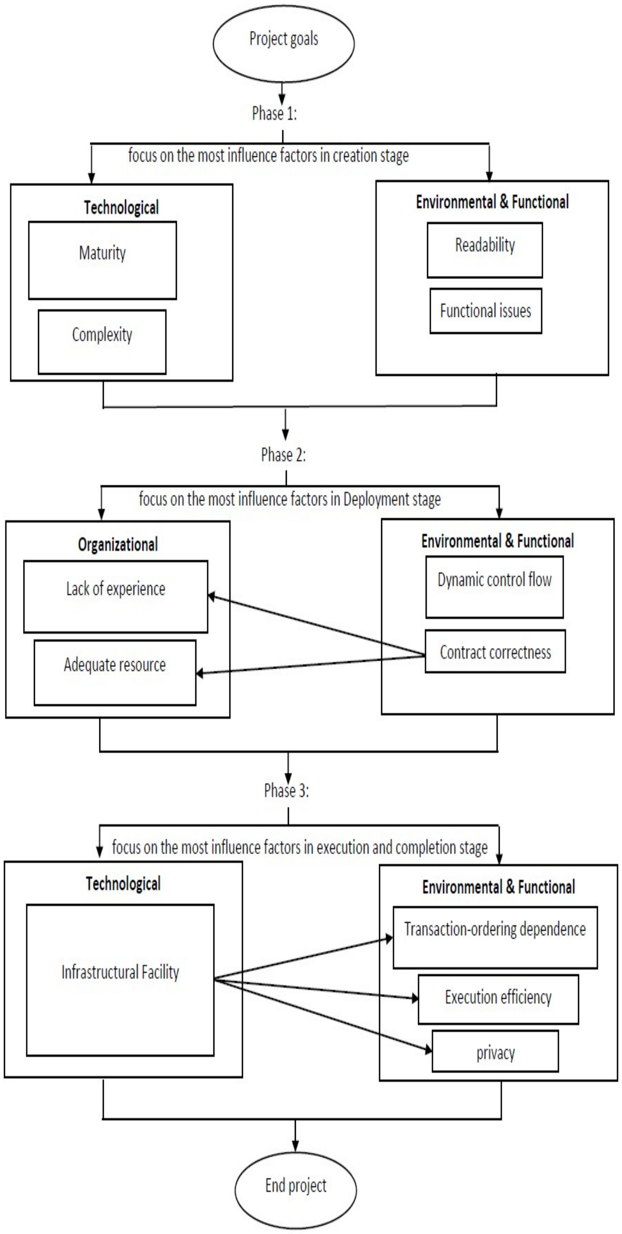
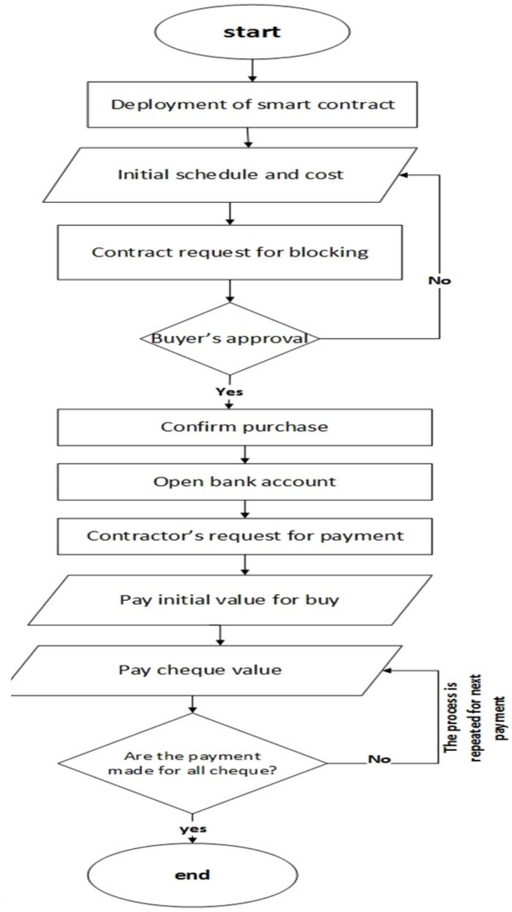


Figure 9: Success model



ure 10: Flow chart of the proposed system

VALIDATION OF SC SUCCESS MODEL: SUBSIDY SYSTEM

This section aims to validate the proposed success model by applying it to Egypt's ısidized social housing land. Because the subsidy tem is vital social importance, it consumes ısiderable portions of many countries' national lgets; however, many subsidy programs are ıcribed as inefficient and ineffective.

One of the most important subsidy programs is housing which is not only a cornerstone for any country's economic growth and stability but is crucial for its urban residents' social welfare [34]. The Egyptian government, among many other governments, achieves that through regulating the allocation and the use of subsidized housing land. However, guaranteeing a good reach of a subsidy program while preventing fraud requires enormous administration because lean, easily accessible subsidy programs face high fraud rates. On the other hand, tightening the program

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control while maintaining lean program administration complicates access to the program fund and excludes many eligible beneficiaries from accessing subsidized land.

The Egyptian government runs a subsidized housing lands program to solve the housing problem for its citizens. Each citizen and his/her dependent can apply for one and only one piece of the subsidized land. Consequently, the successful implementation of smart contracts can mitigate fraud while maintaining a lean, accessible subsidy program. Therefore, using the proposed smart contracts success model can address the subsidy problem of this program. Furthermore, the proposed system provides an efficient and trustworthy project platform without intermediaries like banks. Hence, it can potentially enable savings in fees, reduce administrative costs and burdens, and expedite the payment process, as shown in **Error! Reference source not found.**.

The success model introduced in the previous section is executed to implement the prosed platform. Smart contract creation is achieved by focusing on maturity and readability by using Remix IDE with Solidity 0.4.0 language for the backend of the proposed system's decentralized application (DApp). In addition, the complexity is mitigated in the payments step by including the seller in the system to plan and receive payments based on the project's progress. Therefore, the system promotes transparency and trust among the stack holders, as shown in **Error! Reference source not found.Error! Reference source not found.**. If the buyer misses the deposit or any payments, the system notifies both sides, and the contract is put to hold automatically.

```
function confirmPurchase {

    require please send introduction value
for purchase ;

     buyer. transfer chequevalue;

     buyer = payable(msg.sender);

     for (chequeno=1& chequeno<=3&
chequeno++)

      chequevalue =  chequevalue + 40;

     return chequevalue;

   }
```

Figure 11: Pseudo code of payment process

To ensure the success of the deployments stage, avoiding lack of experience and inadequate resources is handled by deploying it on the Ganache blockchain, as shown in Figure 12, a virtual Ethereum blockchain that does not require any deployment or transaction fees. Also, the transactions on the Ganache blockchain were performed within seconds. On the Ethereum blockchain standard, transactions take between 15 s and 5 min [35]. Unfortunately, the dynamic control flow is not guaranteed because it interacts with other systems for funds transferring and legal registrations. Handling this issue may be a research-worthy topic. Finally, the contract correctness is granted using geographical information systems (GIS) technologies to avoid costly revisions.

During the final execution stage, buyers send transactions to invoke functions such as confirm and purchase to ensure the transaction-ordering dependence while miners pack the transactions into blocks. The infrastructure, execution efficiency, and privacy are provided through the Ganache platform and its DApps. Its transaction page is used to monitor the details of each transaction at any time as shown in Figure 13.

7. CONCLUSION

In recent years, the rapid development of blockchain technologies has made SCs a prominent research topic in academia and industry. But SCs are still in the early stages. Therefore, the present study is designed to identify the key factors that influence the successful adoption of SCs throughout the three phases of adoption and classifies them into three contexts: technological, organizational, and environmental. subsequently, an SC adoption success model for each life stage was proposed. The recent hierarchical DEMATEL ranked and identified the relationship among different success factors. The study concluded that these success factors differ through the adoption life cycle from one stage to another. Moreover, a single factor's prominence varies from one stage to another.

SCs professionals should use less complex and more mature technologies during creation. Such a choice will help them improve their success rate, gain more top management support, and avoid the pitfalls of the lack of experience of the SCs. Moreover, focusing on having more readable SCs with clear functions and gaining social momentum and the appropriate regulation is crucial in this stage. Moving forward to the deployment stage, immutability, contract correctness, and appropriate infrastructure is crucial and result in securing the needed resources, avoiding the lack of experience, and assuring workflow dynamics. Finally, securing the appropriate facilities becomes the most prominent factor during the execution stage and improves the other functional factors.

The proposed success model is applied to an empirical case study in Egypt to validate its efficiency by constructing a smart contract-based subsidy system for allocating and managing social housing land in Egypt, as mentioned in the section on validating the SC success model.

The key findings of the empirical case study application clarify the following:

- The proposed system provides an efficient and trustworthy project platform without intermediaries like banks.
- It can potentially enable savings in fees, reduce administrative costs and burdens, and expedite the payment process, as shown in Figure 9.
- The system promotes transparency and trust among the stack holders, as shown in Figure 10.

While the findings of this study provide valuable insights about CSF in each stage of the SCs' lifecycle, but, there are still many unanswered questions in this study for example:

- How are smart contracts verified and improved using formal approaches and techniques?
- What are the different security vulnerabilities in the smart contract?

Finally, the study paves the way for future research directions such as identifying smart contract's success by determining key performance indicators. Smart contract adoption in the subsidy program remains in its embryonic stages. Still, none of the participants included in the evaluation of the proposed system reported any usability issues. However, the lack of usability testing is another limitation of the proposed system. A more comprehensive evaluation, including a large sample of participants and additional real-life case projects, would provide an in-depth assessment of the proposed system.

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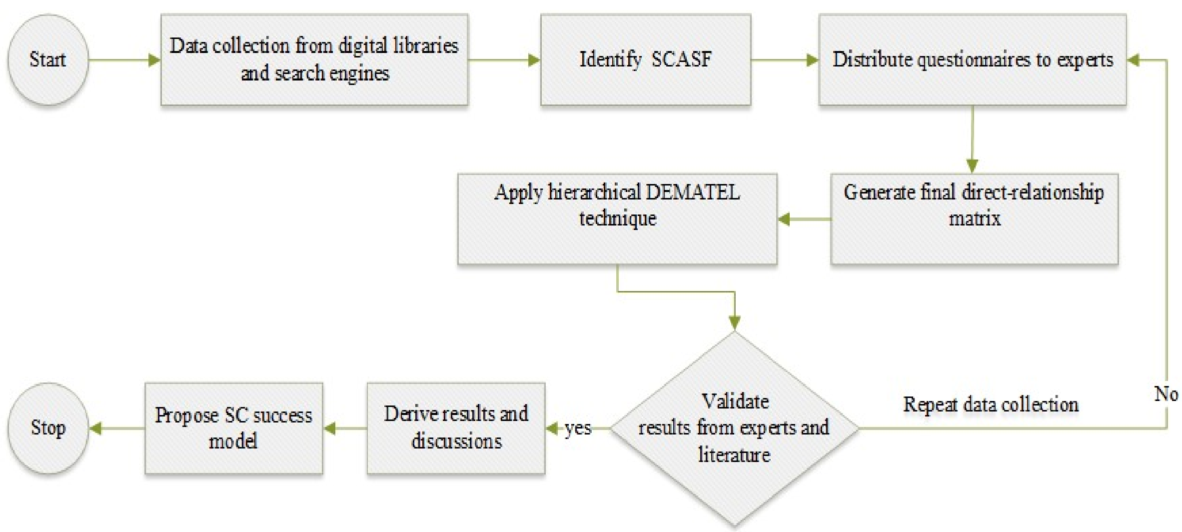

Figure 1: Research Methodology Of The Proposed Study

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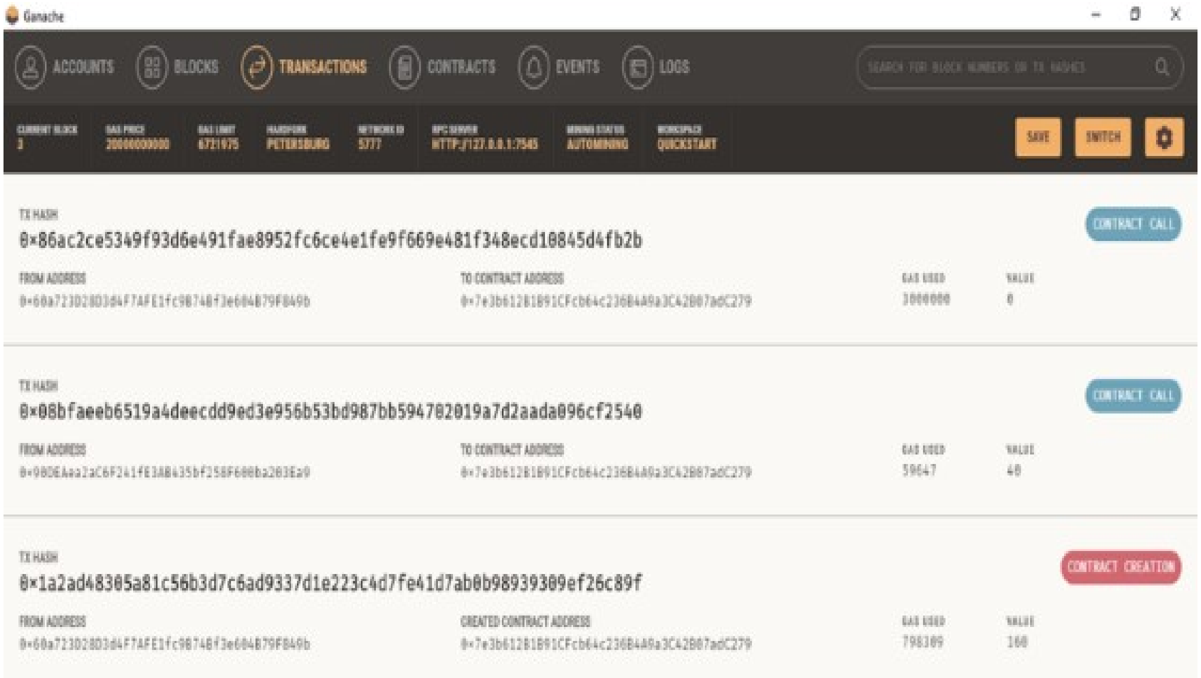

*Figure 12: The First Blocks Of The Propose*d System

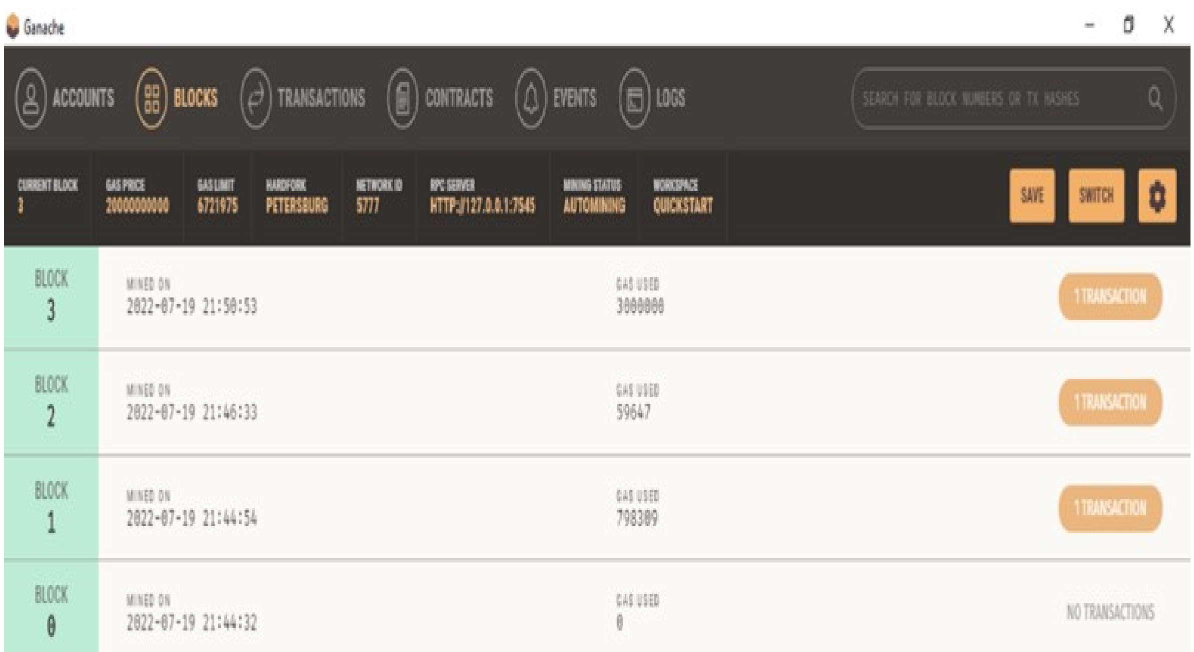

Figure 13: Transaction Example

Table 2: The Prominences Of Factors In The Creation

	Factor		$\bar{r}_i - \bar{d}_i$	$\bar{r}_i + \bar{d}_i$	Ranking
Technological	**f_1**	**Complexity**	**0.02**	**3.73**	**2**
	f_2	**Maturity**	**0.46**	**3.75**	**1**
Organizational	f_3	Lack of experience and knowledge	-0.33	1.47	8
	f_4	Top management support	-0.21	1.55	7
	f_5	Organizational culture	-0.29	1.29	11
	f_6	Adequate resource	-0.41	1.47	9
	f_7	Organization slack	-0.30	1.03	12
Environmental & Functional	f_8	Laws and Policy	0.40	1.78	6
	f_9	Competitive pressure	0.21	1.40	10
	f_{10}	**Functional issues**	**0.11**	**2.01**	**4**
	f_{11}	**Readability**	**0.04**	**2.20**	**3**
	f_{12}	Lack of social context	0.30	1.96	5

Table 3: The Prominences Of Factors In Deployment

	Factor		$\bar{r}_i - \bar{d}_i$	$\bar{r}_i + \bar{d}_i$	Ranking
Technological	f_1	Complexity	0.08	2.06	8
	f_2	Maturity	0.21	1.73	9
	f_3	Infrastructural facility	0.06	2.19	6
	f_4	Compatibility	0.08	2.10	7
Organizational	f_5	Lack of experience and knowledge	-1.35	3.42	1
	f_6	Adequate resource	-0.37	3.27	3
Environmental & Functional	f_7	Dynamic control flow	-0.02	3.37	2
	f_8	Immutability	0.89	2.84	5
	f_9	Contract correctness	0.41	3.14	4

Table 4: The Prominences Of Factors In Execution And Completion

	Factor		$\overline{r}_i - \overline{d}_i$	$\overline{r}_i + \overline{d}_i$	**Ranking**
Technological	f_1	Scalability	- 0.72	3.84	6
	f_2	Maturity	1.14	4.06	5
	f_3	Infrastructural facility	0.90	4.97	1
Environmental & Functional	f_4	Transaction-ordering dependence	- 0.11	4.41	2
	f_5	Execution efficiency	-1.12	4.40	3
	f_6	Issues of privacy	-0.09	4.25	4