APPLICABILITY OF BLOCKCHAIN TECHNOLOGY IN THE SRI LANKAN CONSTRUCTION INDUSTRY

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ABSTRACT

Construction is one of the most significant drivers of economic growth for any nation. In addition to contributing heavily to economic development, it is one of the world's biggest industries. The industry's productivity or effectiveness has often been in doubt whether the industry is productive or effective. To upgrade the standards of the construction industry, different digital tools and software have been introduced. Among numerous innovative technologies spreading across the construction industry, blockchain is emerging as a breakthrough in streamlining the structure and development of various processes. Therefore, this research tends to study how blockchain technology can improve the key performance indicators in the construction industry via various blockchain applications that can be utilized in the construction industry. The correlation and the impact between the applications of blockchain and the construction industry performance were analysed through statistical analysis via SPSS software. A qualitative expert opinion survey with ten construction experts who have experience in blockchain technology, selected through purposive sampling to collect data in Sri Lankan context, was conducted to collect suggestions and recommendations to implement blockchain in the Sri Lankan construction industry. The gathered data was analysed using the content analysis method. The barriers that Sri Lanka must overcome to adopt blockchain technology and the way to mitigate them were included in the study. How can Sri Lanka be prepared to adopt blockchain technology and what applications can be applied in the Sri Lankan construction industry were discussed in this study.

Keywords: Blockchain Technology Application; Implementation; Key Performance Indicators.

1. INTRODUCTION

National economic growth relies heavily on the construction industry. As a result, many jobs and income are created for overall society due to the infrastructure provided by it. This includes infrastructure for health, education, and transportation. Collaborative operations pose many challenges for the construction industry. Several failed projects around the world are caused by poor performances. Unfortunately, a substantial percentage of project activities (e.g., prefabrication) are conducted off-site or offshore, resulting in the loss of management control. In the construction business, numerous

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disputes and litigation problems have arisen about payments withheld, quality fraud, and data authentication. Researchers and practitioners have recognized that construction project business processes lack transparency and accountability.

Supply chain developments in the construction industry are being handicapped by a drop in mean value and a rise in transactions. In construction supply chains, low trust has been an ongoing problem for a long time because of decentralised teamwork. Through digital technology, it may be possible to achieve the criteria of centralised teamwork with high transparency. It is the primary purpose of these technologies to increase trust, visibility, and traceability as well as strengthen partnerships among key stakeholders regarding the sustainability of the materials. With blockchain technology (BCT), knowledge exchange and transactions can be streamlined and protected. An ever-increasing collection of data records is preserved in blockchain technology through a central archive fund. Building a supply chain that utilizes blockchain technology is a relatively new concept.

The problem in the industry based on this study is that the construction industry in Sri Lanka still suffers from poor project performance. This is due to a lack of well-defined practices and strategies and the complex nature of work. Hence, the construction industry in Sri Lanka is yet to be improved with ways for implementing Blockchain Technology to improve. In this research paper, a way of supporting and upgrading the construction industry's performance through digitalization is being researched. Blockchain technology is new to adopt, so this study suggests suggestions for implementing blockchain technology in the Sri Lankan construction industry. This study was done to identify the factors that affect the performances in the Sri Lankan construction industry, to identify the application of blockchain technology, to determine the correlation of blockchain applications with the improvement of performances and evaluate the impact of the application of blockchain in the construction industry and propose suggestions to implement blockchain in the Sri Lankan construction industry.

Many applications of this technology have been proposed and recently discovered in. the construction. industry, including enhancing energy demand and supply, connecting with Building Information Modelling (BIM), and ensuring cyber safety (Khan et al., 2021).

The purpose of this paper is to identify the factors affecting the construction industry in Sri Lanka, as well as how blockchain technology can be applied to the industry. There have been recommendations made for implementing blockchain in the Sri Lankan construction industry based on the evaluation of the application.

2. LITERATURE REVIEW

As a major contributor to the national economy, the construction industry provides substantial employment to many people (Murari et al., 2021). For a project to be successful, it's critical to consider factors like cost, timing, quality, health, safety, and environmental concerns, as well as the effective use of resources (Ahsen et al., 2021). According to the findings, the 10 key performance factors (KPIs) are Time, cost, quality, safety & health, internal stakeholders, external stakeholders, client satisfaction, financial performance, environment, information, technology and innovation (Soewin & Chinda, 2018).

As a major contributor to Sri Lanka's economic growth, the construction industry plays a crucial role. Although the industry faces unique challenges and difficulties, it also faces significant challenges (De Silva et al., 2008). The current context in Sri Lanka shows that

many construction projects have not achieved their cost targets and goals. There have been various project control techniques developed over the past few years (Cooray et al., 2018). As with the Construction Industry, companies have been trying their best to reap the benefits of technology disruption and bring a sense of innovation into an industry that was largely hardwired to the analogue era previously (Narayanan et al., 2016). To achieve process improvement, the concept of digitalization is used to minimize costs, time, and resources. In construction, it is also referred to as digital transformation for operational excellence (Zhang & Zou, 2017). The Block chain technology was introduced simultaneously with Bitcoin. A document titled "Bitcoin: A Peer-to-Peer Electronic Cash System" was published in 2008 by Satoshi Nakamoto. To remain anonymous, the paper was published under Satoshi Nakamoto's name. The author wished to remain anonymous, so no one knows who he is to this day (Lemieux, 2016).

A blockchain preserves transparency and builds trust among its users by consolidating public information and creating checks and balances. As a technology, blockchains are fundamentally about trust optimization (Zheng et al., 2017). Blockchain technology features a central archive function that maintains a growing collection of data records. As a result, blockchain technology can facilitate knowledge exchange and secure transactions (Nakamoto, 2020). According to Royal Institution of Chartered Surveyors (2021), blockchain can be categorized into five types open blockchain, Private blockchain, permissioned blockchain, Hybrid architectures and off-chain storage & Cross-chain interoperability. As a decentralized network, Blockchain eliminates the need for a reliable third party to manage the network or to verify, record, and validate transactions. Due to its distributed nature, blockchain technology automatically shares information between nodes (Okazaki, 2018). As a decentralized network, Blockchain eliminates the need for a reliable third party to manage the network or to verify, record, and validate transactions. Due to its distributed nature, blockchain technology automatically shares information between nodes (Okazaki, 2018).

Blockchain technology has brought to life a key innovation, smart contracts. It is a digital contract that is executed automatically when predetermined conditions are met (Buterin, 2014). By design, smart contracts are unambiguous because they are computer programs. If the input is the same, the output is predictable and deterministic. Further, smart contracts are encoded in computer programs, so users cannot disagree over the contract. As a result of adding a contract to the blockchain, it becomes immutable with one interpretation. Depending on the time, conditions, or the presence of another device, it can be triggered automatically or by defined inputs. In an off-chain system, assets connected to a contract may be moved or transferred (stocks, fiat currency, vehicle titles, etc.).

In the construction sector, blockchain technology has emerged as a breakthrough in transforming the content and expansion of supply chain connections (Khan et al., 2021). Khan et al. (2021) mentioned that construction supply chains benefit from BCT's facilitation of transparency, traceability, information exchange, and trust, which improves supply chain management. It is explored how smart contracts and BCT may help deliver projects (E SUB, 2018). Using blockchain technology, a lack of confidence between the parties would not be a cause for confrontational contractual relationships (Shojaei, 2019).

3.   METHODOLOGY

The main research philosophy for this research is mainly positivism, which is based on the opinions of the people (professionals). To accomplish the study's goals, primary data were gathered thorough a questionnaire survey and semi-structured interviews. A preliminary questionnaire was conducted to obtain data for preparing the expert interviews and a preliminary interview was conducted to obtain data for the preparation of the questionnaire.

Preliminary questionnaire and the main questionnaire were prepared with including the structured and unstructured questions. questionnaire was developed and distributed among the professionals in the constructions industry and familiar with blockchain technology.

The preliminary interview and the expert interview were conducted by using purposive sampling who are experts in the construction industry and familiar with both the Sri Lankan construction industry and blockchain technology.

The preliminary questionnaire was distributed for collecting further data and for gather data required to prepare the expert interview questions. The preliminary interviews were conducted prior to preparing the main questionnaire. The expert interview was conducted with ten experts and the questionnaire was responded by 35 persons. Questions were formed based on the research problem, research objectives, variables, and sub-variables. The following conceptual framework illustrates the relationship between dependent and independent variables.
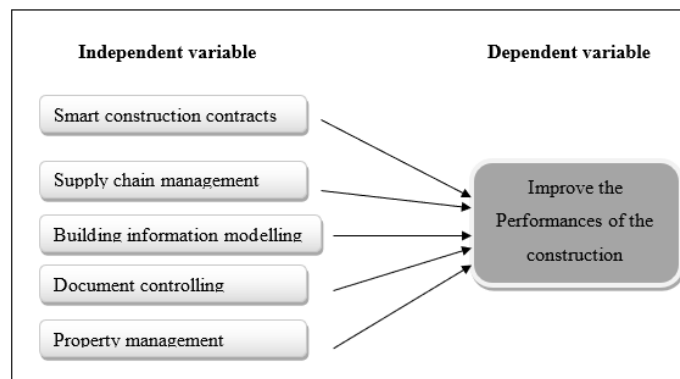

Figure 1: Conceptual Framework

For the expert interviews, professionals representing all disciplines of architecture, quantity surveying, engineering, project management, researchers and academic lecturers who are familiar with blockchain technology and the construction industry were selected. Each interviewee was coded, and they all referred to by their respective code names as shown in Table 1.

Table 1: Details of interviewees

Code	Profession	Experience range
EX1	Researcher / Lecturer	15 – 20
EX2	Researcher / Lecturer	10 – 15
EX3	Quantity Surveyor	Less than 5

Code	Profession	Experience range
EX4	Project Manager	10 – 15
EX5	Engineer	5 – 10
EX6	Quantity Surveyor	5 – 10
EX7	Architect	Less than 5
EX8	Quantity Surveyor	Less than 5
EX9	Engineer	15 – 20
EX10	Project Manager	Above 20

4. DATA ANALYSIS

Preliminary questionnaire data were analysed through a relatively important index analysis. To analyse the data collected from 35 respondents for the questionnaire survey, correlation analysis, and regression analysis were carried out using SPSS Software. After determining the validity of the data, a correlation analysis was conducted to identify how independent and dependent variables are related. Multiple linear regression was used to analyse the independent variables' impact on the dependent variable. Content data analysis was carried out through all the objectives of this study.

5. FINDINGS

5.1 FACTORS AFFECTING THE PERFORMANCE OF THE CONSTRUCTION INDUSTRY

According to the literature survey, there are these ten key performance factors (KPIs) time, cost, quality, safety and health, internal stakeholders, external stakeholders, client satisfaction, financial performance, environment, and information, technology and innovation (Soewin & Chinda, 2018). Those KPIs were used in this study to examine the order of importance. Likert scale accordance with the importance was used for that purpose. RII values for the factors are given in Table 2.

Table 2: Results gained by RII analysis.

Factor	Frequency					Total no of respondents	Total weight	Relative index	Rank
	VI	I	MI	LI	NI				
Time	29	5	1			35	168	0.960	1
Cost	29	4	2			35	167	0.954	2
Quality	29	3	3			35	166	0.949	3
Health & Safety	16	17	2			35	154	0.880	6
Internal Stakeholders	7	22	2	1		35	131	0.749	10
External Stakeholders	5	23	5	2		35	136	0.777	9
Client's satisfaction	20	15				35	160	0.914	4
Financial performances	18	15	2			35	156	0.891	5
Environment	11	20	3	1		35	146	0.834	8
Technology & innovations	11	20	4			35	147	0.840	7

As per the Table, time, cost, and quality are the most important indicators among all the KPIs. This data outcome helped to determine what should highlight in asking questions in the expert interview and what should highlight when analysing the third and fourth objectives.

5.2 APPLICATION OF BLOCKCHAIN TECHNOLOGY

As per the experts, Blockchain technology allows for more automated and autonomous operations than manual human intervention. The main things that differentiate blockchain technology from other technologies are the characteristics of a peer-to-peer network, high security, high transparency, trust, high immutability, high auditability, and high reliability. Some blockchain applications are still used in the construction industry, but many are still in the research stages. The application of BCT to smart contracts, supply chain management (SCM), Building Information Modelling (BIM), facility management, sustainability, contract management, Blockchain-enabled equipment leasing, document management and property management was identified through secondary data.

5.3 CORRELATION BETWEEN BCT APPLICATIONS WITH THE IMPROVEMENT OF THE CONSTRUCTION INDUSTRY

As all the significant values are <0.001, correlation analysis shows that there are relationships between the independent and dependent variables. Results are shown in Table 3.

Table 3 : Results from correlation analysis.

Correlations

		ASCC	ASCM	ABBM	ADCM	ABPM	AABC
ASCC	Pearson Correlation	1	.757**	.657**	.614**	.474**	.509**
	Sig. (2-tailed)		<.001	<.001	<.001	.004	.002
	N	35	35	35	35	35	35
ASCM	Pearson Correlation	.757**	1	.510**	.475**	.484**	.613**
	Sig. (2-tailed)	<.001		.002	.004	.003	<.001
	N	35	35	35	35	35	35
ABBM	Pearson Correlation	.657**	.510**	1	.606**	.424*	.673**
	Sig. (2-tailed)	<.001	.002		<.001	.011	<.001
	N	35	35	35	35	35	35
ADCM	Pearson Correlation	.614**	.475**	.606**	1	.636**	.586**
	Sig. (2-tailed)	<.001	.004	<.001		<.001	<.001
	N	35	35	35	35	35	35
ABPM	Pearson Correlation	.474**	.484**	.424*	.636**	1	.451**
	Sig. (2-tailed)	.004	.003	.011	<.001		.007
	N	35	35	35	35	35	35
AABC	Pearson Correlation	.509**	.613**	.673**	.586**	.451**	1
	Sig. (2-tailed)	.002	<.001	<.001	<.001	.007	
	N	35	35	35	35	35	35

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

ASCC – Application of BCT in Smart construction contracts

ASCM - Application of BCT in Supply chain management

ABBM - Application of BCT in BIM

ADCM - Application of BCT in Document management

ABPM - Application of BCT in Property management

AABC – Improvement of the construction industry performances.

5.4 REGRESSION ANALYSIS - IMPACT OF BCT ON THE CONSTRUCTION INDUSTRY

The regression analysis was employed to identify the impact between these two variables through the SPSS software. The results are shouwn in Table 4.

Table 4 : Results of regression analysis

Coefficients						
		Unstandardized Coefficients		Standardized Coefficients		
Model		B	Std. Error	Beta	t	Sig.
1	(Constant)	.030	.682		.044	.965
	ASCC	.375	.214	.367	1.752	.090
	ASCM	.603	.213	.514	2.828	.008
	ABBM	.536	.178	.489	3.007	.005
	ADCM	.279	.181	.273	1.543	.134
	ABPM	.005	.176	.004	.026	.980
a. Dependent Variable: AABC						

As per the results, the construction industry improves its performance by 37.5% by implementing BCT in smart construction contracts, 60.3% in supply chain management, by 53.6% in BIM, by 27.9% in document management and 0.5% by implementing BCT in property management.

5.5 CORRELATION BETWEEN BCT APPLICATIONS AND THE IMPACT OF THE APPLICATION OF BCT IN THE CONSTRUCTION INDUSTRY

According to the experts, all the performance indicators of the construction industry can be improved with adopting to the blockchain technology. Other than the KPI's, as 'Trust and Transparency' are also mentioned throughout the Project Management Body of Knowledge (PMBOK) as significant aspects to be followed, the management process in the construction sector is also can be improved with adaptation to blockchain technology.

As per the experts, there are very few blockchain applications used in construction industry. However, there are many proof-of-concept projects, or prototype systems being developed.

5.6 SUGGESTIONS AND RECOMMENDATIONS TO IMPLEMENT BCT IN THE SRI LANKAN CONSTRUCTION INDUSTRY

5.6.1 Sri Lanka's Readiness for Applying BCT

According to the experts, Sri Lanka is not in an appropriate level to adopt blockchain technology. The main barrier is there is no policies established regarding using blockchain technology. Resistance to change could be a big barrier too because people don't like to change from what they are used to.

BCT is not only for use by one single company. It's a more ecosystem. That means, everybody should use it. To get the full advantage of blockchain, every party should use BCT. The knowledge gap is also a big barrier and the lack of capability of technical feasibility. The initial cost of implementing can be expensive. Those barriers can be found in Sri Lanka that effects to block the implementation of Blockchain technology.

5.6.2 Suggestions and Recommendations to Implement Blockchain Technology in the Sri Lankan Construction Industry

As per the experts, construction companies should avoid ad hoc behavior and implement most of the practices that Project Management Body of Knowledge (PMBOK) mentions to stay on the right track prior to implement an advance technology like blockchain technology.

According to some respondents, a proper knowledge regarding blockchain technology should be given in organizational level and undergraduate level. If there's a need to use Information Technology (IT) professionals to do some jobs, it is preferred to go for joint ventures or collaborations with companies. As parties can exchange knowledge and construction professionals can benefit from each other's experience, integrating with another company could be cost-effective. IT companies can develop the system.

Another comment that came up is Involved in research and development. Another thing is, the client should get an idea about blockchain concepts and what are the advantages of that. Again, from the contractor's point of view, they should be able to deal with this one. Even if the clients are ready for that, if the contractors are not ready to use it yet, it still cannot be done. Another thing is the government should apply or create relevant legal policies to allow blockchain to be used in the Sri Lankan context. Stakeholders should then be informed that changes need to be made. They should understand what the challenges in the construction industry are and how they can be mitigated through blockchain concepts.

After the above suggestions fulfilled, the experts recommend in starting to apply blockchain for payment handling system. The respondents mentioned that after a payment handling system is adopted, then quality tracking in the supply chain can follow. BCT can be used to track the certification of raw materials and intermediate products. In this way, it can solve supply chain management problems very well.

One respondent said further about the areas that can adopt BCT as document management. Trust in the documents, maintenance, facility management, and asset management are the prominent areas in the Sri Lankan construction industry which can use BCT for future implementations.

6. CONCLUSIONS AND RECOMMENDATIONS

The study has identified the performance indicators that affect the improvement of the construction industry.

Preliminary interviews conducted among four experts in the industry who are familiar with blockchain technology indicated how blockchain differs from other technologies and what the characteristics of BCT benefit the construction industry. Some visible and research-level blockchain applications were identified are possible to apply in the construction industry. The analysis proved that there is a relationship and impact between variables.

The main outcomes that were obtained are, about the characteristics of BCT that will benefit to improve the KPIs with the performances of the construction industry and the BCT applications that are used in the world in construction.

The main outcomes of the expert interviews are:

1. About the reasons for not using blockchain in Sri Lanka's construction industry,
2. About the readiness of Sri Lanka to adopt BCT,
3. About the barriers to implementing BCT in the Sri Lankan construction industry, and
4. suggestions and recommendations of professionals on what solutions can be put into practice by the Sri Lankan construction industry to implement BCT.

Through the findings and outcomes gained from this study, it is clearly shown that the Sri Lankan construction industry can be improved with the implementation of blockchain applications on it. As per the findings, before implementing blockchain applications in the country following are recommended to get the surrounding that suits to implement BCT:

1. Must establish Government policies regarding using BCT and its applications,
2. It's better to have more research studies regarding BCT and its applications in the construction industry relating to Sri Lanka,
3. Must mitigate the fear of technology in peoples' minds. For that training sessions, workshops or other programs can be followed at the organizational level,
4. The country should produce IT professionals with also having the construction industry practice,
5. Avoiding ad hoc behaviours in the construction industry practices. For this aspect, good management practices should be followed. It is recommended to follow the PMBOK, and this should follow at the organizational level,
6. The financial capacity should be assessed, and
7. It is recommended that the government must allow blockchain to be used in the central bank.

After these recommendations are fulfilled even up to an adequate level, the following recommendations can be given regarding implementing BCT in the Sri Lankan construction industry:

1. At first, Blockchain applications should be developed according to the construction industry in Sri Lanka or must observe what applications can be bought and adopted with Sri Lanka,
2. Sri Lanka must produce more Blockchain developers,
3. It is better to adopt the applications that have been practiced earlier in construction companies if there's a lack of capacity for risk-taking, and
4. The applications that are in use overseas can be adopted by configuring their pros, cons, and nature. Those applications that can be recommended are BCT to supply chain management, BIM and financial management (payment processes) when considering the Sri Lankan context.

Blockchain technology is an upcoming topic, and it is gaining traction in developed countries. The study focused on Sri Lanka's construction industry and provided suggestions for implementing BCT applications. The study illustrates several areas in the construction industry where the blockchain concept can be easily adopted. As a result of this study, it has been demonstrated that the use of BCT has a significant influence on the performance of the construction industry. BCT can be implemented in the construction industry as a great parameter for improving performance. It is therefore important for Sri Lanka's construction industry to follow such a concept. Further development of this research has been identified in the following areas.

- Regarding the digitalization of the country

As the world rapidly develops with digitalization, it's better to adopt that wave to the construction industry in Sri Lanka also. When technologies like BCT appear in the world, Sri Lanka must have the environment to adopt them as the first thing. It is therefore possible to conduct further research on that subject as follows. How to build Sri Lanka that is technologically dense, in terms of its capability to adopt such technologies, and feasibility studies relevant to the adoption of BCT.

- Regarding adopting BCT in the construction industry in Sri Lanka.

Processes related to payment, administration, document handling, supply chain management, and BIM applications can be followed to analyse how these applications adapt to Sri Lanka. In addition, the impact they have on the construction industry can be discussed.

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