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READINESS AND ACCEPTANCE OF BLOCKCHAIN TECHNOLOGY IN THE MALAYSIAN CONSTRUCTION INDUSTRY

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ABSTRACT

Blockchain as one of the key technologies of Industry 4.0, requires the transformation of trusted behaviour from the human trust to coding trust. The objectives of this study are to uncover the theoretical principles underlying blockchain technology and to explore its potential applications to the construction industry. Literatures related to blockchain reviewed are synthesis to six imperatives in adoption of Blockchain technology, i.e. distributed ledger, trust-less system, immutable records, smart contract, time-stamped transaction and pseudo-anonymous database. Online questionnaires survey responded by 150 shown that construction practitioners agreed 'information should be synchronized in digital platform in real time', 'proper traceable system improves workflow of project', 'delay in transferring information causes disputes or misunderstandings' and 'insufficient of information causes poor decision making'. More than 90% of the respondents' companies 'trusted documents that have been certified by central authority', 'provided correct information to stakeholders' and 'had a smooth workflow because of traceable information'. However, there are more than a third of the respondents' organisation 'delayed payment to other parties', 'always experienced privacy problem because of information sharing', 'were allowed to access to all information regarding to the project', 'often experienced hacking and tampering of data' and 'experienced data being modified even after it was published'. The study concluded that blockchain technology could overcome several issues and problems encountered by the construction industry. However, the construction industry is still traditionally accustomed to third party certification in solving the trust problem, hence, this forms the greatest hindrance towards the adoption of blockchain technology.

Keywords: Blockchain, distributed ledger, trust-less system, immutable records, smart contract, time-stamped transaction, pseudo-anonymous database

INTRODUCTION

Blockchain is one of the key technologies in Industry 4.0. Blockchain technology is lauded for its approach in switching away central trusted authority to a massively distributed network. One of the vital transformations involves trusted behaviour whereby human trust metamorphoses to coding trust. There previous research of blockchain were focusing on its role, which included the current status, classification and open issues (Casino, Dasaklis and Patsakis, 2019), enhancement and transformation of supply chain (Min, 2019; Wang, Singgih, Wang and Rit, 2019), renovation of distributed database (Muzammal, Qu and Nasrulin, 2019), potential to enable trust and decentralization in service systems (Seebacher et al., 2017).

Wang, Wu, Wang and Shou (2017) advocated that blockchain is able to eliminate the payment and cash-flow issues, improves the efficiency of the contract administration process and supply chain management, builds trust between the construction parties and achieve information sharing in good manner. Turk and Klinc (2017) found that blockchain provided a trustworthy infrastructure for information management during all building life-cycle stages and improves the reliability and trustworthiness of construction logbooks, works performed and material quantities recorded on the construction site. In the facility maintenance phase, blockchain's main potential is the secure storage of sensor data which are sensitive to privacy. These studies had uncovered the potential applications of blockchain technology, but the empirical principles in adoption of blockchain technology are yet to be uncovered. Hence, the objectives of this study is to explore the theoretical principles underlying blockchain technology and the responses of the construction industrial practitioners towards these principles.

BLOCKCHAIN

Blockchain is an open and decentralized ledger that shares data in peer-to-peer (P2P) network. The transactions are shared and accessible by all nodes of network by applying the consensus mechanism, monitored and maintained by every nodes on the P2P network but controlled by no one (Feng, He, Zeadally, Khan and Kumar,

2019). P2P network is a self-organizing and decentralized network which composed by more than two or more PCs connected and shares the resources without going through a central authority (Deokate et al., 2019). The fundamental transformation that blockchain technology brings is an approach of switching away central trusted authority in a massively distributed network (Dhillon, Metcalf and Hooper, 2017). Blockchain offers disintermediation by reducing reliance on third parties (Wang, Singgih, Wang and Rit, 2019). In fact, "trust" is impossible to be achieved when there is no central authority since price of centralization is trust. The users need to trust centralized operators with data kept by centralized authority (Fillippi, 2016). The consensus mechanism in blockchain makes the data much reliable since the data are validated by all the peers on the network. A consensus mechanism is an algorithm that contains set of rules and agreements to create a fair environment in distributed network (Muzammal, Qu and Nasrulin, 2019). However, decentralized systems are much more difficult to implement than centralized platforms due to difficulty to allow for an effective coordination amongst a distributed network of peers (Fillippi, 2016).

In a nutshell, there are eight blockchain technology highlighted in the published literature as summarized in Table 2.1: Distributed ledger, trust-less system, transparent database, immutable records, Smart contracts, Timestamped transaction and pseudonymous identity.

Table 2.1: Blockchain Technology

Blockchain Technology	In text citation
Distributed ledger	• No single body or individual is able to control or authorise the blockchain network (Feng, He, Zeadally, Khan and Kumar, 2019). • Blockchain enables the transaction of assets or data without the immediate need for one central connecting organization (Muzammal, Qu and Nasrulin, 2019). • The blockchain consists of replicated data and distributed to each and every node in blockchain network (Muzammal, Qu and Nasrulin, 2019).. • Blockchain offers automatic traceability, since append-only distributed databases of transaction records can be shared across the entire P2P network and those historical records remain forever with permanent footprints (Min, 2019).
Trust-less system	• Blockchain technology creates a trust-less decentralised environment that has consensus algorithm as its operational engine (Muzammal, Qu and Nasrulin, 2019). • Trust is embedded and programmed into the technological platform (Wang, Singgih, Wang and Rit, 2018). • Blockchain replaces the need for intermediaries by redirecting the trust to decentralised systems (Macrinici, Cartofeanu and Gao, 2018). • …participants involved don't need to have an established trust relationship if they trust the blockchain itself (Wang, Wu, Wang and Shou, 2017). • Blockchains are an application enable economic transactions without requiring a trusted third party (Li, Greenwood and Kassem, 2019) • Consensus is achieved by executing the rules of the blockchain without any central authorization (Feng, He, Zeadally, Khan and Kumar, 2019).
Immutable records	• The blocks in blockchain cannot be altered once they are added to the chain, which makes the chain of transactions publicly verifiable and totally immutable (Taylor, 2017).

	• Once the blocks are connected within a chain, they become immutable (Swan, 2015). • Blockchain relies on cryptographic signatures makes it difficult for anyone to tamper (Hackett, 2017).
Smart contract	• Blockchains can be programmed to automatically trigger actions between nodes such as payments or other events once certain conditions are met (Wang, Singgih, Wang and Rit, 2018). • By using blockchain, device management could be automated and data synchronization could be easier and faster among IoT devices (Feng, He, Zeadally, Khan and Kumar, 2019). • This network of things will transition toward becoming a network of Smart contracts that talk to each other and—hopefully—make smart decisions without the need for human intervention or interpretation (Bambara and Allen, 2018).
Timestamped transaction	• The availability of a real-time, change-resistant and hack-resistant record of data with trustworthy time entries increases the reliability, integrity and transparency of the data (Li, Greenwood and Kassem, 2019). • The blockchain's database operations are performed in near real-time (Muzammal, Qu and Nasrulin, 2019).
Pseudo-anonymous database	• Identity of those involved in the transaction is represented by an address key in the form of a random string (Bambara and Allen, 2018). • The information within blockchain is viewable by all participants (Wang, Singgih, Wang and Rit, 2018). • Anyone on the network can browse via a designated website and see the up-to-date ledger (Bambara and Allen, 2018).

RESEARCH METHODS

A questionnaire survey was conducted to explore the perceptions and experiences of industrial practitioners towards some current practices of the construction industry which are imperative to the adoption of blockchain technology. The first part of the questionnaire consists of 25 statements which sought

(i) the degree of agreement of current practices in the construction industry; and

(ii) the experiences encountered in the construction project involved.

The statements of both parts of the questionnaire are generated from the six imperatives synthesize from the literature reviewed. Seven points Likert-scale is applied to every question from strongly agree to strongly disagree.

Table 2: Perceptions on Construction Management Practices and the Related Blockchain Technology

Statements	Construction Management Practices	Blockchain Technology
S1	All information regarding to project should be transparent to whole project team.	Pseudo-anonymous database
S2	All information regarding to project should be accessible by whole project team.	Pseudo-anonymous database
S3	Insufficient of information causes poor decision making.	Pseudo-anonymous database

S4	Transparency of information leads to privacy problem.	Pseudo-anonymous database
S5	Third authorities such as banks and lawyers are necessity in construction project in certifying documents.	Distributed ledger
S6	Removing involvement of third party is disadvantageous.	Distributed ledger
S7	The engagement of third party incurs unnecessary cost.	Distributed ledger
S8	The information should be synchronized in digital platform in real time.	Timestamped transaction
S9	Delay in transferring information causes disputes or misunderstandings.	Timestamped transaction
S10	Stakeholders do not provide real-time-synchronized information.	Timestamped transaction
S11	Stakeholders are always providing correct information.	Timestamped transaction
S12	Lack of trust prohibits information sharing.	Trust-less system
S13	Third party certification is more likely to be trusted.	Trust-less system
S14	Paper-contract is more reliable than e-contract.	Trust-less system
S15	Late or no-payment always happened in construction industry.	Smart contract
S16	Back-to-back payment causes payment problem.	Smart contract
S17	Payment is better to be generated automatically upon completed works assigned.	Smart contract
S18	Payment is better to be generated directly from client to contractors and suppliers.	Smart contract
S19	Data is unsecured when anyone can modify it even after it is published.	Immutable records
S20	Hacking and Tampering of data is not likely to happen in construction industry.	Immutable records
S21	Lack of awareness prohibits improvement of information security system.	Immutable records
S22	Lack of ability prohibits improvement of information security system.	Immutable records
S23	Current construction supply chain is complex in nature.	Timestamped transaction
S24	Tracking of historical information is difficult in the project.	Timestamped transaction
S25	Proper traceable system improves workflow of project.	Timestamped transaction

Table 3: Results of Experiences Encountered and the Related Blockchain Technology

Statements	Construction Management Practices	Blockchain Technology
P1	Our company always shared information to every member in project team.	Pseudo-anonymous database
P2	Our company was allowed to access to all information regarding to the project.	Pseudo-anonymous database
P3	Our company made poor decision because of insufficient of information.	Pseudo-anonymous database
P4	Our company always experienced privacy problem because of information sharing.	Pseudo-anonymous database
P5	Our company engaged third party such as banks and lawyers to certify our documents.	Distributed ledger
P6	Our company removed involvement of third party.	Distributed ledger
P7	Our company always paid extra cost for the services from third party.	Distributed ledger
P8	Our company updated information to stakeholders in real time.	Timestamped transaction
P9	Our company was involved in disputes because of delay in receiving information.	Timestamped transaction
P10	Our company would prefer to use system that provides real-time-synchronized-information.	Timestamped transaction
P11	Our company provided correct information to stakeholders.	Timestamped transaction
P12	Our company only shared information to others who are trusted.	Trust-less system
P13	Our company trusted documents that have been certified by central authority.	Trust-less system
P14	Our company relied more on paper-contract instead of e-contract.	Trust-less system
P15	Our company always experienced late or no-payment.	Smart contract
P16	Our company always delayed payment to other parties.	Smart contract
P17	Our company would prefer payment method that generates automatically upon completed works.	Smart contract
P18	Our company would prefer payment method that generates directly from client to others.	Smart contract
P19	Our company experienced data being modified even after it was published.	Immutable records

P20	Our company often experienced hacking and tampering of data.	Immutable records
P21	Our company was unaware of importance of security system.	Immutable records
P22	Our company was lack of ability to improve security system.	Immutable records
P23	Our company was involved in construction supply chain which consists of parties from various industries.	Timestamped transaction
P24	Our company was able to track historical information.	Timestamped transaction
P25	Our company had a smooth workflow because of traceable information.	Timestamped transaction

The data collected were tested with reliability test and non-parametric test such as Chi-square test and Extension of Median test. Cronbach's Alpha Reliability test is conducted in order to validate the questionnaire construct. The Chi-square goodness-of-fit test is a non-parametric test to find out the significant difference by comparing the observed sample distribution with expected probability distribution. Extension of median test is non-parametric test, extended version from Mood's Median Test, that used to test whether two or more independent groups have been drawn from a population with the same or different median (Gibbons and Chakraborti, 2010; Daniel, 1990).

RESULTS AND DISCUSSION

A total of 185 sets survey's requests were sent out but only 150 sets data duly filled replies are received and the respondents' demographic details were summarized in Table 4 below.

Table 4: Attributes of Respondents (N=150)

General Information	Categories	Frequency	Percentage (%)
Business Nature	Construction Business	49	32.7
	Property Development	34	22.7
	Consultancy Services	55	36.7
	Others	12	8.0
Profession	Architect	30	20.0
	Engineer	32	21.3
	Quantity Surveyor	57	38.0
	Others	31	20.7
Size of Company	Small (5 to 30 employees)	40	26.7
	Medium (30 to 75 employees)	67	44.7
	Large (>75 employees)	43	28.7

The Cronbach alpha value of reliability tests on the 25 statements of current practices in the construction industry and experiences of respondents encountered in the construction project involved related to the blockchain imperatives are 0.810and .757 respectively as shown in Table 5 indicated that the constructs are internally consistent.

Table 5: Results of Reliability Analysis

Statements	N of items	Cronbanch's Alpha
Perceptions on construction management practices	25	.810
Experiences encountered	25	.757

Table 6 indicates that the Chi-square test results of all the 25 statements on current practices in the construction industry shown statistically significant different by comparing the observed sample distribution with expected probability distribution. All the 25 statements received more than 50% agreements from the respondents with S8 - "*The information should be synchronized in digital platform in real time*" (95%), S25 - "*Proper traceable system improves workflow of project*" (93%), S9 - "*Delay in transferring information causes disputes or misunderstandings*" (90%) and S3 - "*Insufficient of information causes poor decision making*" (90%) received more than 90% of agreement.

Table 6: Results of Perceptions on Construction Management Practices and Related Blockchain Technology

Statement	1	2	3	4	5	6	7	Agree (≥5)	Chi-square	Sig.	Blockchain Technology
S8	0	1	0	7	31	84	27	142 (94.7%)	155.200	0.000	Timestamped transaction
S25	0	1	1	8	22	77	41	140 (93.3%)	176.400	0.000	Timestamped transaction
S9	0	1	1	12	28	77	30	135 (90.0%)	162.640	0.000	Timestamped transaction
S3	0	0	2	13	20	86	29	135 (90.0%)	143.667	0.000	Pseudo-anonymous database
S17	0	0	3	13	21	46	67	134 (89.3%)	90.800	0.000	Smart contract
S5	0	1	1	16	22	86	24	132 (88.0%)	198.560	0.000	Distributed ledger
S19	0	2	6	12	35	73	22	130 (86.7%)	138.880	0.000	Immutable records
S12	0	2	4	14	36	78	16	130 (86.7%)	164.080	0.000	Trust-less system
S18	0	6	11	9	14	50	60	124 (82.7%)	111.360	0.000	Smart contract
S15	0	1	10	15	26	66	32	124 (82.7%)	105.280	0.000	Smart contract
S5	0	1	4	22	33	61	29	123 (82.0%)	96.080	0.000	Transparent database
S22	3	6	9	9	42	66	15	123 (82.0%)	155.760	0.000	Immutable records
S13	0	1	10	20	28	76	15	119 (79.3%)	141.440	0.000	Trust-less system
S6	0	2	4	26	45	41	32	118 (78.7%)	67.040	0.000	Distributed ledger
S23	0	2	5	26	26	74	17	117 (78.0%)	135.840	0.000	Timestamped transaction
S14	0	4	14	18	26	54	34	114 (76.0%)	61.360	0.000	Trust-less system

S10	0	4	7	26	41	51	21	113 (75.3%)	68.560	0.000	Timestamped transaction
S21	1	7	16	13	25	78	10	113 (75.3%)	189.920	0.000	Immutable records
S24	0	7	22	12	42	49	18	109 (72.7%)	56.640	0.000	Timestamped transaction
S4	1	10	8	22	46	41	22	109 (72.6%)	80.067	0.000	Pseudo-anonymous database
S1	2	6	21	14	23	58	26	107 (71.3%)	94.813	0.000	Pseudo-anonymous database
S7	0	7	18	20	45	52	8	105 (70.0%)	72.640	0.000	Distributed ledger
S2	2	8	20	16	32	45	27	104 (69.3%)	60.093	0.000	Pseudo-anonymous database
S20	3	10	12	26	56	37	6	99 (66.0%)	105.267	0.000	Immutable records
S16	0	9	14	28	51	34	14	99 (66.0%)	50.560	0.000	Smart contract
S11	2	8	19	28	31	55	7	93 (62.0%)	94.907	0.000	Timestamped transaction

Noted: 1: Strongly Disagree, 2: Disagree, 3: Slightly Disagree, 4: Neutral, 5: Slightly Agree, 6: Agree, 7: Strongly Agree

Table 7 indicates that the Chi-square test results of all the 25 statements related to the experiences encountered in the construction project involved are statistically significant different by comparing the observed sample distribution with expected probability distribution. 19 out of 25 statements received more than 50% agreements from the respondents with P13 - "*Our company trusted documents that have been certified by central authority*" (96%), P11 - "*Our company provided correct information to stakeholders*" (93%), P25 - "*Our company had a smooth workflow because of traceable information*" (92%). The statement received less than 50% approval are: P16 - "*Our company always delayed payment to other parties*" (47%), P4 - "*Our company always experienced privacy problem because of information sharing*" (39%), P2 - "*Our company was allowed to access to all information regarding to the project*" (39%), P20 - "*Our company often experienced hacking and tampering of data*" (39%), P19 - "*Our company experienced data being modified even after it was published*" (33%) and P6 - "*Our company removed involvement of third party*"(9%).

Table 7: Results of Experiences Encountered and Related Blockchain Technology

Statement	1	2	3	4	5	6	7	Agree (≥5)	Chi-square	Sig.	Blockchain Technology
P13	0	1	0	5	29	101	14	144 (96.0%)	225.467	0.000	Trust-less system
P11	0	0	1	10	41	68	30	139 (92.7%)	93.533	0.000	Timestamped transaction
P25	1	2	3	6	36	88	14	138 (92.0%)	283.347	0.000	Timestamped transaction
P14	0	0	6	10	18	77	39	134 (89.3%)	113.667	0.000	Trust-less system

P10	1	0	3	12	33	79	22	134 (89.3%)	168.720	0.000	Timestamped transaction
P23	0	1	6	11	36	92	4	132 (88.0%)	247.360	0.000	Timestamped transaction
P17	0	1	2	16	11	97	23	131 (87.3%)	262.800	0.000	Smart contract
P5	0	1	5	13	28	94	9	131 (87.3%)	245.840	0.000	Distributed ledger
P9	1	5	4	10	39	78	13	130 (86.7%)	219.413	0.000	Timestamped transaction
P15	1	1	10	15	45	57	21	123 (82.0%)	131.960	0.000	Smart contract
P3	0	2	8	19	27	88	6	121 (80.7%)	207.520	0.000	Pseudo-anonymous database
P21	6	6	7	12	30	81	8	119 (79.3%)	213.533	0.000	Immutable records
P12	0	7	16	11	46	52	18	116 (77.3%)	72.800	0.000	Trust-less system
P18	0	11	10	16	11	75	27	113 (75.3%)	128.080	0.000	Smart contract
P22	3	14	14	11	41	49	18	108 (72.0%)	79.973	0.000	Immutable records
P1	0	9	19	15	54	50	4	108 (72.0%)	92.480	0.000	Pseudo-anonymous database
P7	0	3	8	35	33	68	3	104 (69.3%)	130.800	0.000	Distributed ledger
P8	0	6	25	22	61	31	5	97 (64.7%)	84.080	0.000	Timestamped transaction
P24	2	13	37	26	41	31	6	78 (52.0%)	67.467	0.000	Timestamped transaction
P16	8	22	25	25	48	16	6	70 (46.7%)	55.053	0.000	Smart contract
P4	6	21	32	32	30	22	7	59 (39.3%)	34.707	0.000	Pseudo-anonymous database
P2	7	31	34	19	29	24	6	59 (39.3%)	35.733	0.000	Pseudo-anonymous database
P20	13	30	31	18	23	31	4	58 (38.7%)	30.133	0.000	Immutable records
P19	2	31	39	28	24	24	2	50 (33.3%)	56.547	0.000	Immutable records
P6	29	59	32	17	6	6	1	13 (8.7%)	116.373	0.000	Distributed ledger

Noted: 1: Strongly Disagree, 2: Disagree, 3: Slightly Disagree, 4: Neutral, 5: Slightly Agree, 6: Agree, 7: Strongly Agree

Distributed Ledger

The trust problem has been around since beginning of time. People has to cooperate with each other in order to progress. However, when people are doing collectively, they tend to open themselves being deceived,

misled, and subsequently disappointed. Hence, societies have instituted trusted third party to address the trust problem (Bambara and Allen, 2018). This type of centralised way to solve the trust problem is reflected in the result shown in Table 6 above, where 88% of the respondents agreed that "*Third authorities such as banks and lawyers are necessity in construction project in certifying documents*" (S5). Similarly, 78.7% of the respondents agreed that "*Removing involvement of third party is disadvantageous*" (S6), even though "*The engagement of third party incurs unnecessary cost"* are agreed by 70% of the respondents. 87% of the respondents' companies experienced "*engaged third party such as banks and lawyers to certify our documents*" (P5) and 69% always experienced "*paid extra cost for the services from third party*" (P7) as shown in Table 7.

Blockchain Technology provides an alternatives to solve the trust problem. It uses a distributed ledger (or shared ledger) and combining this with a consensus methodology. A single copy of each transaction is send to all parties in the network instead of logging transactions with a single third party. All parties in the network would have to keep an ongoing ledger of all transactions and each party in the network would have the exact same set of transactions (Bambara and Allen, 2018).

Trust-less System

Blockchain technology is often referred to as a trust-less system. There is no need to place any trust in any human interaction because everything is taken care by the platform technology. The participants on the network need to give up their computing resources to this process (Bambara and Allen, 2018). However the result in Table 6 shown that 87% of the respondents agreed that "*Lack of trust prohibits information sharing*" (S12), 79% of them concurred that "*Third party certification is more likely to be trusted*" (S13) and 76% consented "*Paper-contract is more reliable than e-contract*" (S14). In practice, 96% of the respondents' companies *"…trusted documents that have been certified by central authority*" (P13), 89% of the respondents' companies *"…relied more on paper-contract instead of e-contract*" (P14) and 77% of the respondents' companies *"…only shared information to others who are trusted*" (P12).

Timestamped Transaction

95% of the respondents opined that "*The information should be synchronized in digital platform in real time*" (S8) and 90% and 75% of them concurred that "*Delay in transferring information causes disputes or misunderstandings*" (S9) and "*Stakeholders do not provide real-time-synchronized information*" (S10) respectively (Table 6). Only 52% of the respondents agreed that their companies "*was able to track historical information*" (P24), although 92% of them claimed that their companies "*had a smooth workflow because of traceable information*" (P25) as shown in Table 7.

Blockchain maintains a doubly linked list of ordered blocks. Each block contains control data such as a timestamp, a link to a previous block, some other fields. The blocks once recorded are designed to be resistant to modification; the data in a block cannot be altered retroactively. The network timestamps transactions by hashing them into an ongoing chain of hash-based proof-of-work, forming a record that cannot be changed without redoing the proof-of-work. By a peer-to-peer network and a distributed timestamping server, a public blockchain database is managed autonomously (Bambara and Allen, 2018).

Immutable Records

87% of the respondents agreed that "*Data is unsecured when everyone can modify it even after it is published* (S19), although 66% opined that "*Hacking and tampering of data is not likely to happen in construction industry*" (S20) (Table 6). However, in practice, 39% of the respondents' companies experienced "*hacking and tampering of data*" (P20) and 33% of respondents experienced "*data being modified even after it was published*" (P19) as shown in Table 7. 79% and 72% of the respondent's companies were "*unaware of importance of security system*" (P21) and "*lack of ability to improve security system*" (P22) respectively (Table 7).

Blockchain technology has a potential to overcome this issue. The block validation system is designed to be immutable. Once the block is part of the blockchain it is an immutable record, i.e., none of the transactions can be changed, the transaction entry in it is permanent. All transactions old and new are preserved forever with no ability to delete. Anyone on the network can browse via a designated website and see the ledger. This provides a way for all participants to have an up-to-date ledger that reflects the most recent transactions or changes. In this way, blockchain establishes trust, which as we shall see facilitates transactions and brings many cost-saving efficiencies to all types of transactional interactions (Bambara and Allen, 2018).

Pseudo-anonymous database

90% of the respondents agreed that "*insufficient of information causes poor decision making*" (S3), 83% of the respondents concurred that "*transparency of information prevents corruption*" (S5), however, 73% of the respondents also concerned "*transparency of information leads to privacy problem*" (S4). There are 71% and 69% of the respondents opined all information regarding to project should be *"transparent to whole project team*" (S1) and "*accessible by whole project team*" (S2) respectively (Table 6).

Table 7 shows that 81% of the respondents' companies experienced "*making poor decision because of insufficient of information"* (P3), 72% "*always shared information to every member in project team*" (P1); however, only 39% of the respondents' companies "*allowed to access to all information regarding to the project*" (P2) and "*always experienced privacy problem because of information sharing*" (P4) (Table 7).

The blockchain is pseudo-anonymous database. The identity of those involved in the transaction is represented by an address key in the form of a random string. Different types or categories of blockchain have emerged, such as public, private, and even hybrid blockchains. Public blockchains can be accessed and updated by everyone, private blockchains can be accessed and updated by a limited group within an organization. The third kind of blockchains, a consortium of blockchains, are used in collaboration with others. The consortium facilitated trades at an institutional level among the members (Bambara and Allen, 2018).

Transparency is providing the right information to the right people. Transparency and truth seeking are complementary characteristics of trust. Transparency asks the question: can we see it? Truth asks: can we verify it? Blockchains offers truth and transparency as a base layer. Blockchain technology offers a degree of transparency and access to truth that can prevent breaches of trust. Blockchain technology promises to serve up and expose transparency in its rawest forms. Providing more transparency about their trust layers, organizations would fail less, not just because they will be more on guard, or fear getting questioned, but because they can decentralize their potential failures, and enabling early warning systems, and consequently, that should result in lowering their overall risks (Mougayar, 2016).

Smart Contract

89% and 83% agreed that payment is better to be generated "*automatically upon completed works assigned*" (S17) and "*directly from client to contractors and suppliers*" (S18). Another 83% agreed that "*Late or no-payment always happened in construction industry*" (S15). In practice, 87% and 75% of respondents' company would prefer payment method that generates "*automatically upon completed works*" (P17) and "*directly from clients to others*" (P18) respectively. 82% of the respondents'' companies experienced "*always late or no-payment*" (P15). However, 46% of the respondents' companies "*always delayed payment to other parties*" (P16).

Smart contracts are a key underpinning of blockchain technology. Smart contracts help make the breach of an agreement expensive because they control a real-world valuable property via "digital means." So, a smart contract can enforce a functional implementation of a requirement and can show proof that certain conditions were met or not met. Smart contracts, being computer programs, are just the enabling technology, but the consequence of their actions can be made part of a legal agreement. A smart contract outcome could be used as an audit trail to prove if terms of legal agreement were followed or not. Smart contracts are software code representing business logic that runs a blockchain, and they are triggered by some external data that lets them modify some other data. They are closer to an event-driven construct, more than artificial intelligence. Smart contracts are usually part of a decentralized (blockchain) application. There could be several contracts to a specific application. Smart contracts are ideal for interacting with real-world assets, smart property, Internet of Things (IoT), and financial services instruments. They are not limited to money movements. They apply to almost anything that changes its state over time and could have a value attached to it (Mougayar, 2016).

CONCLUSION

In a nutshell, the study shows that the construction practitioners agreed that '*information should be synchronized in digital platform in real time*' with '*proper traceable system* [to] *improves workflow of project'*, Any '*delay in transferring information causes disputes or misunderstandings*' and '*insufficient of information causes poor decision making*'. There are more than a third of the respondents' organisation '*delayed payment to other parties*', '*always experienced privacy problem because of information sharing*', '*allowed to access to all information regarding to the project*', '*often experienced hacking and tampering of data and experienced data being modified even after it was published*'. Blockchain technology enable transparency of information

and access to truth that can prevent breaches of trust with its pseudo-anonymous database. In addition, the timestamp transactions, forming a record that cannot be changed without redoing the proof-of-work. The block validation system preserves immutable permanent records. The ability of smart contract in enforcing a functional implementation of a requirement can pre-empt late and no-payment issues in the construction industry.

Nevertheless, there are more than 90% of the respondents' company trusted documents that have been certified by central authority, which reflects that the industry is very much accustomed to third party certification in solving the trust problem. This poses the greatest hindrance towards the successful adoption of blockchain technology in the construction industry.

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