Using Blockchain as a Project Management Device

استخدام سلسلة البلوك كجهاز لإدارة المشروع

by

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ABSTRACT

Blockchain technology is a revolutionary computing innovation. Blockchain technology allows people and companies to make agreements and store information safely without a middleman or entity (Novotny, 2018). It is groundbreaking technology that changes the communication methods of people and organizations across borders. Hence, the aim of this research is to propose an integrated framework for introducing Blockchain technology in the Project Management profession. The paper focuses on the using and applying blockchain tech in construction PM practices.

This research paper proposes using blockchain technology in the construction field using the smart contract functionalities. It is expected that the blockchain- based solutions and platforms can make significant contributions to construction projects. The goal is to illustrate how UAE construction companies can implement blockchain technology, to create value addition and other improvements to overcome obstacles facing the industry. The research findings showed that PM can be Impacted by the introduction of Blockchain Technology, especially via smart contract functionalities. It also shows that blockchain smart contracts can be used in certain areas of PM.

Overall, Nakamoto creates an amazing P2P system that lets users transfer Bitcoin directly, which does not need the presence of an intermediate figure. The focus is to minimize the broken trust digitally, with the concept of the blockchain. Some people believe that blockchain can move societies to operate digitally. It is a blend of old technologies already existing for a long time. For example, smart contracts are a blockchain based solution that involves linking applications to blockchain (Risius & Spohrer, 2017). It is architecturally decentralized, in the Blockchain. Blockchain is a groundbreaking technology that changes

the communication methods of people and organizations across borders. a private blockchain is an invitation-only network governed by a single entity (Yang et al, 2020). Participants would need to gain permission into the network, to access the blockchain.

In this paper, a blockchain-based model is used to show that a Blockchain infrastructure can be applied in Project Management (PM). The model is based private cloud infrastructure (i.e. private blockchain). In other words, the characteristics are established on access control mechanisms, regarding sharing project information (Erhan et al, 2019). With this infrastructure, a company has control over who has access to project aspects (Erhan et al, 2019). It can also disperse any or all parts of project information (Erhan et al, 2019). Since it is blockchain-based, carrying out obligations does not require a managing authority. Hence, the data and information are under the authority of the data owner and the sharing of data cannot be altered or removed, without the permission of the project owner (Erhan et al, 2019).

Furthermore, the greater demand for blockchain technology justifies the need for block-chain based solutions, such as smart contracts because these solutions are more effective and dependable approaches that can modernize construction PM, especially in the UAE. For this reason, this study can help researchers further uncover critical areas in construction PM that were deemed too complicated or unexplorable to integrate with blockchain technology. Overall, researchers will be informed and guided (by the recommended approaches derived from the research findings) on what factors should be emphasized, to further incorporate blockchain-based solutions into various UAE industries.

It is important to have an effective information platform that can 1) gather project information; and 2) provide information (from planning to closing) to relevant parties (Teresko, 2004). It also key that this ‘platform’ allows information to be open, transparent,

and comprehensive, especially for complex projects (Teresko, 2004). This is where the technological power of blockchain technology and block-chain based solutions can revolutionize project management.

This research paper proposes applying blockchain technology in construction projects through smart contract functionalities. It is expected that the blockchain- based solutions and platforms can make significant contributions to construction projects. The research methodology utilizes the use of both secondary and primary sources.

It applies a literature review approach, which involved finding and identifying relevant articles related to the topic, to review and analyze. It also utilizes a survey questionnaire to gain more insight into the overall attitudes towards the technology. Specifically, it measures attitudes and investments about using blockchain in the UAE. The research paper examines the impact of blockchain technology on project management practices in three phases. First, it discusses the fields of Construction and Project Management (PM) before the creation and evolution of blockchain technology.

Second, it examines the project life cycle & standard PM approach as well as the effective implementation of life cycle management (LCM) in construction projects. Third, it conveys that the applying blockchain in the construction industry means improving PM. The goal is to illustrate how UAE construction companies can implement blockchain technology, to create value addition and other improvements to overcome obstacles facing the industry.

نبذة مختصرة

تقنية سلسلة الكتل هي ابتكار حوسبي ثوري. تسمح تقنية سلسلة الكتل للأشخاص والشركات بإبرام اتفاقيات وتخزين المعلومات بأمان دون وسيط أو كيان (Novotny، 2018). إنها تقنية رائدة تعمل على تغيير طرق الاتصال للأشخاص والمنظمات عبر الحدود. ومن ثم، فإن الهدف من هذا البحث هو اقتراح إطار عمل متكامل لإدخال تقنية سلسلة الكتل في مهنة إدارة المشاريع. تركز الورقة على استخدام وتطبيق تقنية سلسلة الكتل في ممارسات إدارة المشاريع الإنشائية.

تقترح هذه الورقة البحثية استخدام تقنية سلسلة الكتل في مجال البناء باستخدام وظائف العقود الذكية. من المتوقع أن تقدم الحلول والمنصات المستندة إلى سلسلة الكتل مساهمات كبيرة في مشاريع البناء. الهدف هو توضيح كيف يمكن لشركات البناء الإماراتية تنفيذ تقنية سلسلة الكتل، لإنشاء قيمة مضافة وتحسينات أخرى للتغلب على العقبات التي تواجه الصناعة. أظهرت نتائج البحث أن PM يمكن أن يتأثر بإدخال تقنية سلسلة الكتل، خاصة عبر وظائف العقود الذكية. كما يوضح أنه يمكن استخدام عقود سلسلة الكتل الذكية في مناطق معينة من PM.

بشكل عام، أنشأ ناكاموتو نظام P2P مذهلاً يتيح للمستخدمين نقل البتكوين مباشرةً، والذي لا يحتاج إلى وجود رقم وسيط. ينصب التركيز على تقليل الثقة المكسورة رقميًا، من خلال مفهوم سلسلة الكتل. يعتقد بعض الناس أن سلسلة الكتل يمكن أن يدفع المجتمعات للعمل رقميًا. إنه مزيج من التقنيات القديمة الموجودة بالفعل لفترة طويلة. على سبيل المثال، العقود الذكية عبارة عن حل قائم على سلسلة الكتل يتضمن ربط التطبيقات بـ سلسلة الكتل (Spohrer & Risius، 2017). إنه لامركزي معماريًا في سلسلة الكتل .سلسلة الكتل هي تقنية رائدة تعمل على تغيير طرق الاتصال للأشخاص والمؤسسات عبر الحدود. سلسلة الكتل الخاص عبارة عن شبكة مدعوة فقط يحكمها كيان واحد (Yang et al، 2020). سيحتاج المشاركون إلى الحصول على إذن للدخول إلى الشبكة للوصول إلى سلسلة الكتل.

في هذا البحث، يتم استخدام نموذج قائم على سلسلة الكتل لإظهار أنه يمكن تطبيق البنية التحتية لـ سلسلة الكتل في إدارة المشاريع (PM). يعتمد النموذج على البنية التحتية السحابية الخاصة (أي سلسلة الكتل الخاصة). بمعنى آخر، يتم تحديد الخصائص على آليات التحكم في الوصول، فيما يتعلق بمشاركة معلومات المشروع (Erhan et al، 2019). من خلال هذه البنية التحتية، تتحكم الشركة فيمن يمكنه الوصول إلى جوانب المشروع (Erhan et al، 2019). يمكنه أيضًا تفريق أي جزء من معلومات المشروع أو كلها (Erhan et al، 2019). نظرًا لأنه قائم على سلسلة الكتل، فإن تنفيذ الالتزامات

لا يتطلب سلطة إدارية. وبالتالي، تخضع البيانات والمعلومات لسلطة مالك البيانات ولا يمكن تغيير أو إزالة مشاركة البيانات، دون إذن صاحب المشروع (Erhan et al، 2019).

علاوة على ذلك، فإن الطلب المتزايد على تقنية سلسلة الكتل يبرر الحاجة إلى حلول قائمة على سلسلة الكتل، مثل العقود الذكية لأن هذه الحلول هي نهج أكثر فعالية ويمكن الاعتماد عليها ويمكنها تحديث إدارة المشاريع الإنشائية، خاصة في الإمارات العربية المتحدة. لهذا السبب، يمكن أن تساعد هذه الدراسة الباحثين في اكتشاف المزيد من المجالات الحرجة في PM البناء التي تم اعتبارها معقدة للغاية أو لا يمكن استكشافها للتكامل مع تقنية سلسلة الكتل. بشكل عام، سيتم إعلام الباحثين وتوجيههم (من خلال النهج الموصي بها المستمدة من نتائج البحث) حول العوامل التي يجب التأكيد عليها، لمزيد من دمج الحلول القائمة على سلسلة الكتل في مختلف الصناعات الإماراتية.

من المهم أن يكون لديك منصة معلومات فعالة يمكنها 1) جمع معلومات المشروع؛ 2) تقديم المعلومات (من التخطيط إلى الإغلاق) للأطراف ذات الصلة (Teresko، 2004). من المهم أيضًا أن تسمح هذه "المنصة" للمعلومات بأن تكون مفتوحة وشفافة وشاملة، خاصة بالنسبة للمشاريع المعقدة (Teresko، 2004). هذا هو المكان الذي يمكن أن تحدث فيه القوة التكنولوجية لتقنية سلسلة الكتل والحلول القائمة على سلسلة الكتل ثورة في إدارة المشروع.

تقترح هذه الورقة البحثية تطبيق تقنية سلسلة الكتل في مشاريع البناء من خلال وظائف العقود الذكية. من المتوقع أن تقدم الحلول والمنصات المستندة إلى سلسلة الكتل مساهمات كبيرة في مشاريع البناء. تستخدم منهجية البحث استخدام كل من المصادر الثانوية والأولية. يطبق منهج مراجعة الأدبيات، والذي تضمن إيجاد وتحديد المقالات ذات الصلة بالموضوع، لمراجعتها وتحليلها. كما أنه يستخدم استبيان المسح لاكتساب المزيد من التبصر في المواقف العامة تجاه التكنولوجيا. على وجه التحديد، يقيس المواقف والاستثمارات حول استخدام سلسلة الكتل في الإمارات العربية المتحدة. تدرس الورقة البحثية تأثير تقنية سلسلة الكتل على ممارسات إدارة المشروع في ثلاث مراحل. أولاً، يناقش مجالات البناء وإدارة المشاريع (PM) قبل إنشاء وتطوير تقنية سلسلة الكتل.

ثانيًا، يفحص دورة حياة المشروع ونهج PM القياسي بالإضافة إلى التنفيذ الفعال لإدارة دورة الحياة (LCM) في مشاريع البناء. ثالثًا، يشير إلى أن تطبيق سلسلة الكتل في صناعة البناء يعني تحسين PM. الهدف هو توضيح كيف يمكن لشركات البناء الإماراتية تنفيذ تقنية سلسلة الكتل، لإنشاء قيمة مضافة وتحسينات أخرى للتغلب على العقبات التي تواجه الصناعة.

DEDICATION

I dedicate my dissertation work to my family. A special feeling of gratitude to my loving parents, Rafea Al Tekreeti and Ihan Attallah whose words of encouragement always ring in my ears. My brother Sarmad Al Tekreeti and my sister Samar Al Tekreeti who are always by my side and are very special.

ACKNOWLEDGMENT

I would like to express my gratitude to my advisor, Dr. Maria Papadaki whose sincerity and encouragement I will never forget. This thesis would not have been possible without Dr. Maria, whose guidance from the initial step in research enabled me to develop an understanding of the subject. I am thankful for the extraordinary experiences she arranged for me and for providing opportunities for me to grow professionally.

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1. INTRODUCTION

Blockchain technology is a revolutionary computing innovation. It is a distributed database (or ledger) that is stored in multiple locations (using cloud technology), usually by different entities on the network (Zheng et al, 2017). According to Downes & Reed (2018), the primary purpose of distributed ledgers is to store information, proof of transactions, which includes asset rights and records of all actions and sides. Blockchain allows the (old) traditional transactional models to change. For instance, the traditional multilateral model requires that registries be stored in a single, central location (Downes & Reed, 2018).

This 'typical' transaction is based on trust in an authoritative intermediary. However, blockchain technology allows the elimination of the 'middleman'. In fact, the use of a 'middleman' to control, access and disclose information could lead to irregular information flows and reduced transaction transparency. Data can also become vulnerable to malicious actions (e.g., hacking) or destructive events (e.g., natural disasters) (Downes & Reed, 2018). Thus, this traditional model is inefficient because the use of intermediaries involves longer processing times and increased costs (Downes & Reed, 2018).

Blockchain allows for the revamping and alteration of the former models and systems. For example, using blockchain, parties can transact directly (peer-to-peer) and rely on the technical immutability of the ledger to provide the trust previously established by authoritative third parties (Downes & Reed, 2018). A blockchain is made up of two main parts: a decentralized system, and an unalterable ledger in this system (Atlam et al, 2018). It is possible for all parties in the network to view the combined record. **Figure 1 (See Below)** depicts an overview of centralized versus decentralized blockchain network.

Figure 1: Distributed vs Centralized vs Decentralized Network

Distributed

- ***All nodes are independent and interconnected with each other***

Centralized

- ***All nodes associated to one server***

Decentralized

- ***Nodes not controlled by one master (individual entry)***

As seen in **Figure 1**, there is no single organization (or authority) controlling that data, due to the decentralized trust. In other words, there are no outside persons acting as online overseers.

Blockchain can support different forms of operations (Downes & Reed, 2018). For example, smart contracts use the blockchain technology to lessen setbacks, intrusions and to lessen documentation in contract making (Mancone, 2018). Smart contracts explain the guidelines and consequences for agreements, but unlike traditional contracts, smart contracts automatically carry out these agreements. The contracts are coded, so they are released after completing a certain task or obligation (Hewavitharana et al, 2019).

In addition, blockchain can find and observe digital identities due to the authorization systems used in the technology (Hewavitharana et al, 2019). The distributed data storage

mechanism enables the mitigation of data risk. According to Jiang et al, (2019), blockchain technology connects with distributed IoT devices to get data and distribute this data with member nodes. On the other hand, some drawbacks exist in blockchain technology. For one, blockchain-based technologies, such as mining or creating blocks, consumes vast amounts of electric energy and computing power in the process. In addition, blockchain technology does not simply allow the overwriting or changing of data, so this limits the flexibility of correcting errors (if wrong data was inserted).

It is a relatively new technology, so it is difficult to make and apply blockchain-based solutions. Overall, it is still a very long way before blockchain technology can fully replace other traditional software solutions. Regardless, it is unlikely that another upcoming venture has been more hyped and advertised than blockchain technology. In fact, many companies worldwide have begun to invest in the technology. For example, Samsung recently joined forces with Blocko, which would permit the credit cards to operate based on blockchain technology (Morabito, 2017).

Blocko is a commercial blockchain infrastructure provider (*About Blocko*, 2020). It is a blockchain specialized technology company that concentrates on enterprise-IT integration and cloud deployment (*About Blocko,* 2020). Blocko develops blockchain solutions that helps enterprises to use blockchain in a variety of ways. In this case, Blocko partnered with Samsung to build a blockchain credit management system because Samsung intends to invest in new business ventures digitally, regarding money and payment (Morabito, 2017).

Blockchain is a groundbreaking technology that has impacted businesses across varying industries worldwide. It presents a trusted and transparent infrastructure that shapes

the boundaries between the physical, digital, and biological worlds. For example, several startup companies use blockchain tech for various operations, including making payments and tracking sales. Other companies, such as Microsoft and IBM, use the blockchain cloud infrastructure to create specialized blockchains for clients (Morabito, 2017).

Blockchain technology enables companies and organizations to do business with one another more easily, with blockchain-based solutions, such as smart contracts, cloud storage and other instruments encoded within a common platform. Hence, we need to consider the integration of blockchain technology into the construction business. It is on the verge of enhancing its efficiency and productivity with new, digital technologies.

Hence, blockchain is the latest technology that can revolutionize the digitalization of the construction industry. In construction project management especially, blockchain can help make processes more cost-effective, transparent, and improve accountability between all sides. In fact, there is a high probability that blockchain technologies can positively change and evolve current project management practices. It is important for project management to succeed because it is considered as the 'nerve' of construction projects. For this reason, we have to look at the role that blockchain can play in project management practices in construction.

Blockchain is a technology that lets people and organizations to achieve agreements as well as store transactions and data transparently, without an intermediary (Novotny, 2018). It can be used to create a fair, wide-ranging, reliable, and autonomous digital economy. It is simply a type of diary with information about transactions. It is a very secure system because the Blockchain updates itself every 10 minutes (Shackelford & Myers, 2017). The Blockchain becomes a database, whereby every node has access to the chain. Hence, it is

almost impossible to fake a block as it needs to be valeted by other nodes. (Shackelford & Myers, 2017).

Blockchain's security is top-notch because it is encrypted and decentralized. There are thousands of these nodes scattered worldwide, so trying to capture (or mimic) the system needs incredible computer power. Overall, Blockchain is a ledger of transactions that automatically verifies itself (Novotny, 2018). No single node (or computer) controls the data. They can however confirm the ledger, without the use of intermediaries to control or regulate (Novotny, 2018). It is architecturally decentralized, in the Blockchain. Blockchain is a groundbreaking technology that changes the communication methods of people and organizations across borders.

Blockchain is a connective intelligence that entails apps, data, concepts, and people being connected by a decentralized system that does not require intermediaries to protect or store data (Lee, 2019). Overall, blockchain technology represents a tectonic change in the world of business. The technology will transform the culture of how businesses and organizations interact in the digital world. The research paper focuses on the applying and using blockchain in the UAE construction industry. The findings of this study can benefit the UAE considering that the construction industry and blockchain technology are fast becoming natural partners in this technological revolution. Thus, the resulting framework will consist of strategies and practices that could be used to enhance construction project management (PM). It is a perfect illustration of how UAE construction companies can form strategic alliances with blockchain tech firms, to create value addition and other improvements to overcome obstacles facing the industry.

Furthermore, the greater demand for blockchain technology justifies the need for block-chain based solutions, such as smart contracts because these solutions are more effective and dependable approaches that can modernize construction PM, especially in the UAE. For this reason, this study can help researchers further uncover critical areas in construction PM that were deemed too complicated or unexplorable to integrate with blockchain technology. Overall, researchers will be informed and guided (by the recommended approaches derived from the research findings) on what factors should be emphasized, to further incorporate blockchain-based solutions into various UAE industries.

Hence, this research paper focuses on the applicability and implementation of blockchain in the construction industry. Specifically, the research paper focuses on strategies and practices that could be used to enhance Construction Project Management (PM). The paper discusses the history and evolution of Blockchain technology, from the publishing of Nakamoto's 'White Paper' to the emerging innovations that excelled beyond Bitcoin. It describes the key principles of blockchain and how the blockchain (BC) technology works. The paper presents blockchain technology via smart contracts as a key technique to enhance building projects.

The proposed conceptual model is based on private cloud infrastructure (i.e. private blockchain) because the level of analysis is organizational. In other words, the characteristics are established on access control mechanisms, regarding sharing project information. The theoretical framework is also expanded on, based on the implementation process of BC-based solutions, such as smart contract functionalities. Overall, the aim of this research is to propose an integrated framework for introducing Blockchain technology in the Project Management

profession. The resulting framework will consist of strategies and practices that could be used to enhance Project Management. The research question for this paper is as follows:

RQ 1 - Will PM be Impacted by the introduction of Blockchain Technology?

RQ 2 - Which areas of PM will have the potential of using blockchain technology?

Hypotheses:

H1: There is a strong impact on using block chain smart contracts in construction.

H2: There is a strong impact on using block chain smart contracts on PM practices

H3: There is a strong impact on using block chain smart contracts on construction PM

This research paper proposes applying blockchain technology in construction projects through smart contract functionalities. It is expected that the blockchain- based solutions and platforms can make significant contributions to construction projects. The research methodology utilizes the use of both secondary and primary sources.

It applies a literature review approach, which involved finding and identifying relevant articles related to the topic, to review and analyze. It also utilizes a survey questionnaire to gain more insight into the overall attitudes towards the technology. Specifically, it measures attitudes and investments about using blockchain in the UAE. The research paper examines the impact of blockchain technology on project management

practices in three phases. First, it discusses the fields of Construction and Project Management (PM) before the creation and evolution of blockchain technology.

Second, it examines the project life cycle & standard PM approach as well as the effective implementation of life cycle management (LCM) in construction projects. Third, it conveys that the applying blockchain in the construction industry means improving PM. The goal is to illustrate how UAE construction companies can implement blockchain technology, to create value addition and other improvements to overcome obstacles facing the industry.

2. LITERATURE REVIEW

2.1 Fast-growing technology

The aim of this research is to propose an integrated framework for introducing Blockchain technology in the Project Management profession. Hence, the paper focuses on the applying and implementing blockchain in PM practices. Thus, this section of the paper discusses the history and evolution of Blockchain technology, from the publishing of Nakamoto's 'White Paper' to the emerging innovations that excelled beyond Bitcoin.

Satoshi Nakamoto 'White Paper' began a revolution in the world of fintech. Nakamoto collaborated others to create the popular invention, Bitcoin. There is plenty of speculation about the identity (e.g. nationality, gender) of Nakamoto, but none have been confirmed to be true or factual. Furthermore, Bitcoin's white paper redefines the definition of money, as we know it. For example, the paper discusses a crucial case concerning new online payment systems (Nakamoto, 2008).

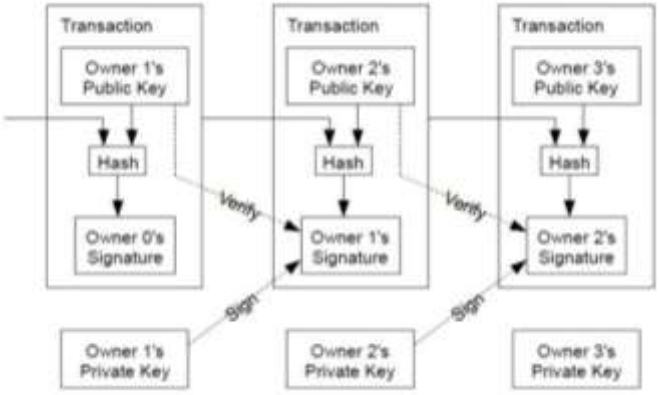
Currently, people connect bank accounts and cards, or use PayPal, to make payments online. Specifically, third-party authority figures make sure that services provided are done correctly (Nakamoto, 2008). However, avoiding disputes is one of the main problems arising from third parties. For instance, merchants cannot be sure that payment for services is always guaranteed, so they tend to require sensitive information from customers (Nakamoto, 2008). For this reason, Nakamoto (2008) stresses on the importance of having an automated payment system without the 'middleman'.

This new electronic system would enable the two sides to deal with one another directly without a 'middleman' or third party. (Nakamoto, 2008). Therefore, the 'third party'

(i.e. middleman) is replaced with an absolute chain of deals that require computational proof to validate as well as many connected peers prompted to keep the same records (Nakamoto, 2008). In addition, Nakamoto introduces the concept of the 'coin' in this paper. According to Nakamoto (2008), Bitcoin is defined as, "a chain of digital signatures". In other words, an electronic coin (e.g. bitcoin) is a chain of digital signatures.

Figure 2 (See below) depicts the nature and method of transferring cryptocurrency, such as Bitcoin, in a P2P Network.

Figure 2: 'Coin' Transaction through a P2P Network



Source: Nakamoto (2008)

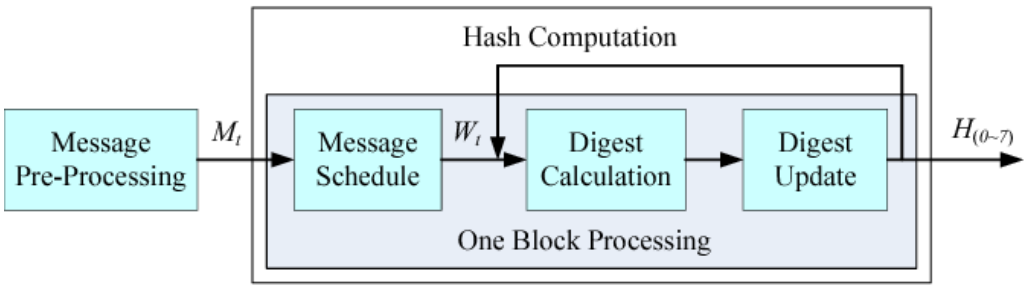
As seen in **Figure 2**, you can own a bitcoin when you by signing its unique hash on the blockchain, which can only be done after another peer has sent it to you. After sending, you can check all past signatures through your part, to continue the chain to all Bitcoin's participants (Nakamoto, 2008). Ultimately, peers must verify the ownership of funds using the blockchain. The transaction becomes irreversible once it has been inserted into the blockchain.

Hence, all sides need to agree on the record of the operations, which helps to avoid fraud. This can be done by using timestamps on the transaction (Nakamoto, 2008). It is a

shared transaction log ('ledger') that acts as a timestamp server. Any new timestamp includes the old-time stamp, which creates an entirely certifiable chain of events (Nakamoto, 2008). The paper also introduces the proof of work system, which works with an algorithm that used to verify any operation and make new blockchains.

Figure 3 (See below) depicts a block with a SHA-256 hash algorithm.

Figure 3: SHA-256 Hash Function



Source: Nakamoto (2008)

By representing a block (as a SHA-256 hash), peers need a lot of computer energy to make a similar hash, which is added to the ledger (Nakamoto, 2008).

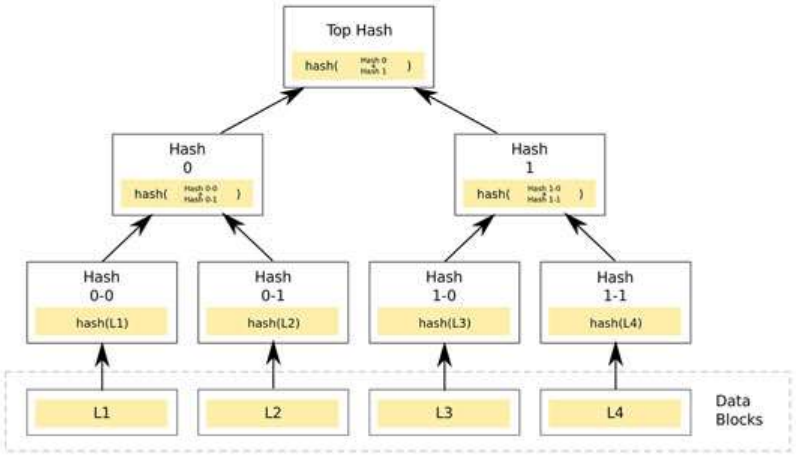
Nodes (i.e. users/computers) work together for verification and continuity, especially to sign a block into the chain. In other words, the nodes must reach a consensus about the new block in the transaction. Nevertheless, the POW is required to achieve this consensus, to make and verify blocks. For this reason, it is very pricey to hack Bitcoin, because the computing resources needed for most blockchains are enormous.

According to Shackelford & Myers (2017), current blockchain designs run on algorithms that can consume a vast amount of energy (up to 215 kWh per transaction. Evidently, blockchain needs large amount of processing power, especially to validate and secure transactions. For example, the bitcoin blockchain uses more processing power

(between 10 and 100 times) than Google's serving farms put together (Shackelford & Myers, 2017). Satoshi Nakamoto anticipated the large 'size' of the blockchain as a potential problem.

Thus, Nakamoto (2008) illustrated the Merkle Tree system to create a chain of referrals back to a root hash. **Figure 4 (See Below)** depicts a Merkle tree, which is a binary hash tree.

Figure 4: A Merkle Tree



Source: Beck (2018)

According to Beck (2018), a Merkle tree is a data structure used in the bitcoin and blockchain technologies to summarize all the transactions in a block. As seen in **Figure 4**, it is made up of numerous hashes, but squeezes all into one, while still being able to verify the data of each specific hash. It summarizes all the transactions in a block, but still possible to check every transaction in a block (Beck, 2018). This structure minimizes the blockchain, which allows less CPU power to be used to process and verify blocks.

Thus, basic devices can have a mini version of the blockchain, to connect as blockchain nodes. In other words, nodes (i.e. devices) can join a Merkle Tree branch, instead

of every hash. They would be able to carry out deals still related to the chain. Moreover, Satoshi also describes how Bitcoin can achieve data privacy for its customers. For example, banks have the power to reduce the amount of transactions, while being the only side with access to users' identities.

However, Bitcoin publishes each transaction in real time, but the users identify each other in the network with a public key while using an associated private key to access coins dispersed to them (Nakamoto, 2008). This way, their identity and transactions are protected. **Figure 5 (See Below)** explains digital signatures (e.g. private key) needed to carry out transactions.

Figure 5: Digital Signatures explained

Source: Beck (2018)

As seen in **Figure 5**, the private key is made up of randomized numbers, that must be kept secret. For example, if 'user X' intends sends to 'user Y', they must sign with the private key (Beck, 2018). Afterwards, the message is sent & broadcasted throughout the blockchain. Thereafter, the nodes analyze the memo to ensure the validity of the transaction. Once confirmed, the transaction transmits on a block, unable to be altered afterwards (Beck, 2018). The system of two keys is a crucial and momentous process (Beck, 2018).

Nevertheless, Nakamoto (2008) stresses more on the (almost) un-hackable nature of Bitcoin. For example, creating a chain to imitate an honest (real) blockchain is futile because it is impossible to make Bitcoin from nothing, so the nodes will automatically reject the false operation (Nakamoto, 2008). Finally, Nakamoto's 'white paper' illustrates that Bitcoin provides a trustworthy and transparent system (Nakamoto, 2008). The system entails the implementation of secure channels, specifically encrypted public channels. Overall, Nakamoto creates an amazing P2P system that lets users transfer Bitcoin directly, which does not need the presence of an intermediate figure. The focus is to minimize the broken trust digitally, with the concept of the blockchain. Some people believe that blockchain can move societies to operate digitally.

Blockchain improves digital trust as it stores unaltered data in a public space that can always be referred to if needed (Beck, 2018). This exposure makes fraud & deception more difficult. It is a blend of old technologies already existing for a long time. For example, cryptography and payment form cryptocurrency. It represents values (i.e. payment through a token) that, when merged, creates the entirely new concept of cryptocurrencies. Cryptocurrency merges the idea of money, sending and receiving money online, together with being able to trade safely through a token (Lee, 2019). For example, Bitcoin was made to disperse the Bitcoin cryptocurrency, but it clearly has a much larger potential today. Hence, the blockchain tech of Bitcoin was altered to be able to store more than the data about transferring coins (Beck, 2018).

It is the technology that lets emerging cryptocurrencies to flourish and function. **Table 1 (See below)** outlines the top 10 cryptocurrencies, by market capitalization, as of

2020. There are over five thousand cryptocurrencies traded, worth up about $201bn (Li et al, 2020).

Top 10 cryptocurrencies, by market capitalization (2020)		
Name	**Founding**	**Worth (billion, in US dollars)**
1. Bitcoin (BTC)	August 2008, By Satoshi Nakamoto	128bn
2. Ethereum (ETH)	July 2015, by Vitalik Buterin	19bn
3. Ripple (XRP)	May 2012, by Arthur Britto	8.22bn
4. Tether (USDT)	July 2014	6.4bn
5. Bitcoin Cash (BCH)	August 2017	4.1bn
6. Bitcoin SV (BSV)	November 2018	3.4bn
7. Litecoin (LTC)	October 2011, by Charlie Lee	2.6bn
8. EOS (EOS)	June 2018	2.4bn
9. Binance Coin (BNB)	2017	2.4bn
10. Tezos (XTZ)	July 2018, by Arthur Breitman	1.5bn

In fact, the blockchain technology is the secret weapon behind the cryptocurrency's rise. Bitcoin showed the world what blockchain can do (Beck, 2018). It began a monetary revolution that hyped the power of the cryptocurrency (Beck, 2018). Hence, the fundamental technology (blockchain) that operates bitcoin, splits from the currency, and applied elsewhere for all kinds of other operations (Risius & Spohrer, 2017). This innovation has paved the way for numerous block-chain based solutions in the past decade. For example, smart contracts are a blockchain based solution that involves linking applications to blockchain (Risius & Spohrer, 2017).

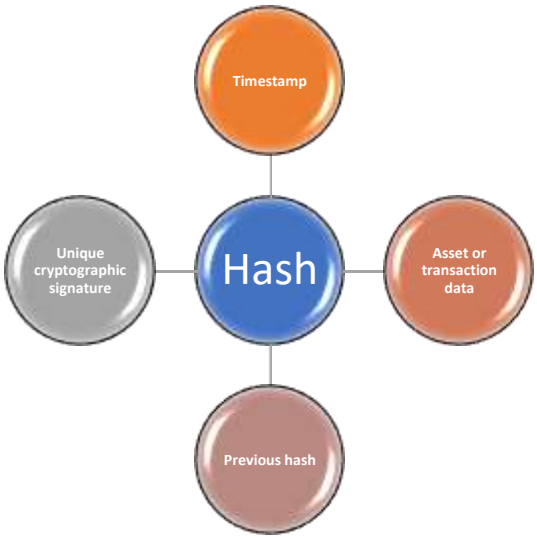
The Ethereum smart contract platform is a good illustration of this innovation. Ethereum is a public blockchain program that was launched in 2015 (Tapscott &Tapscott,

2016). It is based on its own cryptocurrency (named ether). The platform also creates and supports Smart Contracts and Distributed Applications (ĐApps). The Ethereum smart contract platform is worth billions, with hundreds of projects worldwide (Tapscott &Tapscott, 2016). This innovation is made up of over a decade of work by the world's leading group of smart minds (Beck, 2018). The innovative momentum, however, has not stopped because the full potential of these technological breakthroughs continues to penetrate different societies and industries. As blockchain technology develops in functionality and popularity, it will continue to extend into everything, from the life of an individual to the business operations of organizations. Therefore, the next chapter of the paper discusses the key principles and applications on which blockchain technology is based on.

2.2 Basic Concepts

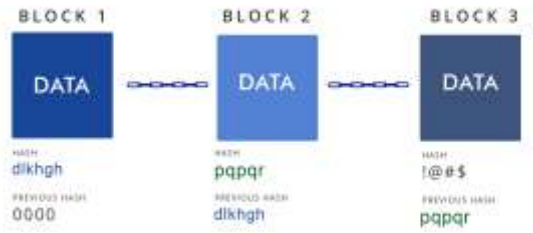
This section provides a detailed explanation of blockchain, such as the key principles of blockchain and how the blockchain technology works. Blockchain is a technology that lets people and organizations to achieve agreements as well as store transactions and data transparently, without an intermediary (Novotny, 2018). It can be used to create a fair, wide-ranging, reliable, and autonomous digital economy. It is simply a type of diary with information about transactions. **Figure 6 (See below)** depicts the components of a single 'block' in a chain.

Figure 6: Main Components of a Block



As seen in **Figure 6**, each block consists of coded hashes that bundle time-stamped transactions together. Transactions are entered in the order of occurrence because order is very important. The hash depends on the current transaction, and the previous transaction's hash (Zheng et al, 2017). **Figure 7 (See below)** illustrates a combination of blocks that form a chain.

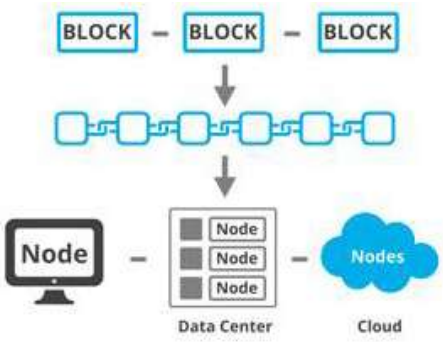
Figure 7: Forming the Blockchain, (from a chain of blocks)



Source: Shackelford & Myers (2017)

As seen in **Figure 7**, the combination of blocks, which forms a chain, is distributed across a global network of nodes. **Figure 8 (See below)** shows the distributed and interconnected network of blockchain and nodes.

Figure 8: Blockchain and Nodes



Source: Shackelford & Myers (2017)

The nodes inspect the hashes to ensure that a transaction has not been changed (Zheng et al, 2017). An approved transaction by nodes is written into a block. As seen in **Figure 8**, each block refers to (& has data from) the previous block, so the blocks join the Blockchain. Blockchain is highly useful because, as it disperses over many computers, a computer (node) can have a version of the Blockchain (Shackelford & Myers, 2017). In addition, peers are directly communicating with one another, so any information regarding the Blockchain is stored and passed on. As a result, data spreads rapidly in the network.

Furthermore, it is a very secure system because the Blockchain updates itself every 10 minutes (Shackelford & Myers, 2017). The Blockchain becomes a database, whereby every node has access to the chain. Hence, it is almost impossible to fake a block as it needs to be valeted by other nodes. (Shackelford & Myers, 2017). Blockchain's security is top-notch because it is encrypted and decentralized. There are thousands of these nodes scattered worldwide, so trying to capture (or mimic) the system needs incredible computer power. Overall, Blockchain is a ledger of transactions that automatically verifies itself (Novotny, 2018). No single node (or computer) controls the data. They can however confirm the ledger, without the use of intermediaries to control or regulate (Novotny, 2018). It is architecturally

decentralized, in the Blockchain. Blockchain is a groundbreaking technology that changes the communication methods of people and organizations across borders.

Furthermore, there is a lot of discussion regarding public blockchain versus private blockchain. On one hand, public blockchains involve cryptocurrencies, (e.g. Bitcoin) that enable P2P transactions. It needs tokens, and has its own rules in the P2P network (Yang et al, 2020). On the other hand, private blockchains use blockchain-based apps, which operate on a private cloud infrastructure (Yang et al, 2020). The distributed ledger consortium, R3, is a good illustration of private blockchain platform. R3 (R3 LLC) is a blockchain techn company that partners with different firms to build distributed applications on top of Corda (known as CorDapps), to be used across various industries (Yang et al, 2020).

For example, R3 entered a partnership with the Hong Kong and Thai central banks in January 2020. The project involves utilizing central bank digital currencies on Corda to make payments (installments) between the two countries more productive (Yang et al, 2020). Simply said, a public blockchain is open so anyone can join, but a private blockchain is an invitation-only network governed by a single entity (Yang et al, 2020). Participants would need to gain permission into the network, to access the blockchain.

Blockchain is a groundbreaking technology that changes the way organizations communicate and operate across borders. For example, smart contracts are block-chain based solutions that can automate and digitize traditional contracts (Cuccuru, 2017). It is a flexible mechanism that can be used for contract management, from overseeing agreements and data exchanges to verifying someone's identity (Cuccuru, 2017). There are several smart contract apps currently being used in different capacities. For example, Everledger is a blockchain-

based fraud-detection system for valuable physical assets, particularly jewelry and diamonds (Groopman & Owyang, 2018).

It employs a hybrid blockchain that uses smart contracts to certify physical jewels (Groopman & Owyang, 2018). The goal is to combat the sale of conflict diamonds by keeping a transaction history for each gem. Mycelia is another example of blockchain tech and smart contracts' potential for digital rights management (DRM) (Groopman & Owyang, 2018). Mycelia incorporates smart contracts in digital music files or other copyrighted material. The goal is to enable artists market directly to fans, as well as implementing the automatic payment of royalties (Groopman & Owyang, 2018).

Blockchain is a connective intelligence that entails apps, data, concepts, and people being connected by a decentralized system that does not require intermediaries to protect or store data (Lee, 2019). Overall, blockchain technology represents a tectonic change in the world of business. The technology will transform the culture of how businesses and organizations interact in the digital world.

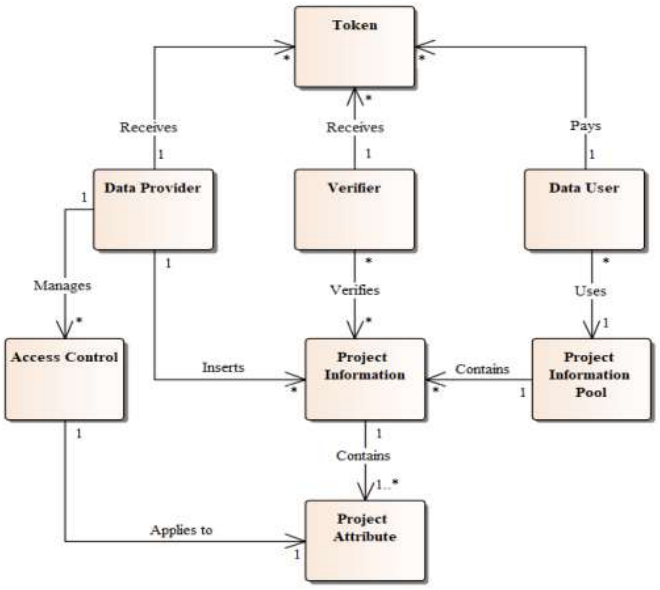
2.3 Applicability & Feasibility

This section includes a blockchain-based model to show that a Blockchain infrastructure can be applied in Project Management (PM). The model is based private cloud infrastructure (i.e. private blockchain). In other words, the characteristics are established on access control mechanisms, regarding sharing project information (Erhan et al, 2019). With this infrastructure, a company has control over who has access to project aspects (Erhan et al, 2019).

It can also disperse any or all parts of project information (Erhan et al, 2019). Since it is blockchain-based, carrying out obligations does not require a managing authority. Hence,

the data owner controls data and information, so it cannot be altered or removed, without the permission of the project owner (Erhan et al, 2019). In addition, the security features mitigate the risk of project information being hacked. **Chart 1 (See Below)** shows the model interpretation of the blockchain-based (BB) software.

Chart 1: Conceptual Model for Blockchain-based Software



Source: Erhan et al (2019)

Data Provider (DT): They embed project data into the data and oversee inserted data. Access are overseen by other data users (included in the project) with project information that the data provider needs to concede admittance to (Erhan et al, 2019). Consequently, project data sharing is enabled based on attributes. Just the data provider with the project data is approved to oversee access controls (Erhan et al, 2019). The data provider gets tokens as a byproduct of project data. No one has access except from the data provider.

Verifier (V): The verifiers are chosen to concede admittance to extend data. The reliability rating of embedded task data is resolved by the verification results (Erhan et al, 2019). The verifier acquires tokens after finishing the verification process.

Data User (DU): They make inquiries in the data and allows admittance. Access to project data will be permitted on the project-specific basis (Erhan et al, 2019). The project data which has higher rate is more dependable on the grounds that it has been validated by more verifiers (Erhan et al, 2019).

Project Information Pool (PIP): This is a combination of all the projects' data. The data that data providers have included, and data users have utilized data found in this record (Erhan et al, 2019). This information can be utilized when project managers make estimations.

Project Information (PI): This characterizes information of the software project. Specifically, it contains the properties of the software project.

Project Attribute (PA): This (or characteristic) is data that decides the properties of a software or a program. In this case, a project attribute can be a program inserted within the framework of an application (Erhan et al, 2019). Having access control over project data is made based on these attributes.

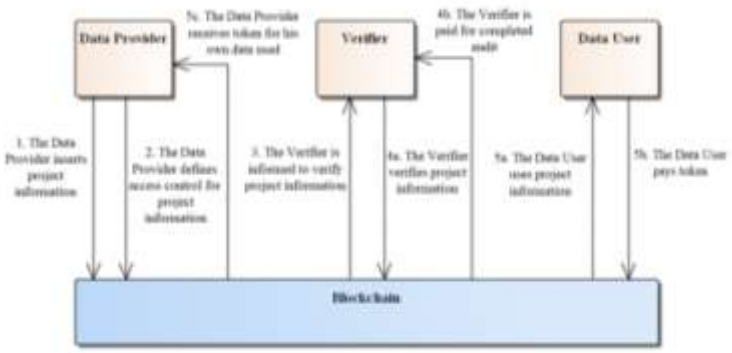
Access Control (AC): This is utilized to allow data providers have authorization that they require. This can be performed by the data provider who is the proprietor of data (Erhan et al, 2019).

Token (T): This allows all parts to gain from the framework (Erhan et al, 2019). The data provider is propelled to include project data. The verifier receives tokens by confirming project data (Erhan et al, 2019).

2.4 Example Scenario

Figure 15 (See Below) demonstrates the main flow of operations via the blockchain-based infrastructure. Specifically, it shows the sharing, verifying, and using project information in numerical order (Erhan et al, 2019).

Chart 2: Main Flow of Operations via the blockchain-based infrastructure



Source: Erhan et al (2019)

1. First, DT makes the project data, then embeds the data into the PIP.
2. Second, DP provides access data via project attributes.
3. Third, the verifiers are notified in a request.
4. The verifier checks whether project data is appropriate and then confirms it. The verifier receives tokens after completing confirmation process.
5. The data user reviews the PIP regarding certain criteria to get the project information data set and ready to utilize.

This example scenario can be possible by creating a program that will utilize blockchain (Erhan et al, 2019). We can smart contracts especially to store data and access control mechanisms. The case study applies smart contracts functionalities to PM practices in construction industry.

3. METHODOLOGY

The literature review entails a well-founded method for a collecting existing knowledge within the area of interest. For this reason, the research methodology in this paper applies a literature review approach.

3.1 Significance of the Study

The research paper focuses on the applying and using blockchain in the UAE construction industry. The findings of this study can benefit the UAE considering that the construction industry and blockchain technology are fast becoming natural partners in this technological revolution. Thus, the resulting framework will consist of strategies and practices that could be used to enhance construction project management (PM). It is a perfect illustration of how UAE construction companies can form strategic alliances with blockchain tech firms, to create value addition and other improvements to overcome obstacles facing the industry.

Furthermore, the greater demand for blockchain technology justifies the need for block-chain based solutions, such as smart contracts because these solutions are more effective and dependable approaches that can modernize construction PM, especially in the UAE. For this reason, this study can help researchers further uncover critical areas in construction PM that were deemed too complicated or unexplorable to integrate with blockchain technology. Overall, researchers will be informed and guided (by the recommended approaches derived from the research findings) on what factors should be emphasized, to further incorporate blockchain-based solutions into various UAE industries.

3.1 Materials

The research methodology utilizes the use of both secondary and primary sources. First, this paper applies a literature review approach, which involved finding and identifying relevant articles related to the topic, to review and analyze. They were publishing between 2000-2019 to limit the searching range. In addition, various keyword searches within the ScienceDirect, JSTOR & Google Scholar was conducted. Specifically, several phrases such as, “blockchain in construction”, “blockchain and project management practices”, “Industry 4.0”, “blockchain in the UAE” were used to find some related articles. Approximately, over thirty articles were reviewed to check their relevance to the impact of blockchain technology to construction PM practices.

The research methodology also utilizes survey questionnaire techniques, as opposed to other data collection methods. The survey was carried out to gain more insight into the overall attitudes and investments in blockchain technology. Specifically, it measures their attitudes and investments regarding the use of blockchain technology in the UAE. The survey questionnaire consists of closed-ended questions, meaning the respondents chose one specific answer from a few preset options. The survey questionnaire consists of fifteen questions in total (**See Appendix A).** The answers received were used to collect quantitative data, which are mapped out on charts and graphs. The questionnaire questions refer to the elements from the independent variables and dependent variables. Specifically, the questions are categorized based on these elements & variables. Group A consists of questions and elements from the dependent variable; Group B consists of questions and elements from the independent variable 1; and Group C consists of questions and elements from the independent variable 2.

3.3 Participants

The survey polled 20 companies within the UAE construction industry. Specifically, the survey respondents consisted of 60 senior executives with some understanding of blockchain and were able to talk about their organizations' investment strategies. These companies generated at least between $100 million and $1 billion, in annual revenues (between 2018 and 2019). The survey was carried out to measure the attitudes regarding the use and adoption of blockchain technology in the UAE, especially construction project management.

3.4 Procedures

The survey was administered between August 1, 2020 and August 15, 2020. The survey was created on the survey monkey website, and so, respondents accessed the online survey questionnaire through survey monkey links. The online survey questionnaire was also distributed to the participants through various online media platforms, such as Email, WhatsApp, Instagram, and Facebook. All the participants answered the surveys online, and not through a face-to-face survey (in person). Unfortunately, it was impossible to implement the face to face method, due to the recent COVID-19 outbreaks.

On another note, distributing the survey questionnaire online saved a lot of time, for the researcher and the respondents. However, there can be some issues regarding reliability and credibility. For example, there is no way to control the circumstances around the respondents, such as ensuring the questionnaire was answered fairly and individually without interference. For this reason, conducting a face to face surveys would have resolved this limitation, but the COVID-19 situation made it extremely difficult to administer in-person.

In addition, it is a time-consuming process, especially because some of the respondents may be extremely busy.

Some difficulties, especially from company executives regarding sharing information about the company's scientific, technical, legal, and contractual issues, is also expected. Overall, there are both positive and negative factors while administering this online survey, but it was important to review the answers to the best of my ability, to receive the most beneficial findings for discussions. After reviewing the primary and secondary sources, an analysis of the impact of blockchain technology to project management practices was performed.

The variables that were used were:

Independent Variable-1: Blockchain

Independent Variable-2: Smart Contracts

Dependent Variable: Construction PM

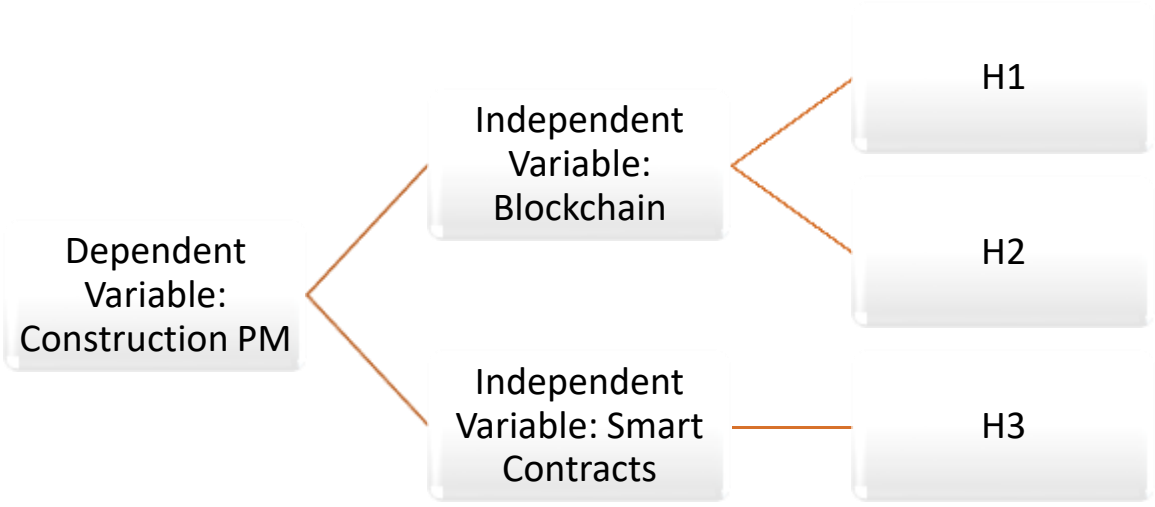
H1: There is a strong impact when utilizing block chain smart contracts in construction.

H2: There is a strong impact when utilizing block chain smart contracts on PM practices

H3: There is a strong impact when utilizing block chain smart contracts on construction PM

The conceptual framework depicts the effects of the block chain technology on project management practices in the construction industry, in the UAE. The three hypotheses

being tested consist of one dependent variable (construction project management) and two independent variables (blockchain & smart contracts). Specifically, it aims to show the role and importance of implementing blockchain technology and smart contracts in construction PM, as opposed to current systems. In fact, there is a strong link between smart and PM tools. Smart contract functionalities can manage invoices and payments, collect performance data pertaining to the project, store project status reports, project procurement decisions and other vital data pertaining to the project.



4. SYSTEMATIZATION OF BLOCKCHAIN IN PROJECT MANAGEMENT

This chapter analyzes & discusses the impact of blockchain technology on project management practices. First, it discusses the fields of Construction and Project Management (PM) before the creation and evolution of blockchain technology. Second, it examines the project life cycle & standard PM approach as well as the effective implementation of life cycle management (LCM) in construction projects. Third, it conveys that the application of blockchain in the construction industry entails the optimization of project management. In this case, the PM practices were categorized, according to the Project Management Body of Knowledge (PMBOK) guidelines.

4.1 Construction and Project Management: Pre-Block Chain Era

The field of Construction and Project Management have gone through many remarkable changes, even though they have always been considered as the industries that are either reluctant to change or adapt slowly to change. Regardless, this drawback has not prevented the internet and other IT from improving the methods of managing projects. Likewise, improvements in construction processes, advances in the field of engineering and architecture, new construction materials, a more qualified staff and access to the international market have made the construction projects reach a level of competitiveness (Walker, 2015).

In fact, Blockchain is one of the key technological foundations behind many of the advancements occurring in both fields today. For example, the intelligent contracting, the decentralization of the databases, the value exchange, intelligent identification and the smart supply chains, are some of the tools that work with this technology and its application to the Construction sector and to the Project Management (Lee, 2019). This yields greater

collaboration, decentralization of transactions, savings of money between transactions, open and transparent contracts, greater competitiveness, and greater efficiency in approval periods, among others (Walker, 2015).

Both Construction and Project Management are two highly structured fields governed by a multitude of processes and procedures, which involve many third parties and intermediaries (Walker, 2015). Consequently, this dependence increases inflexibility in the face of change. For instance, people can see this when they use the steps to follow for the construction of a new bridge that connects two nearby locations, as an illustration of a project type.

1. Bidding and Contracting: preparing the contract, followed by a public announcement. Then, the companies interested in the contract and that meet the requirements, will present the necessary documentation, which always involves other parties (Walker, 2015). Once the documentation has been reviewed, the bids are evaluated, and the presentation of the definitive guarantee and remaining documentation is requested (Walker, 2015). Once the resolution is published, the signing of the contract becomes effective.

2. Design and Purchases: during the bidding process, attaching and reviewing documents such as the Descriptive Report, Budget, Plans and Work Plan, among others (Walker, 2015). These documents will be the basis for the execution of the works and to carry out the procurement process, hiring subcontractors and supplying materials for the execution of the works: formwork, concrete, scaffolding, steel, etc.

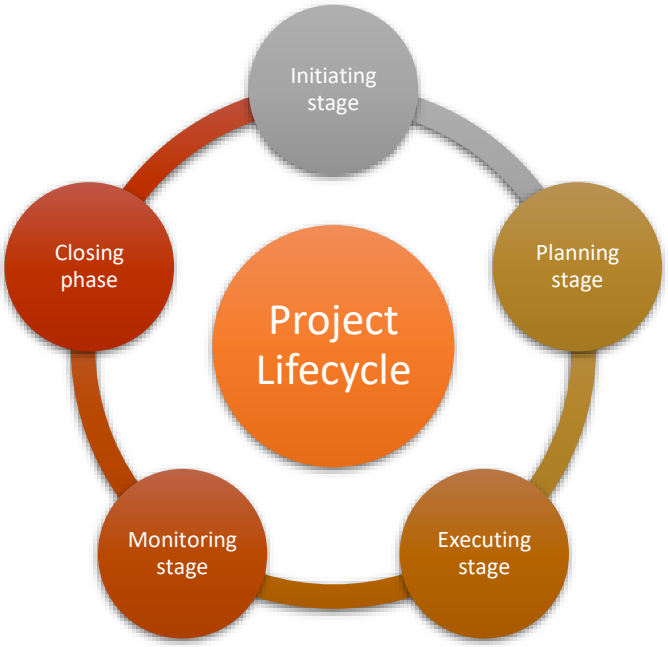
3. Execution of the works: it is time to build and set up what until now only existed on paper. Now it will also be necessary to negotiate with the local authorities and the security forces the detours of traffic, new signage, etc. (Walker, 2015). Once all the interfaces that exist between the parties involved have been resolved, the work is carried out.

4. Delivery and Commissioning: finally, the bridge is delivered to the client with a series of necessary documentation.

Evidently, it is a tedious process with a multitude of actors in decision making, such as governments, banks, and other companies. Construction project management especially can be divided into some stages. According to PMBOK, a project life cycle defines the phases that connect the beginning and end of a project (Burke, 2013). It usually entails what work must be fulfilled, what deliverables must be produced and checked on, who must be included, & how to manage and approve each stage (Burke, 2013).

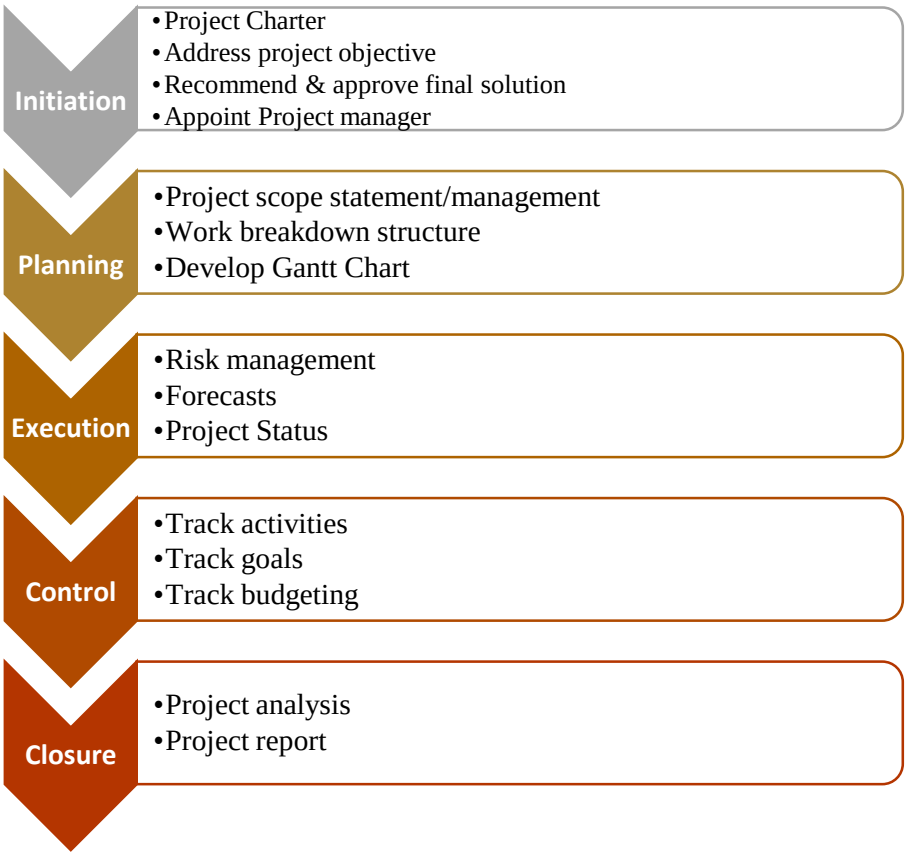
There is no exact number of phases that a project can have. **Figure 9 (See Below)** depicts a summary of the key phases involved in the project life cycle.

Figure 9: Key Phases of Project Life Cycle



As seen in **Figure 9**, the key phases are (in order of occurrence) initiation, planning, execution, control, and closure. A standard project typically has the following major phases, and each major phase involves its own assignments and issues (Burke, 2013). Overall, these phases describe the direction of a project from the start to finish. It can also be known as the project "life cycle." (Burke, 2013). **Figure 10 (See Below)** outlines the (typical) project life cycle of a typical project.

Figure 10: Traditional Project Life Cycle



Construction project management especially is usually divide into several phases, such as (but not limited to) planning, design, construction, commissioning etc. However, each phase is implemented separately. For example, some designs usually need to be changed in a project. However, there exists a huge communication & collaboration gap between designers and constructors. For one, an architect (or design personnel) cannot effectively support design changes.

In most cases, the design personnel's tasks are completed, once a design is done and given to constructors (Walker, 2015). This is a recurring drawback stemming from the traditional project management method. Consequently, this leads to serious time or cost overruns (Ellicott, 1994). Hence, the application of the Life Cycle Management (LCM)

approach can offer many solutions to solve these problems. According to Teresko (2004), LCM merges all phases of project management between the relevant parties. In other words, all concerned parties can be in contact with one another in real time.

This approach observes the construction time and cost to ensure consistency overall, as well as protect stakeholder interests as they relate with other parties involved (Teresko, 2004). Implementing LCM effectively relies on an interactive platform because information sharing is key (Teresko, 2004). It is important to have an effective information platform that can 1) gather project information; and 2) provide information to relevant parties (Teresko, 2004). It also key that this 'platform' allows information to be open, transparent, and comprehensive, especially for complex projects (Teresko, 2004). This is where the technological power of blockchain technology and block-chain based solutions can revolutionize project management.

4.2 Blockchain Changes Project Management

A block chain comprises of several points in which several individuals involved in the project can communicate with others (Hewavitharana et al, 2019). All communication and exchanges are recorded for full transparency. In addition, budgeting is better handled because participants can see all purchases or transfers. For the project manager, it creates a framework that permits for input, but also performs oversight that's more productive compared to conventional PM systems (Hewavitharana et al, 2019). Essentially, it could appear like this framework of management is like other means of operating projects.

However, once the necessary people are assigned, the project is given pre-set objectives, and all the outside variables are similarly taken cared of (Hewavitharana et al, 2019). Furthermore, it is a decentralized system, so there are various points of entry. This

implies that the project management itself is not a top-down procedure, but rather one that pulls involvement from all parties with full transparency (Hewavitharana et al, 2019). The difference is all communication streams through the input of the assigned staff and no one else. In addition, all communications are secured, due to the minimum number of persons with access to data and other sensitive information.

Based on how data is dispersed through the system, the data transfer is secure because of the difficulty that outsiders experience to break into the management process. This includes cloud storage systems that are more vigorous and secure. It diminishes risks, as the project manager is directly involved. In addition, blockchain technology allows the project manager to keep things on track. Moreover, it correct mistakes, and keep projects focused. It is also efficient because it also limits discussions to project issues, as these must transmit through the blockchain system.

Moreover, the project manager will have access to all information and can alter appropriately when there is a need for a change. The blockchain itself can handle all transactions to make them more efficient. There are several real-world use cases on utilizing blockchain on construction projects. For example, a blockchain firm called Briq is working to save project's data on a ledger (Hewavitharana et al, 2019). Briq is a construction fintech firm that connects operations and accounting in one modern platform on a construction data cloud.

In this case, the platform offered by Briq enables all parties involved to navigate the system. In addition, they created the ledger to exist in numerous (synchronized) databases. Each ledger is a protected copy and trying to make changes is an infringement on the protocol. Overall, Hewavitharana et al, (2019) claims that 95 percent of all data is usually

lost because of handovers within the construction industry, so this solution is extremely valuable. With this new blockchain technology, we can see the numerous potentials that Blockchain has within the Construction Industry and Project Management.

First, there would be a reduction of costs in both the number of intermediaries and the time of transactions. It means being able to deal directly with companies located anywhere in the world, to hire any service or product. The stored data can help locate the best company to perform certain jobs and the creation of Smart Contracts would facilitate the transaction. In addition, there would be a 'own payment method', about specific payment methods for certain sectors (Walker, 2015). In other words, there could be specific cryptocurrencies for payment of energy, for transportation, insurance etc.

Smart Contracts are also more of a transparent and agile contracting system that would be key to an improvement in these two sectors (Walker, 2015). Using smart contracts allows legally binding forms and printed material to be computerized, which reduces costs, frees important assets and hastens up project delivery. (Hewavitharana et al, 2019). Since it is activated upon completing pre-set tasks, it allows all relevant parties (e.g. supervisors) to monitor stages and recognize responsibilities (Hewavitharana et al, 2019). Furthermore, it also serves as a ledger of certifications, showcasing all incidents occurring in the process (e.g. building).

The purchasing process ordinarily begins with a client, its consultants, and the main contractor. The main contractor can employ subcontractors to perform specialized work, such as (but not limited to), carpentry, electrician, technician, and masonry. Some other mediators exist too. Following subcontractors and their assignments can be hard. For example,

remodeling an office building can take at least 15 subcontractors working over numerous floors (i.e. taking care of equipment, managing building access entry, handle deadlines).

In this case, blockchain can play a role, because a 'reputation ledger', for example, has the ability to track subcontractors' deliverables as well as become a point of reference during the recruitment process (Hewavitharana et al, 2019). This function makes it easier to manage the construction process, as well as discover dependable subcontractors for a project. In addition, it depicts moving to a contractual relationship based on recorded data on the blockchain that can be alluded to when required (Turk & Klinc, 2017).

This will be especially helpful with maintaining projects afterwards, to redesign and follow regulations. Moreover, the records can store guarantees and certifications. It can also ensure the construction process is protected from corruption and fraud, since project attributes (e.g. materials) can be put away and followed on the blockchain (Turk & Klinc, 2017). This will enable simple comparison to benchmarks, as well as streamlining reviews. It can also be utilized to store incidents occurring within the building process. The record can be an effective means to enhance procedures to find and communicate information with the specified people and companies (Turk & Klinc, 2017).

Payments could be made instantly, without waiting. These transactions would be viable from anywhere in the world. The smart contracts and the elimination of intermediaries helps the development of the technology, so new business models based on P2P business would be created. By reducing the number (and role) of intermediaries, blockchain tech brings about greater transparency because anyone would be able to know the status and history of transactions (Turk & Klinc, 2017). On the other hand, the data stored in Blockchain

cannot be manipulated (easily). It would be clear who hired, whom you hire, why you hire, how much you hire and when you hire.

Evidently, blockchain can be of importance, especially regarding data management. It simply provides a communication platform between different players, as well as enable them to handle the workflow more efficiently (Turk & Klinc, 2017). It allows tracking data, reducing delays in sending (and receiving) documents, as well as boost decision-making procedures. Overall, the main applications of blockchain technology entails the optimization of project management in several ways.

4.3 Blockchain & Project Management Practices

Blockchain-based apps & solutions further develop (construction) project management. Hence, the PM practices were categorized and outlined into five models, which are purchase management, asset & inventory management, contract administration, finance management and subcontractor management.

1. **Purchase Management**

Purchase management is part of supply chain management. There are plenty of moving parts, that must be overseen in a productive and cost-effective way (Turk & Klinc, 2017). The basic components are traceability and communication (Nanayakkara et al., 2015). In fact, many components (e.g. notes and invoices) are still paper based or centralized programs or frameworks. Blockchain technology expels this manually operated system and switches these systems into distributed digitalized forms (Turk & Klinc, 2017). It can also make decision making clear and transparent, with respect to products and its elements.

In addition, a blockchain-based supply chain can trace the location of project assets at any moment (Mancone, 2018). Therefore, it is structured on a strong build of trust (Novotny, 2018). Moreover, the tech is efficient to execute transactions stored in distributed records (Zheng et al., 2017). The network itself monitors its security and updates in real-time.

2. Asset & Inventory Management

Construction organizations are project-based entities, where the clients have distinctive inclinations with respect to the items (Hewavitharana et al., 2019). For this reason, it is essential to have proper quality control from the beginning of the project to the conclusion of the project. Moreover, construction workers must keep up a well-structured supply chain, since the nature of the industry allows the opportunity to select their resources and materials (Perera et al., 2014). By utilizing blockchain, authorized parties can certify the whereabouts, type, and logistics of materials (Morabito, 2017). Consequently, construction companies can operate lower the cost, accelerate the schedules, and reduces wastes (Rothrie, 2018). On another note, construction companies rarely know everything about the inventory control. For instance, they may not know about the supplies in stock needed before beginning a project. This unplanned situation can cause delays and lead to more expenses (Rothrie, 2018).

Through the blockchain solutions, there will be more accountability and transparency. For example, the BIM model can successfully distinguish the source of a transaction through gathering the complete set of data on the blockchain (Wang et al., 2017).

3. Contract Administration

The early phases of the construction project is more expensive, but more important than other stages, as there are inherent risks and fear. Stakeholders frequently attempt to

relieve that hazard by utilizing legitimate contract planning and data hoarding. Hence, blockchains and smart contracts are presented with the point of minimizing the risk (Morabito, 2017). A smart contract is a computer program that automatically executes on if/then rule. Every situation is pre-recorded on the blockchain. There are two kind of smart contracts: deterministic and non-deterministic. Deterministic contracts only require the data that exists within the blockchain (Morabito, 2017).

Deterministic (smart) contracts do not require any outside information, to execute and work efficiently. Hence, it functions executes and functions based on the data available within the blockchain. Non-deterministic (smart) contracts require additional information than the available information in the blockchain (Morabito, 2017). Hence, non-deterministic (smart) contracts require a trusted third party (known as "Oracles") from outside the blockchain to execute the contracts. However, "Oracles" need to be approved by the involved parties, to provide smart contracts with the required information (Morabito, 2017). Overall, smart contracts are the best alternative for the traditional systems.

Smart contracts are also cost-effective in several ways. For one, smart contracts are entirely in programming languages (Wang et al., 2017). In addition, it is based on blockchain technology, which is built upon the trust of accomplishing a task. Once one assignment is completed, a smart contract is accomplished and thus, when the project is planned, hundreds of smart contracts would be obvious to all included parties (Cuccuru, 2017). Consequently, the risk of opportunistic behavior is also mitigated.

4. Finance Management

In the construction industry, late payments and cash flow issues are enduring problems. These conditions can be risky to the whole supply chain, especially for the SME's

who lack the ability to bear the significant upfront costs without continuing payment as well as the financial resources to maintain a proper supply chain (Ramachandra and Rotimi, 2011). Therefore, it is necessary for transparency and tractability of payments in the construction industry.

Using blockchain technology, companies can send money across borders with lower fees, without intermediaries (Nanayakkara et al., 2019). The absence of a 'third party' makes the process easier and quicker than the traditional way. In the finance operation especially, most of the transactions require the authorization of top management (Turk and Klinc, 2017). This process improves the productivity of the construction organization in terms of handling the cash (Turk and Klinc, 2017).

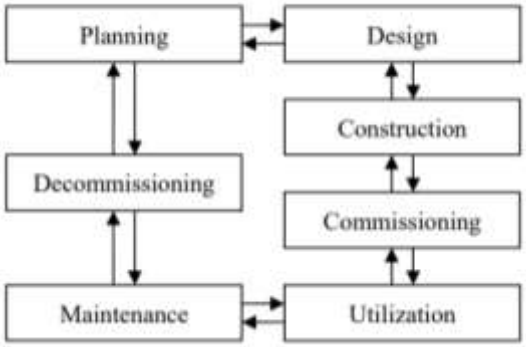
5. Subcontractor Management

The construction industry is unique when compared to other industries. For instance, subcontractors are the temporary employees involved in the projects. However, the main contractors handle them, so they can perform assigned tasks (Wang et al, 2017). Project managers face challenges regarding measuring accomplished work and the interim payments, mainly because there can be numerous subcontractors involved in one project (Ramachandra and Rotimi, 2011). Blockchain-based solutions can offer a solution to this problem. For example, transactions can relate to blockchain technology, whereby smart contracts handle all payments, orders, deliveries and invoicing (Zheng et al, 2017). This removes any need for intermediaries, which simplifies faster payments (Zheng et al, 2017). Overall, it is evident that blockchain-based apps & solutions can offer many opportunities (construction) project management, from managing subcontractors and efficient payment systems, to digitizing contracts and managing assets and inventories.

4.4 Blockchain Technology and Construction Industry

Blockchain can work, utilizing smart contracts, in every stage of a project. This blockchain-based technology is a useful tool, especially for facilitating interaction between the relevant parties in different elements. **Figure 11 (See Below)** depicts the life cycle phases based on the features of construction projects.

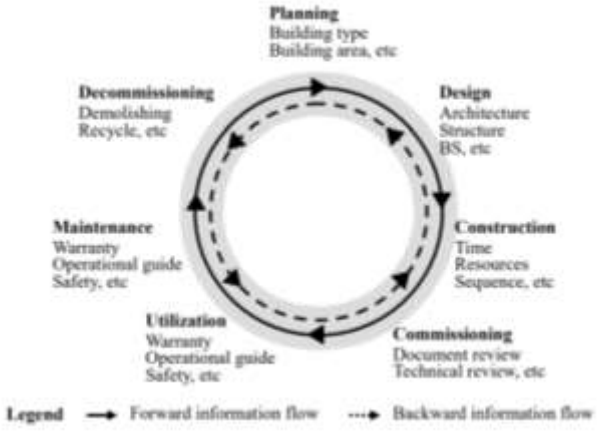
Figure 11: Life Cycle of a Construction Project



Source: Novotny (2018)

According to Turk and Klinc (2017), the LCM of construction projects includes all the multiple project phases. **Figure 12 (See Below)** depicts an information flow chart, concerning information on all phases.

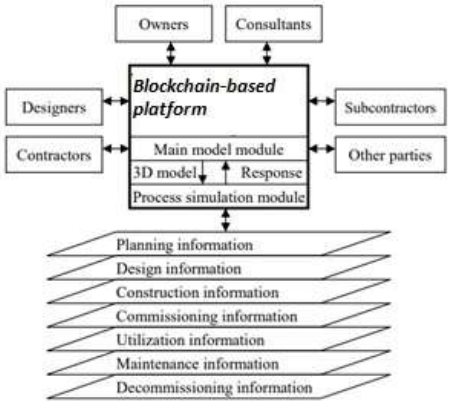
Figure 12: Information flow chart for construction projects



Source: Turk and Klinc (2017)

As seen in **Figure 12**, the vast information can be integrated into a blockchain. Therefore, a theoretical model of a blockchain-based platform is developed as shown in **Figure 13 (See Below).**

Figure 13: Model of Blockchain (BC)-based information platform



Source: Turk and Klinc (2017) & Novotny (2018)

Based on both preliminary models, this BC platform provides a virtual environment that includes two main modules (main & simulation). The former consists of a sample of the life cycle phases of the project, whereas the latter focuses on the dynamic information of projects. In this case, all parties can share data in real-time. This ensures a smooth construction process and reduces rework risks, since we know that the construction process can often be a bit complicated. On one hand, the design of the building should take its construction into consideration (Wang et al, 2017). Hence, the BC model permits testing and trying the maintenance and demolition processes and methods of the building on the platform.

Overall, this is a good illustration of project modelling, which illustrates the nature and requirements of final projects. Once completed, smart contracts are initiated, and triggered. Particularly, each exchange within the project model will relate to smart contracts.

This process makes and oversees the budget, to guarantee that individuals will be paid. Once the commitments of the contracts are met, at that point they begin the works that are planned. After the contractor completes his/her assigned tasks, reviews are done, and endorsements or dismissals are given for the errands completed. On the off chance that the work is acknowledged and rejected, at that point the financing will be discharged, and significant parties will be paid.

It can help to simplify every phase of the project delivery, which minimizes the role of intermediaries, especially regarding contract processing and payment (Novotny, 2018). As an alternative, blockchain permanently stores records of transactions, once it is approved by the participants. The data related becomes stored, which eases the document sharing between involved parties, so in the end, the security and transparency of the transaction is ensured (Turk and Klinc, 2017).

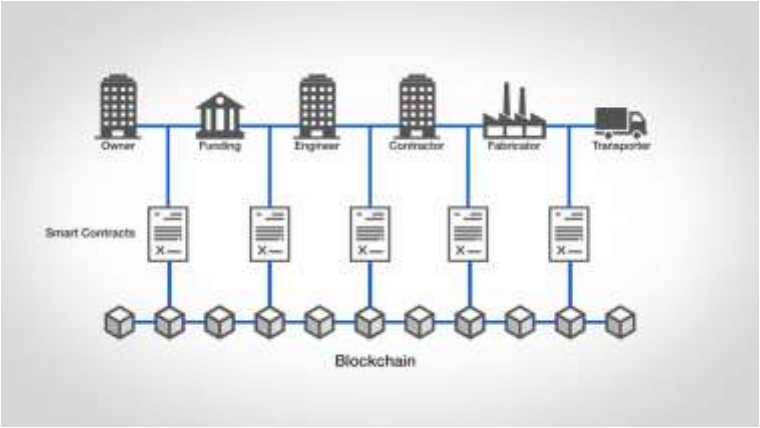
Communication and accessibility of the data ought to be altogether progressed to move towards smart cities and blockchain-based solutions. Blockchain will affect construction activities in numerous ways. For the foremost part, it impacts project management practices of the construction field (Hewavitharana and Perera, 2019). Blockchain can positively influence the project management practices, using smart contracts. For one, BIM and blockchain can work together to develop the effectiveness of smart contracts. For example, in BIM, the model itself can be utilized as portion of the contract between the parties included within the work. Therefore, all the parties are aiming to mirror the actual physical construction of the project to the BIM model in the contract (Rothrie, 2018).

It helps to hold all parties on a project responsible and increase transparency. Smart contracts can be utilized to ensure that all stakeholders on a project get timely payments. It can improve the payment process by increasing security and creating traceable information. In other words, blockchain ensures that subs are paid fast, without any disputes. Blockchain combined with smart contract functionalities can improve supply chain management. It can track items from point A to B. It can also improve transparency, which benefits all parties, so they remain on the same page and dodge potential pitfalls and oversights.

5. SMART CONTRACT STRUCTURE

Smart contracts extend transaction logic with programmed logic, including data storage. **Figure 14 (See below)** depicts a basic structure behind smart contracts

Figure 14: Smart contracts in Blockchain



As seen in **Figure 14**, a smart contract, involves different parties coming together to define the rules, regulations, and penalties pertaining to the collaborated project. After defining and agreement, the system automatically enforces these rules. For example, if a material were shipped late, the blockchain system would put it on record, and enforce the pre-agreed upon rules and regulations (Abeyratne and Monfared, 2016). Fundamentally, implementing smart contracts improves efficiency and resolve disputes before they even occur. It also acts to hold the parties involved more accountable.

5.1 Smart Contract for Construction Industry

The following section describes the steps using Smart Contracts in construction projects.

5.2 Planning

Smart contracts can be executed through the blockchain, within the start of the planning stage. For example, the proprietors (Owners) say their idea of the project, the

consultant/designer can discuss with them to get their conclusions based on the data within the blockchain. The proprietor and consultants may talk about and alter plans until it fulfills the owner's needs. It gives a virtual environment for quick revamping or alteration. After the visual planning is wrapped up, the significant data may be saved into the smart contract, to direct the plan/design.

5.3 Design

After the planning phase, design personnel (i.e. architect) designs collaboratively via the blockchain. Traditionally, structure and building services is independently conducted from the design plan, so clashes between these separate design plans happen regularly, but the continuity and transparency of the blockchain allows design personnel to view the preliminary phases, to identify the constructability of the design. In the smart contract, also includes the knowledge of design and comments of the owner and consultants. This enables a smooth process and reduces the cost and time of the project.

5.4 Construction

Within the development stage, the center lies on strategies, methods, the using of assets to monitor time, cost, and quality (Hewavitharana and Perera, 2019). Diverse projects require diverse construction strategies, so construction strategies for projects are very specific. The contractors or subcontractors can utilize smart contracts to settle on the method of construction that includes the ideal construction strategy, construction arrangement, and resource leveling and test unused construction methods prior to beginning actual construction.

This makes the planning of construction, smooth and straightforward in the virtual environment. It also makes tasks comprehensible for the subcontractors and other workmen

and improves the quality of projects. Unlike traditional project management approaches, which does not prioritize that the owners or consultants, smart contracts eliminate time spent on the approving statements.

5.5 Commissioning

Smart contracts need kind of documents. Smart contracts via the blockchain can be used to outline instructions (and preferences) easily and clearly. As a result, when the project is delivered, this information is stated and stored for other involved parties in the project to be made aware of.

5.6 Utilization

Conventionally, owners usually may only have one major idea about the project, but they do not know a lot about the elements of all the stages. For example, they do not know how to use or operate some devices in the building. Hence, smart contracts (data cloud storage) can include digital documents to help them become informed and aware of the building characteristics. This saves the owner a lot of resources. Smart contracts also offer a data management platform for property management.

5.7 Maintenance

Afore mentioned, smart contracts shift organizations away from the paper-based activities and provides digital, and visual information. This is valuable because the drawings, for example, related to a building can be excessive and detailed, which can be very difficult to preserve. Overtime, they can be lost or destroyed, which means that relevant drawings will not be available when it is time to maintain the building. However, data management via smart contracts can store manufactures' information, and the information of devices or

materials. This information is integrated into the blockchain, which can help maintainers see the relevant materials, devices, etc.

In other words, relevant (and updated) information is only a click away! In addition, maintenance solutions also be stored, so this information is made available to relevant parties in the project. This helps to minimize costs and risks of maintaining. It also enables all the information to be easily and conveniently managed.

5.8 Decommissioning

In the end, the stored data and information can be used, as a reference for several things, including demolition. For example, the information helps identify some key structures. Additionally, this also makes the demolition process smooth. Overall, the process of implementing blockchain technology for construction projects using the smart contract functionalities. It is evident that the blockchain- based solutions and platforms can make significant contributions to construction projects.

5.9 Understanding smart contracts & blockchain

Blockchain and blockchain-based apps (e.g. smart contracts) are an integral part of the new technological advancements. Simply said, this technology transaction to be recorded and stored on a distributed ledger. Part of (upcoming) research methodology examines the role and importance of these technologies in the UAE construction industry and whether there is a strong need (and demand) for this technology in the industry. The fact remains that the construction industry tends to be a bit behind other industries when it comes to embracing new technological advancements.

For example, the slow adoption of technological programs, such as Building Information Modelling (BIM), is a good illustration of this slacking progression. There are

two main divisions regarding the implementation of blockchain technology in the construction industry: 1) those who believe blockchain technology is important, and offer exciting opportunities for the future; 2) those skeptics who claim automation has no place in construction. There is a general fear of the uncertainty and skepticism, especially regarding the possibility of full automation in the construction industry (Mason & Escott, 2018).

For this reason, a survey questionnaire was created and shared to look into the attitudes towards blockchain technology, and to determine whether there is a strong demand on the need of blockchain technology in the construction PM. The survey questionnaire is intended for construction companies in the UAE, but mainly responses upper and senior management. Although the UAE is a technological advanced environment, the rigid reality of the construction may permeate views and perceptions of the survey respondents. However, this does not change the fact that blockchain technology has numerous advantages. For example, the technology can be beneficial when it involves contract administration and management.

Specifically, smart contracts can replace simple supply-type contracts, which reduces the huge paper load associated with processing contracts (Mason & Escott, 2018). Even though there is a belief throughout the industry that disputes cannot be solved with a computer, the technology can help to be more transparent and organized, which can help to avoid disputes in the first place. In addition, some people also believe the technology diminishes human interaction and relationships (Mason & Escott, 2018). On another note, blockchain-based solutions enhance the position. A smart contract especially is a key innovation that can save people a lot of time, energy, and resources.

It is basically a digital contract, because terms and agreements can execute automatically when the predefined conditions are met (Mason & Escott, 2018). Originally

related on the Ethereum platform, smart contracts can process computer codes and scripts on the blockchain. Specifically, the codes are secured on the blockchain, as input conditions which come from the blockchain (Mason & Escott, 2018). Such conditional functions act as digitally binding contracts recorded on ledger (i.e. blockchain). Therefore, smart contracts are one of the strongest tools of blockchain technology. With smart contracts, many processes can be more efficient, enhanced, automatized (Mason & Escott, 2018).

For example, every laborer entering a construction site must have a proper identification card, for different reasons (i.e. safety, security etc.). The data on who entered the construction site and how much time they went through on the site working is captured and enlisted on a blockchain empowered disseminated record between the client, the expert and the worker (Artisan & Escott, 2018). Consequently, there is no extra organization required to validate this data, because it has as of now been logged on the blockchain. Moreover, a smart contract can indeed start installment, based on the number of worked hours on location, or based on the concurred terms as well as send installment certifications for all parties, in the event that required (Bricklayer & Escott, 2018).

Hence, this removes any unnecessary queries between stakeholders, who may want to compare the registered hours in their separate ledgers. The information on the blockchain is automatically distributed and updated for every party involved, so the blockchain remains as the single source of reference for all involved parties (Mason & Escott, 2018). This example is a simple illustration of the advantages. Nevertheless, this 'simple' features can be elevated to include the automatic execution of payments, submissions, and project updates, which makes the whole process more effective (Mason & Escott, 2018).

In addition, some other registered data (e.g. the number of hours) and transactions initiated (e.g. payments, project updates sent) are also recorded on the blockchain, which

make the whole system plain and simple for the involved parties. Additionally, a reverse transaction may occur to correct any errors in the smart contract, if all the involved parties agree to the changes (Mason & Escott, 2018). The use of oracles (as collaborators) may also be enabled, to safeguard smart contract management. Overall, optimization and efficiency are key components for success in the construction industry.

For this reason, contractors are under plenty of pressure to deliver promptly and on-budget, so implementing smart contracts can change and improve this stress in the construction industry. Implementing a blockchain-based project creates business value resulting in timesaving, cost removal, and risk reduction (Mason & Escott, 2018). A private blockchain network particularly, works better for project managers who want to oversee the 'big picture'. In other words, this network allows the project manager to communicate with all relevant parties. In addition, the blockchain identifies, verifies, and validates these transactions (Mason & Escott, 2018).

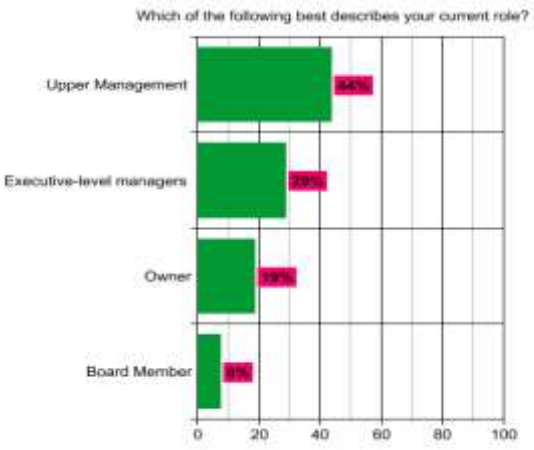
Overall, blockchain revolutionized the way we manage supply chain because this can increase safety measures used to secure ledgers (Mason & Escott, 2018). For example, data related to how much time your employees spend to complete their tasks will also be part of this permanent decentralized record. It also makes sharing data (i.e. document sharing) safer because of the data cloud storage system. This is a cloud storage system that is unchangeable and secure. It is less likely to be prone to human errors, fraud, and data loss (Mason & Escott, 2018).

6. DATA ANALYSIS, FINDINGS AND DISCUSSIONS

The aim of this research is to propose an integrated framework for introducing Blockchain technology in the Project Management profession. Hence, the research paper focuses on using blockchain in construction PM. Specifically, there is a special emphasis on the feasibility of blockchain-based solutions influencing areas of PM practices in the UAE construction industry. For this reason, a survey was carried out to gain more insight into the overall attitudes and investments in blockchain technology. Specifically, the survey polled 20 companies within the UAE construction industry.

The objective is to measure their attitudes and investments regarding the use of blockchain technology in the UAE. The answers received were used to collect quantitative data, which are demonstrated on the charts illustrated below. Although the survey polled 20 companies within the UAE construction industry, the survey respondents consisted of 60 senior executives. **Graph A-1 (See Below)** illustrates that a majority (44 percent) of the survey respondents are from upper management, while 29 percent of respondents are executive-level managers.

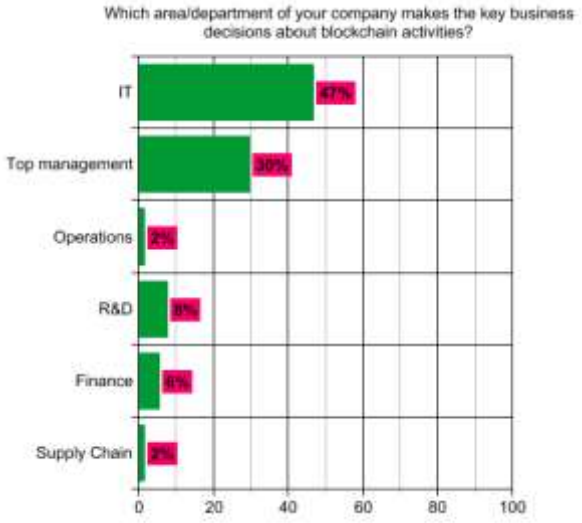
Graph A-1
Respondents, by job role



Overall, most respondents were from upper management and executive level managers in the companies. In addition, the survey targeted senior executives that have a broad understanding of blockchain technology, as well as enough knowledge to comment on their organizations' investment plans. This is crucial because, **Graph A-4 (See below)** illustrates that most respondents (47 percent) stated that the IT department is the leading force behind blockchain decisions in the company. However, top management is the second-highest group (30 percent) that make the key decisions about blockchain in the company.

Graph A-4

Group making key decisions about blockchain



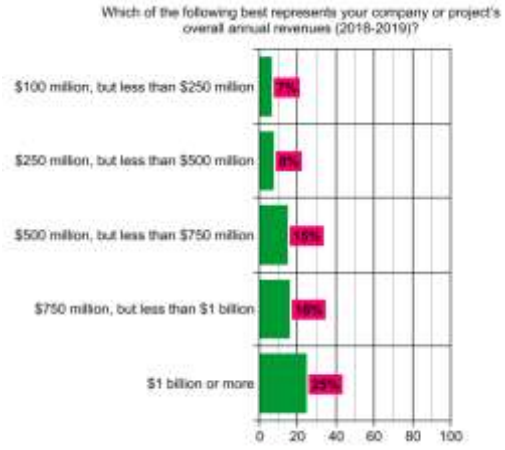
Almost half of the respondents believe that IT professionals are the leading group making the key decisions about blockchain, as well as bolstering the view of blockchain as a technology-driven solution. On another note, survey respondents also cited top management as another key group that emphasizes on the development of blockchain technology as a strategy-focused solution. In other words, IT utilizes blockchain tactically in most projects,

but top management is driven by using blockchain more as a strategic weapon (Atlam et al, 2018).

The role of upper management in the implementation of block-based solutions in construction PM practices should not be overlooked, especially regarding finance management and operations. Money particularly, is a point of discussion for the implementation and applicability of blockchain because the technology consumes an enormous amount of electrical and computational power. **Graph A-2 (See Below)** illustrates the annual revenues of the organizations, from 2019.

Graph A-2

Company overall annual revenues in 2019



As seen in **Graph A-2**, most of the respondents (25 percent) are in companies that earn approximately from 1 billion dollars or more, in annual revenues, while 16 percent of respondents are in companies that earn approximately between 750 million dollars and 1 billion dollars. Although 15 percent of the respondents are in companies that earn approximately between 500 million dollars and 750 million dollars. The job roles of the respondents exemplify that they are upper-level management, but also that most are in large

companies. This is a crucial finding because it can have a (positive or negative) impact regarding how much resources a company can invest into blockchain technology.

Graph A-8 (See Below) illustrates the percentage of respondents by planned investment amounts.

Graph A-8

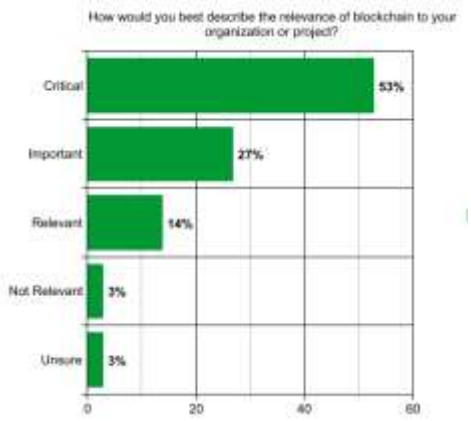
Percentage, planned investment amounts in blockchain

As seen in **Graph A-8,** 35 percent of respondents believe that their companies invest above 5million dollars in blockchain technology, while 27 percent believe their companies only between 1 million dollars and 5 million dollars in blockchain. Overall, most of these organizations have strong blockchain investment plans, which means they view blockchain's relevance in organizations.

Graph A-3 illustrates the views of blockchain relevance within organizations.

Graph A-3

Percentage, views of blockchain relevance

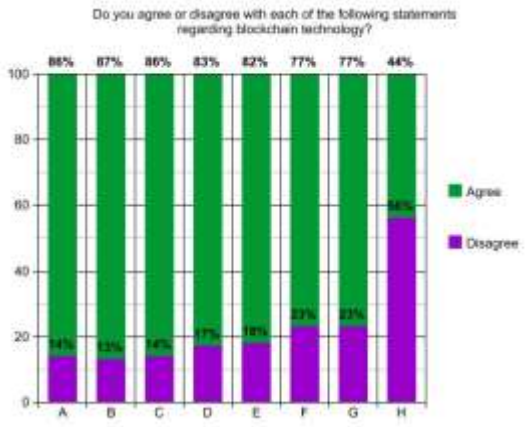


As seen in **Graph A-3**, most of the respondents (53 percent) see blockchain as a top-five strategic priority. However, 27 percent of the respondents believed blockchain to be important, but not a top strategic priority, while 14 percent did not believe blockchain to be critical or important, but still relevant. Overall, most respondents see blockchain as a critical factor relevant to their projects and companies. This is interesting because it shows that blockchain is growing in the eyes of many company executives and other decision-makers, so they are gradually seeing the potential of blockchain technology. However, not everyone is fully on board with the technology's potential, as seen in the results.

These appear to be mixed results regarding the views of blockchain's relevance, so Question 5 **(See Appendix A)** dived deeper into determining attitudes towards certain statements about blockchain technology. **Graph A-5 (See Below)** illustrates the survey respondents' attitudes towards the adoption and implementation of blockchain.

Graph A-5

Survey respondents' attitudes on blockchain and its adoption



As seen in **Graph A-5**, most respondents (86 percent) agreed that blockchain technology is readily available and will eventually become the reach 'norm', while 14 percent disagreed with this statement. It shows that 87 percent of survey respondents believe blockchain can steer business processes into a more modern age, enhance integration towards a more modern business process, but 13 percent disagree with this statement. **Graph A-5 (See Above)** depicts that most respondents agree blockchain makes it possible for new business procedures and revenue streams in the construction industry, but 14 percent of respondents disagreed with this statement.

It shows that 83 percent of company executives believe there is a strong need for blockchain technology in the UAE, while the other 17 percent of company executives disagreed with the notion. It also shows that 82 percent of survey respondents believe the company's suppliers are discussing or working on blockchain solutions, but 18 percent of the survey respondents did not believe that company's suppliers are working on blockchain

solutions. On another note, 77 percent of survey respondents believe that their competitors are also considering using blockchain solutions, but 23 percent of survey respondents were skeptical that their competitors are working on blockchain solutions.

Graph A-5 (See Above) depicts that 77 percent of survey respondents agree that their companies will lose a competitive edge if they do not start using blockchain technology, but 23 percent of survey respondents disagree with this statement. It also shows that 44 percent of the participants agree that blockchain is overhyped, but 56 percent disagreed with that blockchain is overhyped. Taken as a whole, we can see that there are generally positive attitudes regarding blockchain and its adoption. However, the percentage of survey respondents who strongly agree, that blockchain is 'overhyped', is slightly high.

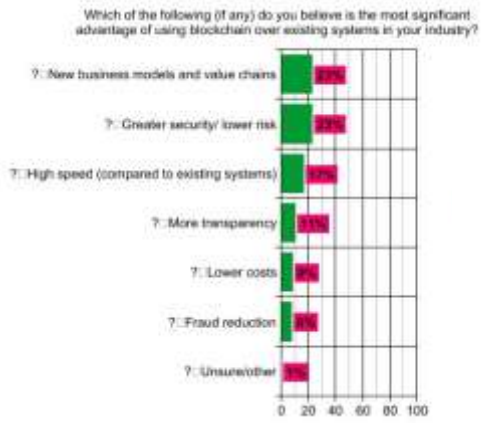
In hindsight, blockchain has been somewhat 'overmarketed' with superlative language (i.e. faster! stronger! better!). Because of this, many people become skeptical about whether (or not) the technology fully lives up the marketing hype. This uncertainty reflects the increasing pragmatic sentiments in the blockchain user community. There are two main divisions regarding the implementation of blockchain technology in the construction industry: 1) those who believe blockchain technology is important, and offer exciting opportunities for the future; 2) those skeptics who claim automation has no place in construction. There is a general fear of the uncertainty and skepticism, especially regarding the possibility of full automation in the construction industry (Mason & Escott, 2018).

Although the UAE is a technological advanced environment, the rigid reality of the construction industry clearly permeates views and perceptions of the survey respondents. However, this does not change the fact that blockchain technology has numerous advantages. They may be cautious, but not unwilling to dive deep into the technology. For example, the

technology can be beneficial when it involves contract administration and management. **Graph A-6 (See Below)** illustrates the respondents' insight regarding the very important advantages of blockchain (when compared to traditional/existing systems).

Graph A-6

Most significant advantage of blockchain



As seen in **Graph A-6**, 23 percent of respondent's view business model/value chain innovation as a key advantage of blockchain technology, but another 23 percent of the survey respondents also chose lower risk as a significant advantage of blockchain technology. In total, 46 percent of survey respondents cited business model/value chain innovation and lower risk as key advantages of blockchain. This is interesting because 'greater transparency' and 'lower (transaction) costs' are one of the strongest selling points used to promote blockchain technology to individual (P2P) users.

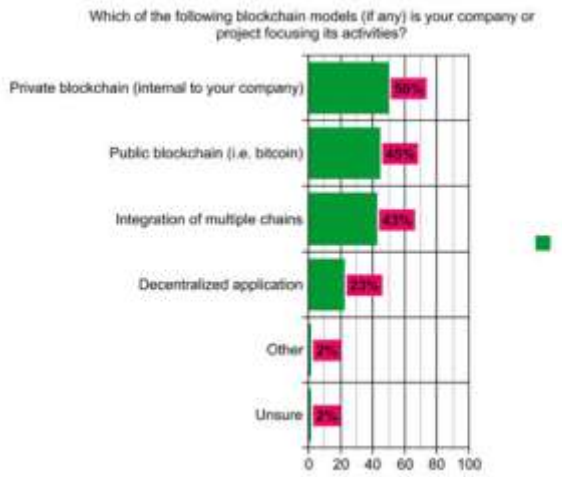
However, it is expected that respondents from enterprise organizations will be interested in other key features of blockchain technology, such as new business models and value chain innovation, greater security and lower risk, as well as greater speed compared to current systems. In other words, large companies deploy blockchain differently. They focus

on developing and implementing new solutions that utilize blockchain's potential on the market. Overall, companies should invest in the blockchain technology, by focusing on specific use cases and their position in the industry.

In addition, **Graph A-10 (See Below)** illustrates the company's preferred blockchain model (if any) for its activities. As seen in **Graph A-10**, most of the respondents (50 percent) preferred to adopt a private blockchain model for its activities.

Graph A-10

Blockchain models



However, these results are too close to count, seeing that around 45 percent also chose the public blockchain model, while another 43 percent chose to adopt an integration of both public and private blockchains. It is evident that most of the construction companies have not made a final decision regarding any one blockchain model or approach. In retrospect, it is possible for public and private blockchains to co-exist.

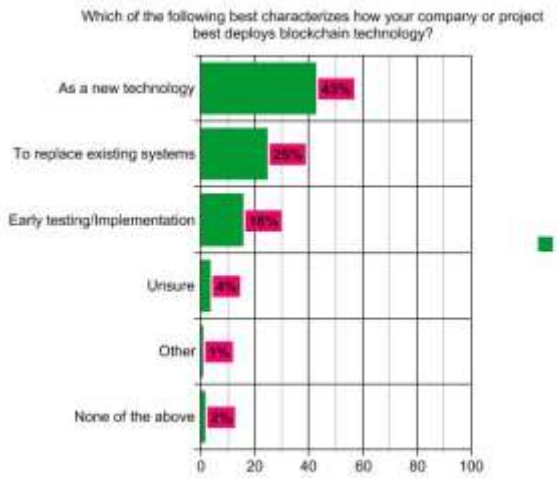
Each of the blockchain models work differently in certain industries, as well as on a case by case basis. In other words, every company must adopt blockchain approaches

depending on each case/project. For example, financial institutions may find private blockchains more appealing, but other industries may lean towards public blockchains. In this case, the respondents from the UAE construction companies have come to realize a private blockchain model (that is internal to the company) works best, when it comes to applying blockchain-based solutions to its projects.

Considering this, **Graph A-9** depicts how blockchain investment is being deployed in these companies. As seen **in Graph A-9**, a majority (43 percent) of the respondents state their companies deployed blockchain as a new technology. On the other hand, twenty-five percent of the respondents admit to replacing existing systems with blockchain technology.

Graph A-9

Deployment of blockchain investment



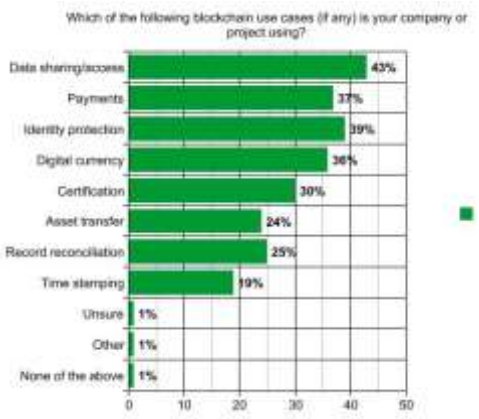
This is quite an enthusiastic (and almost drastic) response, but it does reflect the general attitudes about blockchain in the UAE. Regardless that these are private companies, the UAE government particularly fosters a blockchain-positive environment. In fact, the UAE government recently launched the Emirates Blockchain Strategy 2021 and Dubai

Blockchain Strategy. According to AlTaei (2020), this purpose of this strategy is to transform half of the government's dealings into the blockchain platform by 2021. The UAE Government intends to incorporate blockchain technology into its transactions (AlTaei, 2020). Evidently, the UAE government is making numerous strides towards adopting the latest blockchain technologies and innovation practices.

It is evident that the UAE government as well as business organizations are making numerous efforts to invest in blockchain technologies. Hence, it is important to examine blockchain use cases by these companies (if any). **Graph A-12 (See Below)** examine blockchain use cases that the companies are working with.

Graph A-12

Blockchain use cases



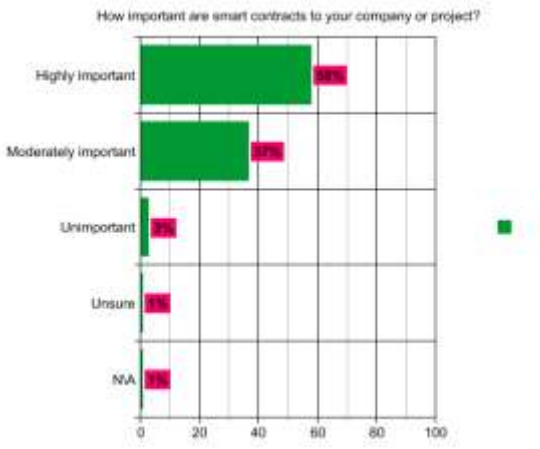
As seen in **Graph A-12**, most respondents (42 percent) use blockchain technology for data sharing/access. Thereafter, there is an even distribution of blockchain use cases in 30-percent-range. Specifically, 39 percent of survey respondents cited identity protection, 37 percent of respondents use blockchain for payments, 36 percent of respondents use it for digital currency, while 30 percent use it for certification. Evidently, these companies are

looking at different uses for blockchain technology, beyond payments and transactions. They apply blockchain-based solutions to different tasks and activities, but more usage for data validation, access and sharing.

This highlights blockchain's long term potential to be used in different capacities. For example, blockchain smart contracts can be used in a wide range of areas, such as interorganizational transactions, invoices, and other warranties financing. **Graph A-13 (See below)** illustrates the importance of smart contracts to companies (or a project).

Graph A-13

Smart contracts as a priority



As seen in **Graph A-13**, most respondents (58 percent) view smart contract as a highly important blockchain capability. However, 37 percent of survey respondents feel that smart contracts are moderately important to the company/project, while 3 percent of survey respondents believe smart contracts are not important to the company. Evidently, most respondents see smart contracts as a highly important and beneficial blockchain-based

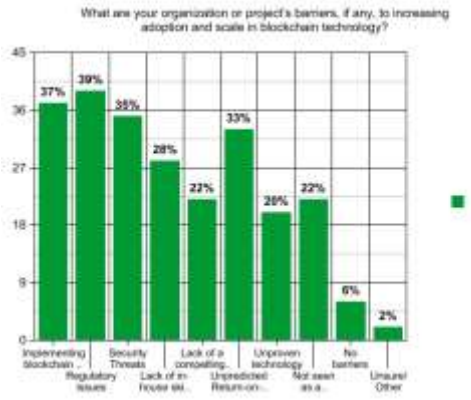
solution for the company. It is interesting to find that smart contracts are considered highly important to projects, by construction companies in the UAE.

In fact, blockchain smart contracts can be used in certain areas of PM. First, it automates transactions related to subcontractors' terms and conditions. For example, smart contract functionalities can manage invoices and payments when deliverables are accepted, or milestones are met (Cuccuru, 2017). Second, it can be used performance data pertaining to the project. Specifically, it can be used to record project phases, team assignments, time sheets, cost sheets, progress reports amongst other things (Cuccuru, 2017). It can also be used to store project status reports, project procurement decisions and other vital data pertaining to the project.

Nonetheless, it is important to determine some (if any) barriers to even more investment in blockchain technology. **Graph A-7 (See Below)** illustrates the (chosen) factors that respondents view as organizational barriers.

Graph A-7

Organizational barriers

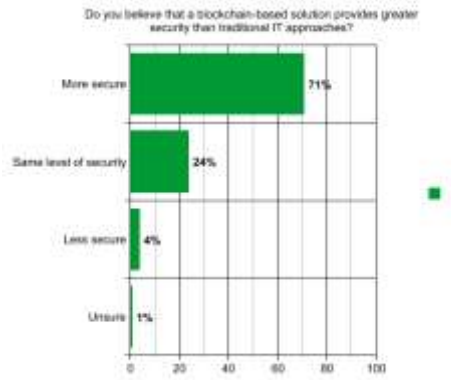


As seen in **Graph A-7**, there is very little consensus regarding organizational barriers to adoption blockchain technology. Although, most cited choices are in the 30-percent-range, most respondents (39 percent) cited regulatory issues as a barrier to further investing and adopting blockchain technology. Another 37 percent of respondents cited implementation as a barrier, which means the issue arises from either replacing or adapting existing system to blockchain. Subsequently, 35 percent of survey respondents believe potential security threats are an issue, while 33 percent see the uncertain ROI as another key issue.

It is evident that there is an even distribution of barriers that prevent companies from making further investment into blockchain technology. The issue of security especially appears to be a recurring (and complex) issue for the respondents. For instance, **Graph A-6 (See Above)** showed that 23 percent of the survey respondents believe greater security/lower risk as a significant advantage of blockchain technology. However, **Graph A-7 (See Above)** 35 percent of survey respondents believe potential security threats are a serious organizational barrier to greater investment in blockchain technology.

Therefore, **Graph A-11 (See below)** illustrates how the respondents feel about the strictness of security in blockchain solutions, when compared to traditional IT solutions.

Graph A-11
Level of Security

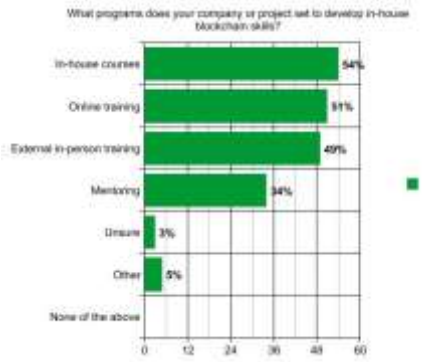


As seen in **Graph A-11**, most respondents (71 percent) believe that blockchain-based solutions are more secure than traditional IT solutions. About 24 percent of respondents believe that blockchain-based solutions and traditional IT solutions offer the same level of security, but only 4 percent of respondents believe blockchain-based solutions are less secure than traditional IT solutions. Evidently, most respondents believe blockchain-based solutions are more secure than conventional IT systems. This finding deserves further consideration, especially by companies' that are on the fence about replacing or adapting existing system to blockchain (implementation).

In addition, this confusion surrounding the implementation and adoption of blockchain technology may also arise from not having basic skills and understanding of the technology. As seen in **Graph A-7**, 28 percent of participants cited this factor as a barrier to further investing and adopting blockchain technology. Hence, it is crucial for these companies to develop in-house blockchain skills. **Graph A-14 (See Below)** illustrates what programs these companies offer to develop in-house blockchain skills.

Graph A-14

Building in-house blockchain skills



As seen in **Graph A-14**, most respondents (54 percent) have in-house courses to develop blockchain skills. 51 percent of survey respondents also offer online training, while 49 percent of survey respondents offer external in-person training to build in-house blockchain skills. It is evident that these companies utilize a wide range of training channels, to build out their blockchain talent base. Overall, these results demonstrate that a positive attitude towards blockchain technology. It shows company executives (and other decision-makers) are increasingly becoming more aware of blockchain's importance as well as becoming more confident in its transformative potential. Generally, it is safe to say that the findings reflect a collective opinion about utilizing the technology in everyday business cases.

Furthermore, survey respondents appear to be optimistic about blockchain because they have had some time to discover the technology, beyond the (over) hype. They see that blockchain is more than bitcoin and the technology of cryptocurrency, because the blockchain technology has the potential to drive innovative in many ways, including

managing data and certifications, and many more uses. Hence, they are trying to ascertain the different roles blockchain can play within their organizations.

For this reason, most companies are interested in exploring a wide range of useful blockchain-based applications & solutions. Top management drives more projects that use blockchain strategically. On another note, regulatory issues remain one of the major organizational barriers to the implementation and adoption of blockchain technology. As seen in **Graph A-7**, most respondents (39 percent) cited regulatory issues as a barrier to further investing and adopting blockchain technology. This issue should be addressed because blockchain regulation has mostly been focused on cryptocurrencies.

In fact, government regulators focus more on the legal status of cryptocurrencies and digital assets than any other aspects of blockchain technology (Girasa, 2018). It is necessary to have additional regulatory developments in other blockchain applications. While some governments merely regulate blockchain technology, other governments advocate and utilize blockchain applications (Girasa, 2018). For example, the UAE government shows interest in blockchain applications, to tactically drive innovation. Some use cases include digital currency & payments, shareholder proxies, and identity management (Girasa, 2018).

Further studies can be done to determine the general attitudes about government as a blockchain user and regulator. Overall, the UAE government as well as business organizations are making numerous efforts to invest in blockchain technologies. In this case, we see blockchain smart contracts are highly important to projects. Blockchain technology (using smart contracts) can impact PM tools and practices.

RQ 1: Will PM be Impacted by the introduction of Blockchain Technology?

It is evident that PM can be Impacted by the introduction of Blockchain Technology. blockchain-based apps & solutions can offer many opportunities (construction) projects management, from managing subcontractors and efficient payment systems, to digitizing contracts and managing assets and inventories. It is especially possible via smart contract functionalities. It can also be used to record and store performance data and other necessary information pertaining to the project.

In fact, blockchain smart contracts can be used in certain areas of PM. For example, smart contract functionalities can manage invoices and payments when deliverables are accepted, or milestones are met (Cuccuru, 2017). Second, it can be used to collect performance data pertaining to the project. It can also be used to store project status reports, project procurement decisions and other vital data pertaining to the project. Blockchain technology allows different PM tools to interoperate provided they agree on formats and data (Erhan et al, 2019). Consequently, the technical details can be hidden, so stakeholders and project managers can only see the project status reports stored in Blockchain.

RQ 2: Which areas of PM will have the potential of using blockchain technology?

Blockchain smart contracts can be used in certain areas of PM. For example, blockchain smart contracts can be utilized in areas of purchase management, which include purchase orders, delivery notes and invoices. It eliminates this paper-based, manually-operated system and switches these operations into distributed digitalized form (Turk & Klinc, 2017). A smart contract mitigates the risk of fraud and opportunistic behavior. Most importantly, smart contracts can manage all transactions related to orders, deliveries, and invoice (Zheng et al, 2017).

For this reason, based on the above and feedback that we have obtained from the questionnaire from these number of people and designations in the field; we have seen a strong demand on the need of blockchain technology in the project management field and therefore it will be a strong tool to adopt and implement in the field of construction.

H1: It is proven that block chain using smart contracts can have a significant effect on the construction sector.

H2: It is proven that block chain using smart contracts has a significant effect on PM practices

H3: It is proven that block chain using smart contracts has a significant effect on construction PM

For the project manager, it creates a framework that permits for input, but also performs oversight that's more productive compared to conventional PM systems (Hewavitharana et al, 2019). Essentially, it could appear like this framework of management is like other means of operating projects. blockchain technology allows the project manager to keep things on track. Moreover, it correct mistakes, and keep projects focused. It is also efficient because it also limits discussions to project issues, as these must transmit through the blockchain system. Moreover, the project manager will have access to all information and can alter appropriately when there is a need for a change. The blockchain itself can handle all transactions to make them more efficient.

Evidently, blockchain can be of importance, especially regarding data management. It simply provides a communication platform between different players, as well as enable them to handle the workflow more efficiently (Turk & Klinc, 2017). It allows tracking data,

reducing delays in sending (and receiving) documents, as well as boost decision-making procedures. Overall, the main applications of blockchain technology entails the optimization of project management in several ways. Specifically, smart contracts can replace simple supply-type contracts, which reduces the huge paper load associated with processing contracts (Mason & Escott, 2018). Even though there is a belief throughout the industry that disputes cannot be solved with a computer, the technology can help to be more transparent and organized, which can help to avoid disputes in the first place. In addition, some people also believe the technology diminishes human interaction and relationships (Mason & Escott, 2018).

It is expected that respondents from enterprise organizations will be interested in other key features of blockchain technology, such as new business models and value chain innovation, greater security and lower risk, as well as greater speed compared to current systems. In other words, large companies deploy blockchain differently. They focus on developing and implementing new solutions that utilize blockchain's potential on the market. Overall, companies should invest in the blockchain technology, by focusing on specific use cases and their position in the industry.

Each of the blockchain models work differently in certain industries, as well as on a case by case basis. In other words, every company must adopt blockchain approaches depending on each case/project. For example, financial institutions may find private blockchains more appealing, but other industries may lean towards public blockchains. In this case, the respondents from the UAE construction companies have come to realize a private blockchain model (that is internal to the company) works best, when it comes to applying blockchain-based solutions to its projects.

The conceptual framework depicts the effects of the block chain technology on project management practices in the construction industry, in the UAE. The three hypotheses being tested consist of one dependent variable (construction project management) and two independent variables (blockchain & smart contracts). Specifically, it aims to show the role and importance of implementing blockchain technology and smart contracts in construction PM, as opposed to current systems. In fact, there is a strong link between smart and PM tools. Smart contract functionalities can manage invoices and payments, collect performance data pertaining to the project, store project status reports, project procurement decisions and other vital data pertaining to the project.

A smart contract especially is a key innovation that can save people a lot of time, energy, and resources. It is basically a digital contract, because terms and agreements can execute automatically when the predefined conditions are met (Mason & Escott, 2018). Originally related on the Ethereum platform, smart contracts can process computer codes and scripts on the blockchain. Specifically, the codes are secured on the blockchain, as input conditions which come from the blockchain (Mason & Escott, 2018). Such conditional functions act as digitally binding contracts recorded on ledger (i.e. blockchain). Therefore, smart contracts is one of the strongest tools of blockchain technology. With smart contracts, many processes can be more efficient, enhanced, automatized (Mason & Escott, 2018).

It helps to hold all parties on a project responsible and increase transparency. Smart contracts can be utilized to ensure that all stakeholders on a project get timely payments. It can improve the payment process by increasing security and creating traceable information. In other words, blockchain ensures that subs are paid fast, without any disputes. Blockchain combined with smart contract functionalities can improve supply chain management. It can

track items from point A to B. It can also improve transparency, which benefits all parties, so they remain on the same page and dodge potential pitfalls and oversights. For example, smart contract functionalities can manage invoices and payments when deliverables are accepted, or milestones are met (Cuccuru, 2017). Second, it can be used performance data pertaining to the project. Specifically, it can be used to record project phases, team assignments, time sheets, cost sheets, progress reports amongst other things (Cuccuru, 2017). It can also be used to store project status reports, project procurement decisions and other vital data pertaining to the project.

7. CONCLUSION & RECOMMENDATIONS

In conclusion, blockchain is a technology that lets people and organizations to achieve agreements as well as store transactions and data transparently, without an intermediary (Novotny, 2018). It can be used to create a fair, wide-ranging, reliable, and autonomous digital economy. It is simply a type of diary with information about transactions. It is a very secure system because the Blockchain updates itself every 10 minutes (Shackelford & Myers, 2017). The Blockchain becomes a database, whereby every node has access to the chain. Hence, it is almost impossible to fake a block as it needs to be valeted by other nodes. (Shackelford & Myers, 2017).

Blockchain's security is top-notch because it is encrypted and decentralized. There are thousands of these nodes scattered worldwide, so trying to capture (or mimic) the system needs incredible computer power. Overall, Blockchain is a ledger of transactions that automatically verifies itself (Novotny, 2018). No single node (or computer) controls the data. They can however confirm the ledger, without the use of intermediaries to control or regulate (Novotny, 2018). It is architecturally decentralized, in the Blockchain. Blockchain is a groundbreaking technology that changes the communication methods of people and organizations across borders.

Blockchain is a connective intelligence that entails apps, data, concepts, and people being connected by a decentralized system that does not require intermediaries to protect or store data (Lee, 2019). Overall, blockchain technology represents a tectonic change in the world of business. The technology will transform the culture of how businesses and organizations interact in the digital world. The research paper focuses on the applying and using blockchain in the UAE construction industry. The findings of this study can benefit the

UAE considering that the construction industry and blockchain technology are fast becoming natural partners in this technological revolution. Thus, the resulting framework will consist of strategies and practices that could be used to enhance construction project management (PM). It is a perfect illustration of how UAE construction companies can form strategic alliances with blockchain tech firms, to create value addition and other improvements to overcome obstacles facing the industry.

Furthermore, the greater demand for blockchain technology justifies the need for block-chain based solutions, such as smart contracts because these solutions are more effective and dependable approaches that can modernize construction PM, especially in the UAE. For this reason, this study can help researchers further uncover critical areas in construction PM that were deemed too complicated or unexplorable to integrate with blockchain technology. Overall, researchers will be informed and guided (by the recommended approaches derived from the research findings) on what factors should be emphasized, to further incorporate blockchain-based solutions into various UAE industries.

The research paper proposes applying blockchain technology in construction projects through smart contract functionalities. It is expected that the blockchain- based solutions and platforms can make significant contributions to construction projects. The research methodology utilizes the use of both secondary and primary sources. It applies a literature review approach, which involved finding and identifying relevant articles related to the topic, to review and analyze. It also utilizes a survey questionnaire to gain more insight into the overall attitudes towards the technology. Specifically, it measures attitudes and investments about using blockchain in the UAE. The research paper examines the impact of blockchain technology on project management practices in three phases. First, it discusses the fields of

Construction and Project Management (PM) before the creation and evolution of blockchain technology.

Second, it examines the project life cycle & standard PM approach as well as the effective implementation of life cycle management (LCM) in construction projects. Third, it conveys that the applying blockchain in the construction industry means improving PM. The goal is to illustrate how UAE construction companies can implement blockchain technology, to create value addition and other improvements to overcome obstacles facing the industry.

Blockchain technology is a transformative technology that can integrated into varying industries and cases. The purpose of this research is to propose an integrated framework for introducing Blockchain technology in the Project Management profession. The paper provided a detailed history and evolution of Blockchain technology, from the publishing of Nakamoto's 'White Paper' to the emerging innovations that excelled beyond Bitcoin. It also provides a detailed description of the key principles of blockchain and how the blockchain (BC) technology works. The paper presents blockchain technology via smart contracts as a key technique to enhance the LCM of construction (building) projects.

In addition, the application of blockchain in the construction industry entails the optimization of project management. The goal is to illustrate how UAE construction companies can implement blockchain technology, to create value addition and other improvements to overcome obstacles facing the industry. The resulting framework will consist of strategies and practices that could be used to enhance Project Management. The research questions are as follows:

RQ 1: Will PM be Impacted by the introduction of Blockchain Technology?

RQ 2: Which areas of PM will have the potential of using blockchain technology?

First, it is evident that PM can be Impacted by the introduction of Blockchain Technology. It is especially possible via smart contract functionalities. Smart contracts can be used to record and store performance data and other necessary information pertaining to the project. Second, blockchain smart contracts can be used in certain areas of PM. For example, blockchain smart contracts can be utilized in areas of purchase management, which include purchase orders, delivery notes and invoices.

It replaces traditional contracts and eliminates this manual (paper) operation system into distributed digitalized form (Turk & Klinc, 2017). A smart contract mitigates the risk of fraud and opportunistic behavior. Most importantly, smart contracts can manage all transactions related to orders, deliveries, and invoice (Zheng et al, 2017). Furthermore, Blockchain technology ensures security and transparency among the relevant parties. Smart contracts could be initiated for every task and every completed item. It can keep track of costs, assignments, and other factors. In the case of financial management, for instance, it can automatically expedite payments and reduce any delays in dispersing funds.

Consequently, deliveries and invoices can be connected to payment, when the work is done, or orders are completed. It can also manage the movement of materials (Hewavitharana et al, 2019). It redefines purchasing systems and eliminates unnecessary storage costs & maintenance costs. For these reasons, blockchain can influence traditional

construction practices, via blockchain smart contracts, as an effective and efficient project management tool for the construction industry.

In addition, construction firms are project-based organizations that constantly demand for more expeditious methods pertaining to, for example, project status reports. To be successful, these methods must avoid the bureaucracy of paperwork or management meetings, and should be fully digitalized, online, and able to report (and update) in real time. Therefore, smart contract functionalities can make significant improvement in project management in the construction industry. It can engage stakeholder on project updates and reviews, which improves trust between PM and stakeholders.

It can also help project managers to monitor and control the project. On one hand, stakeholders are involved to ensure successful project completion, while project managers are made aware of people & tasks, while supervising the project. However, skeptics cite that the technical programming behind the blockchain is a bit too complex, which further complicates investing in, and implementing the technology. According to the survey, 28 percent of participants cited employees lacking basic skills and understanding of the technology as a barrier to further investing and adopting blockchain technology (See Graph A-7).

However, it is not crucial to know everything about the Blockchain underlying technology before integrating blockchain-based solution with project management tools and systems. They can use the available software APIs (i.e. application programming interface) to deliver solid solutions rapidly & transparently (Erhan et al, 2019). Blockchain technology allows different PM tools to interoperate provided they agree on formats and data (Erhan et

al, 2019). Consequently, the technical details can be hidden, so stakeholders and project managers can only see the project status reports stored in Blockchain.

Overall, it is evident that blockchain-based apps & solutions can offer many opportunities (construction) projects management, from managing subcontractors and efficient payment systems, to digitizing contracts and managing assets and inventories. In fact, the research proposes a conceptual model that is based on a blockchain-based software for two main reasons. First, this software encourages stakeholders through information sharing. It can also help project managers to monitor and control the project. On one hand, stakeholders are involved to ensure successful project completion, while project managers are made aware of people & tasks, while supervising the project. However, skeptics cite that the technical programming behind the blockchain is a bit too complex, which further complicates investing in, and implementing the technology. According to the survey, 28 percent of participants cited employees lacking basic skills and understanding of the technology as a barrier to further investing and adopting blockchain technology (See Graph A-7).

Hence, this paper advocates for the use of blockchain smart contract in construction projects because smart contract functionalities meet (and exceed) these key requirements. However, further research can be done to evaluate the standards and the applicability of the technology in other use cases (Erhan et al, 2019). In hindsight, blockchain is an innovative technology that has been somewhat overhyped, leaving skeptics to believe that the technology may possibly fail to meet the (hyped) expectations, and not deliver what it promises. It examines different aspects of applying and using blockchain, such as designing different blockchain systems, deploying blockchains to generate value, as well as managing

and regulating different blockchain systems (e.g. organizational, individual, and artificial systems).

It is vital to investigate implementing blockchain systems on different levels of analysis. Even though the aim of the survey was to collect data on attitudes regarding blockchain systems in organizations, or specifically construction companies, further research needs to be done, for the neglected fields of blockchain. We must also review existing literature on blockchain and go beyond understanding blockchain as cryptocurrencies because blockchain has a lot of potential for various industries.

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APPENDIX A: SURVEY QUESTIONNAIRE

GROUP 1: DEPENDENT VARIABLE A (Construction PM)

1. **Which of the following best describes your current role?**
   - Upper Management (VP, SVP, Director)
   - Executive-level managers (CEO, CFO, COO, CIO)
   - Owner/Partner
   - Board member

2. **Which of the following best represents your company or project's overall annual revenues (2018-2019)?**
   - $100 million, but less than $250 million
   - $250 million, but less than $500 million
   - $500 million, but less than $750 million
   - $750 million, but less than $1 billion
   - $1 billion or more

3. **Which area/department of your company makes the key business decisions about blockchain activities?**
   - IT
   - Top management
   - Operations
   - R&D
   - Finance
   - Supply Chain

4. **Which of the following (if any) do you believe is the most significant advantage of using blockchain over existing systems in your industry?**
   - New business models and value chains
   - Greater security/ lower risk
   - High speed (compared to existing systems)
   - More transparency
   - Lower costs
   - Fraud reduction
   - Unsure/other

GROUP 2: INDEPENDENT VARIABLE A (Blockchain)

5. **How would you best describe the relevance of blockchain to your organization or project?**
   - It is critical, in our top five strategic priorities
   - It is important, but not in our top strategic priorities
   - It is relevant, but not a priority

- Not relevant
- Unsure/undecided

6. **Do you agree or disagree with each of the following statements regarding blockchain technology?**
   A. Blockchain technology is widely accessible and will eventually reach mainstream adoption
      - Agree
      - Disagree
   B. I believe blockchain can enhance integration towards a more modern business process
      - Agree
      - Disagree
   C. I believe blockchain can enable new business functionalities and revenue streams in my industry
      - Agree
      - Disagree
   D. Company executives believe there is a strong business case for blockchain technology
      - Agree
      - Disagree
   E. Our suppliers are discussing or working on blockchain solutions to address challenges in the industry
      - Agree
      - Disagree
   F. Our competitors are discussing or working on blockchain solutions to address challenges in the industry
      - Agree
      - Disagree
   G. We will lose a competitive advantage if we do not adopt blockchain technology
      - Agree
      - Disagree
   H. Blockchain is overhyped
      - Agree
      - Disagree

7. **What are your organization or project's barriers, if any, to increasing adoption and scale in blockchain technology?**
    - Implementing blockchain (to replace existing systems)
    - Regulatory issues
    - Security Threats
    - Lack of in-house skills and understanding
    - Lack of a compelling case showing application of the technology
    - Unpredicted Return-on-Investments (ROI)
    - Unproven technology
    - Not seen as a business priority
    - No barriers
    - Unsure/Other

8. **How much investment does your organization make into blockchain technology?**
    - No investment
    - Prefer not to answer
    - Unsure
    - Less than $100, 000
    - From $100,000 to $500, 000
    - From $500,000 to $1million
    - From $1million to $5million
    - $5million or more

9. **Which of the following best characterizes how your company or project best deploys blockchain technology?**
    - As a new technology
    - To replace existing systems
    - Early testing/Implementation
    - Unsure
    - Other
    - None of the above

10. **Which of the following blockchain models (if any) is your company or project focusing its activities?**
    - Private blockchain (internal to your company)
    - Public blockchain (i.e. bitcoin)
    - Integration of multiple chains
    - Decentralized application
    - Unsure
    - Other
    - None of the above

GROUP 3: INDEPENDENT VARIABLE B (Smart Contracts)

11. Which of the following blockchain use cases (if any) is your company or project using?

- Data sharing/access
- Payments
- Identity protection
- Digital currency
- Certification
- Asset transfer
- Record reconciliation
- Time stamping
- Unsure
- Other
- None of the above

12. How important are smart contracts to your company or project?

- Highly important
- Moderately important
- Unimportant
- Unsure
- Not applicable

13. Do you believe that a blockchain-based solution provides greater security than traditional IT approaches?

- More secure
- Same level of security
- Less secure
- Unsure

14. What programs does your company or project set to develop in-house blockchain skills?

- In-house courses
- Online training
- External in-person training
- Mentoring
- Unsure
- Other
- None of the above

15. Did you enjoy taking this survey?

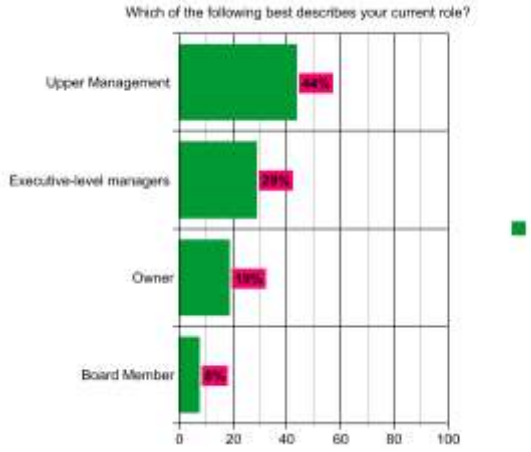
- Yes
- No
- Prefer not to say

Survey monkey link (part 1): https://www.surveymonkey.com/r/SC2MVQP

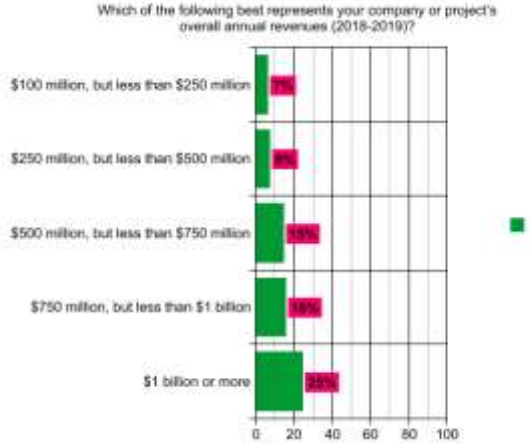
Survey money link (Part 2): https://www.surveymonkey.com/r/S2B9MPR

APPENDIX B: GRAPHS

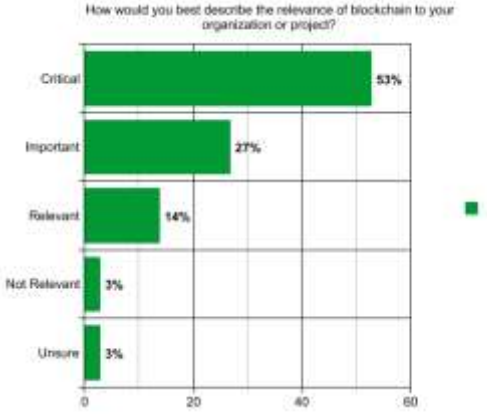
Graph A-1
Respondents, by job role



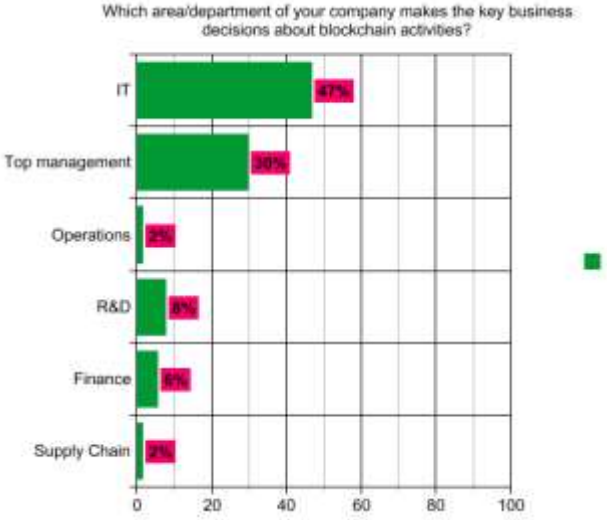
Graph A-2
Company overall annual revenues in 2019



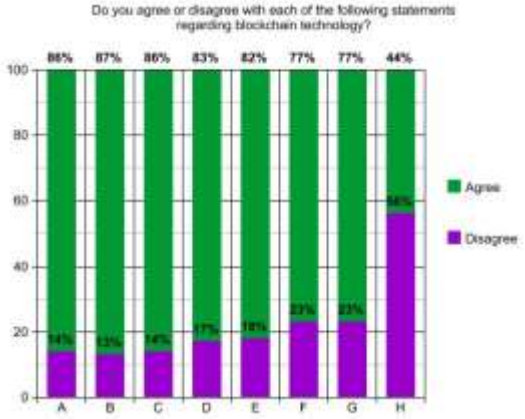
Graph A-3
Percentage, views of blockchain relevance



Graph A-4
Group making key decisions about blockchain

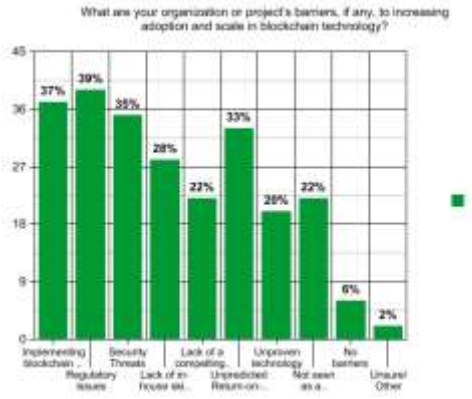


Graph A-5
Survey respondents' attitudes on blockchain and its adoption



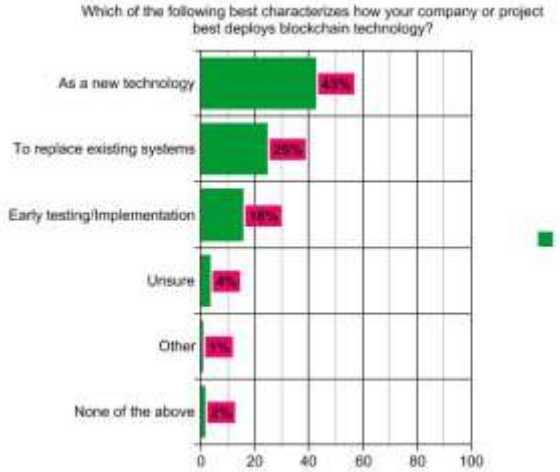
Graph A-6
Most significant advantage of blockchain

Graph A-7
Organizational barriers

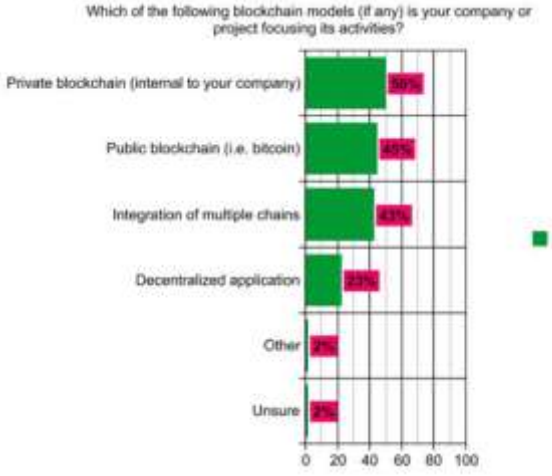


Graph A-8
Percentage, planned investment amounts in blockchain

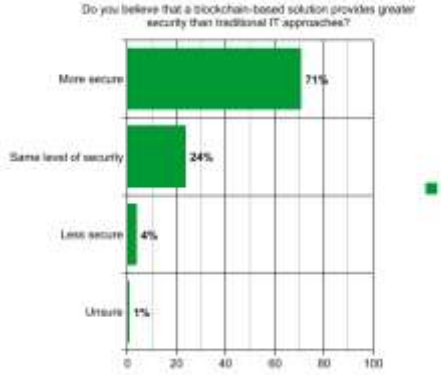
Graph A-9
Deployment of blockchain investment



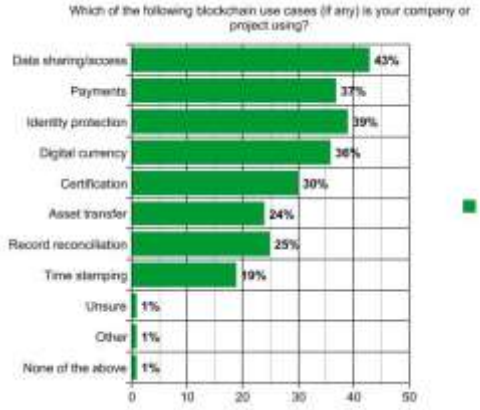
Graph A-10
Blockchain models



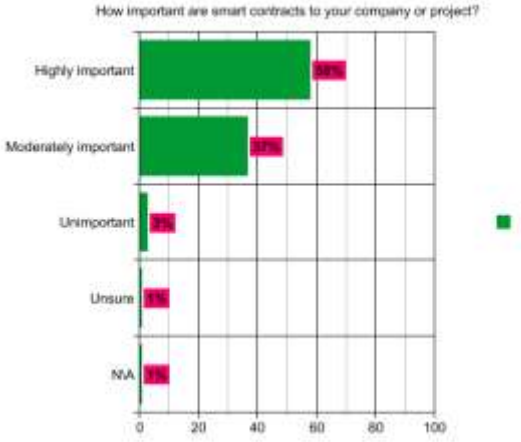
Graph A-11
Level of Security



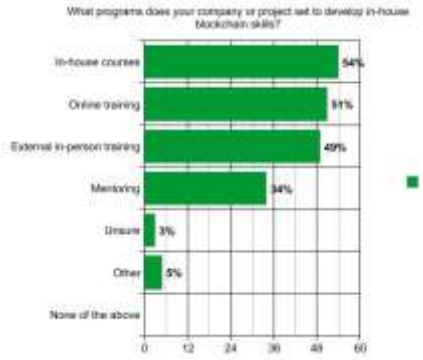
Graph A-12
Blockchain use cases



Graph A-13
Smart contracts as a priority



Graph A-14
Building in-house blockchain skills



APPENDIX C: TABLES

LIST OF UAE COMPANIES (FOR SURVEY)

1. **Al Naboodah Construction Group**
2. **General Construction Co. (GCC)**
3. **Al Geemi & Partners Contracting Company L.L.C**
4. **Pivot Engineering & General Contracting Co. (LLC)**
5. **Ecotherm Contracting L.L.C.**
6. **Target and Jima Construction Company LLC (TJCC)**
7. **Abu Dhabi Construction Company (ADCC) LLC**
8. **ACC Arabian Construction Company**
9. **Amana Contracting & Steel Buildings**
10. **Arabtec Construction L.L.C.**
11. **Al Jaber LEGT Engineering & Contracting (ALEC)**
12. **Al Habtoor Group LLC**
13. **Al Futtaim**
14. **[UNEC] United Engineering Construction Company – Dubai**
15. **Fujairah National Construction Co. L.L.C**
16. **Pravarthi buildings contracting LLC**
17. **Adnan Contracting LLC**
18. **Vision Construction LLC**
19. **Dubai Contracting Company LLC**
20. **Tinka Contracting LLC**