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EMERGING LEGAL ISSUES IN BLOCKCHAIN FOR CONSTRUCTION SUPPLY CHAINS

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ABSTRACT

A complex web of supply chains is a common feature of construction projects. With the different types of parties involved in a project and the amount of paperwork generated, the supply chain process can be time-consuming, an easy target for fraud and is prone to human errors.

Blockchain is an emerging technology that can transform, simplify and make a network of information more secure. In the context of the supply chain, digitalised documents and real-time information can lead to cost-savings in any operation. Its embedded feature of transparency and integrity proves itself to be reliable. In addition, there are two less widely considered advantages that are particularly suitable for applying in the administration and management of the complex web of supply chains in the construction industry. The two additional advantages are dispute avoidance and dispute resolution, which will be discussed in this paper.

The use of blockchain in supply chains carries legal issues. This could be a contributing factor to its slower rate of adoption than widely anticipated after the rapid emergence of its first application in the financial system of cryptocurrency, commonly known as Bitcoin. This paper identifies and proposes solutions to three key legal issues arising from the use of blockchain technology in supply chains. They are (a) restricted use of smart contracts to prescribed outcomes only; (b) concerns relating to access and ownership of using a shared blockchain platform; and (c) multi-jurisdiction concerns over where governing laws apply.

KEYWORDS

Blockchain, construction supply chain, smart contract, digital platform, multi-jurisdiction

1. INTRODUCTION

A complex web of supply chains is a common feature of construction projects. With the different types of parties involved in a project and the amount of paperwork generated, the supply chain process can be time-consuming, an easy target for fraud and is prone to human errors.

Blockchain is an emerging technology that has the potential to transform, simplify and make a network of information more secure. In the context of the supply chain, there are number of distinct advantages over the traditional paper-based procedures and processes that extend beyond the administration and management of the supply chains in the construction industry. However, the use of blockchain in supply chains carries legal issues. This could be a contributing factor to its slower rate of adoption than widely anticipated after the rapid emergence of its first application in the financial system of cryptocurrency, commonly known as Bitcoin. This paper identifies and proposes solutions to three key legal issues arising from the use of blockchain technology in supply chains. They are (a) restricted use of smart contracts to prescribed outcomes only; (b) concerns relating to access and ownership of using a shared blockchain platform; and (c) multi-jurisdiction concerns over where governing laws apply.

The objectives of this paper are three-fold. Firstly, it identifies the benefits of using blockchain technology in complex global construction supply chains by reference to oil and gas offshore construction and supply projects. Secondly, it examines the emerging legal issues arising from the use of blockchain in supply chains. Thirdly, it offers solutions to legal issues identified above.

This paper draws on knowledge in practice from a range of disciplines including law, technology and supply contracts. It is considered a multi-disciplinary approach is important in

analysing the current limitations of using blockchain and steer the direction of further development in this area so that the benefits of using blockchain for supply chains can be maximised.

In Section 2 of this paper, a typical construction project is used to illustrate how a web of supply chains is formed and operated. The use of blockchain in supply chains is introduced in Section 3. The section also identifies the benefits of using blockchain in construction projects. Section 4 explains three potential legal issues as identified in the open literature. Drawing parallels with experiences and lessons learnt from international construction practices, this paper proposes solutions to each of the three issues. In section 5, the implications of the findings from both legal and business perspectives are discussed. Considerations for the way forward for the industry are summarised in the conclusion in Section 6.

2. SUPPLY CHAINS IN CONSTRUCTION PROJECTS

Offshore construction projects involve complex contractual arrangements regulating the relationships of operators, contractors, subcontractors and suppliers. The complexity of construction supply chains is illustrated by reference to a conversion of a merchant tanker to a floating production vessel for extraction, production and processing of hydrocarbons in the North Sea. The offshore floating production system is commonly described as FPSO. Its technical term is Floating Production Storage and Offloading.

Figure 1 shows an FPSO in operation in the North Sea. Oil and gas are extracted from the sea bed. They are transported through the umbilicals and are processed by the equipment on the topsides of the vessel. The processed oil is then stored in the vessel. A tanker attends and collects the processed oil. The oil is offloaded to a tanker which takes the processed oil to terminal onshore.

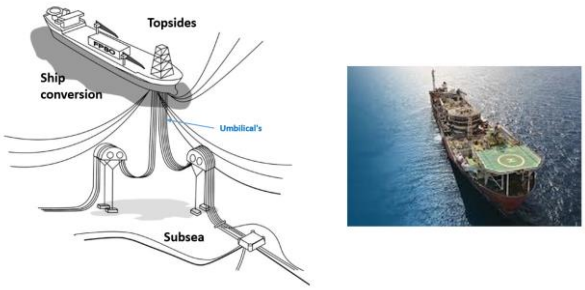

Figure 1: Floating Production Storage and Offloading

The traditional arrangement of an offshore construction project is that the operator sits at the top of the contractual chain and places a contract with the main contractor who, in turn, subcontracts the work to various specialist subcontractors and suppliers. There are other types of contracting strategies including partnering or alliancing, risk and reward, share gain and share pain. The common general arrangement for all these contracting strategies is that somebody carries out work in consideration of payment in accordance with the agreed contractual provisions.

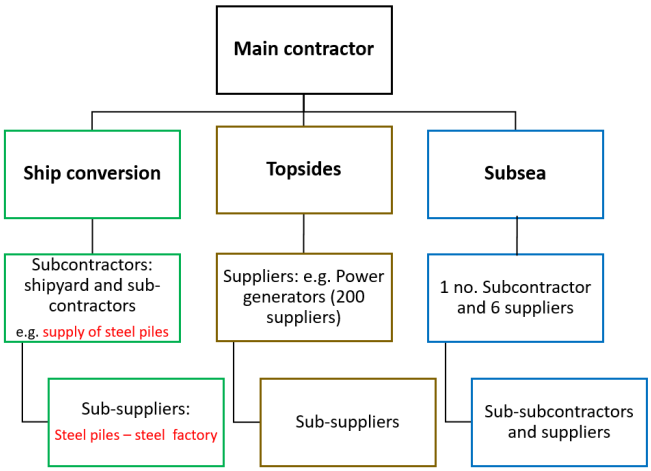

Figure 2: Supply chains in construction project

In this example and is shown in Figure 2, the work is divided into three packages. The first one is to convert a merchant tanker into a floating vessel - ship conversion. The main contractor sub-contracted the work to a shipyard where the modifications and upgrading for the tanker take place. Equipment is purchased and delivered to the shipyard for installation onto the vessel. At the same time, the subsea equipment is designed and manufactured. The subsea equipment and the floating vessel are then installed on the specific location in the North Sea. The main contractor places sub-contract for the installation of the FPSO. The sub-contractors and suppliers, in turn, place further subcontracts and purchase orders to meet their contractual commitments. The sub-contracting chain carried on.

Supply chains are typically flooded with paperwork, from test certificates to delivery notes, travelling from one part of the world to another. This is illustrated by following the journey of a steel pile from a steel factory to its integration with the FPSO. An order is placed with a steel factory. Based on the quality required, suitable steel plates are cut. Quality certificates are then produced. The steel plate is then rolled up to form a pipe. The ends of the steel plate are welded together. Non-destructive tests are performed and documented. The steel pipe is then transported to a fabrication yard to convert the raw steel pipe to a pile in accordance with the engineering specifications. Further tests are conducted on the pile before

it is transported to the main contractor site by road and by sea as appropriate. More papers are produced with more tests certificates, delivery notes, customs clearance. The pile is eventually integrated into the FPSO as an essential component with more test results and more paperwork.

Disputes can happen at any stage of the supply chain of the moonpool. One example is reported in a recent court case in England: Fluor Ltd v Shanghai Zhenhua Heavy Industries Ltd (Fluor, 2017). The matter concerned the supply of monopiles for use in an offshore wind farm project in the North Sea. The windfarm employer placed a contract with Fluor, who, in turn, placed an order with a steel fabrication yard in Shanghai, where the plates were welded together to form a steel column as the monopiles. The welds were subjected to non-destructive tests at the fabrication yard before they were delivered to a staging port in the Netherlands. These monopiles were retested at the port and were found to have cracks in the welds. They were rejected by the windfarm employer. A dispute arose between Fluor and the steel fabricator as to who was responsible for the weld repairs and retests. The test specification and test certificates at various stages of the supply chain were central to the dispute.

As explained later, had blockchain been used in this process, the dispute could have been avoided or at least the problem could have been detected earlier. This is because testing standards are specified and test results generated are distributed to all users when the data are created, any discrepancies in the data would be apparent and would alert parties to take corrective action before any further escalation of the error.

3. Blockchain for supply chains

Blockchain was invented by a person (or group of people) using the name Satoshi Nakamoto in 2008 to serve as the public transaction ledger of the cryptocurrency bitcoin. The invention of the blockchain for bitcoin made it the first digital currency without the need for a trusted authority or central server. The successful development of bitcoin has inspired other business applications using private blockchains.

A definition of blockchain is given in (Yaga *et al*, 2019).

Blockchains are distributed digital ledgers of cryptographically signed transactions that are grouped into blocks. Each block is cryptographically linked to the previous one (making it tamper evident) after validation and undergoing a consensus decision. As new blocks are added, older blocks become more difficult to modify (creating tamper resistance). New blocks are replicated across copies of the ledger within the network, and any conflicts are resolved automatically using established rules.

A blockchain is a growing list of records based on the concept of shared ledgers. Each block of records is linked using cryptography. This leads to a single source of truth. Parties identity and ownership are known to everyone sharing a software platform. This results in transparency. All transactions are recorded when they occur. The time of forming the block is recorded and any transaction data cannot be changed retrospectively. The entire process is computerised. Processing power is high and data management ability is efficient.

In the context of the supply chain, digitalised documents can eliminate human errors and lead to cost-savings in any operation. The availability of real-time information to all parties in the network reduces the time for processing payment and allows both buyers and suppliers predictable cash flow. Small to medium-size companies should find this advantage appealing. Its embedded feature of transparency and integrity proves itself to be reliable.

How blockchain works as a contract administration tool is explained by reference to the web of supply chains in a typical construction project, as shown in Figure 3. The figure shows

- The Main contractor entering a supply contract with 4 package sub-contractors for different aspects of work; for example, packages are allocated for building work, civil and structural engineering, packages of plants, and piping and electrical.

- The 4 package sub-contractors, in turn, enter supply contracts with their sub-suppliers and so on, forming supply chains.

- At the same time, the Main contractor forms contracts with other bodies, for example, insurance companies, publicity services providers and government agencies.

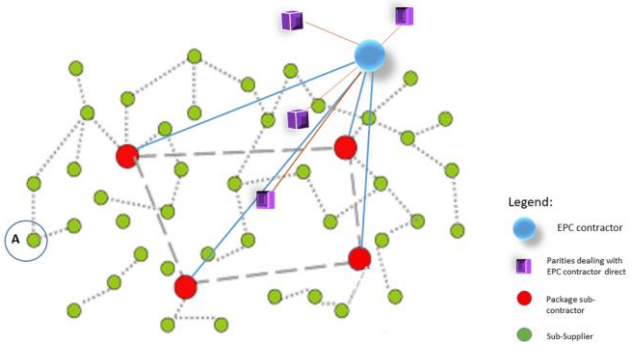

Figure 3: A web of construction supply chains

By using blockchain technology, any event that happens along a particular supply chain is recorded and distributed to all parties within the closed blockchain platform. For example, an event marked as "A" takes place in one of the chains. Other parties within the web, for example, other package sub-contractors or the EPC Main contractor, will know the occurrence of such an event and can prepare for any knock-on effects. Any impact on the progress and/or costs can be adjusted accordingly.

In addition, there are two less widely considered advantages, namely: dispute avoidance and if a dispute arises, blockchain is a very useful tool for dispute resolution. A lack of communication or communication of incorrect information is a major cause of conflict in construction projects (McKinsey & Co., 2016). Blockchain's assured flow of encrypted information in real-time to all parties involved can prevent poor communication or lack of communication resulting in the avoidance of disputes. Even when disputes occur, the immutability, high processing power and efficient data management and the transparent audit trail all assist the dispute resolution process. These features play an important role in the collection and collation of evidence in terms of details and speed. These features can iron out any dispute of facts reducing the scope of the dispute.

4. Legal issues

Three potential legal issues have been identified in the open literature. These issues could deter further development and adoption of blockchain in supply chains. The first issue is smart contracts

4.1 Smart contracts

A supply chain is built starting with a contract between supplier and vendor. The contract defines the obligations and rights of the respective parties. They are defined in words and language. They are contained in documents, which bear the signatory of the parties. This is the traditional 'natural language' contracts that have been in use since the Middle Ages.

Blockchain-based smart contracts display many attractive features including its automation of contract execution, identity verification, provision of permanent records that cannot be altered and can reduce cumbersome documentation. However, such use cannot be capitalised upon if smart contracts are limited only to being applied to a set of prescribed outcomes in a simple contractual relationship.

The definition of smart contracts was given by a computer scientist, Nick Szabo, known for his research on digital currency (Szabo, 1997):

"A set of promises specified in digital form, including protocols which the parties perform on those promises."

A more specific definition is given in (Walport, 2016).

"Smart contracts are contracts whose terms are recorded in a computer language instead of legal language. Smart contracts can be automatically executed by a computing system, such as a suitable distributed ledger system."

A smart contract is, therefore, a computer programme that contains certain inputs and executes a set of instructions to come to one of many predetermined outcomes. Features of a smart contract include:

- Embedded contractual terms into computer codes
- Based on conditional logic – if an event happens then a resulting event is triggered
- The contract defines the obligations and rights of the respective parties.
- The chain of events in related matters can be self-executed resulting in autonomous contracts.

A smart contract, under English law, can constitute a legal contract provided the key elements of a contract are met: offer, acceptance, intention to create legal relations and consideration (Beale, 2018). A valid enforceable contract does not require written confirmation or in any particular format.

Blockchain-based smart contracts are being used in the logistic industry. The process starts from a customer placed a logistic order for delivery of a parcel. When the parcel is delivered from a location in one country to a location in another part of the world. The parcel then went through the logistic process. Upon delivery, the smart contract can trigger payment. Traditional paperwork like bills of lading, test certificates and delivery notes are all available digitally and in real-time to all parties. These records are permanent, cannot be altered and free of human error. With such assurances, upon delivery of the parcel, the performance of the smart contract on the supplier's part is fulfilled. The buyer's obligation under the smart contract is completed upon payment to the supplier. The transaction is then completed.

Can "Smart contracts" replace traditional 'natural language' contracts? The answer is not in the current state. Smart contracts are limited only to being applied to a set of prescribed outcomes in (a) a simple contractual relationship, and (b) when all things go well.

The various stages of the development of smart contracts can be described in 5 stages below in Figure 4.

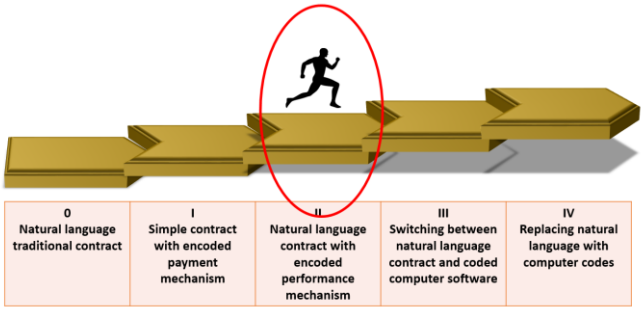

Figure 4: Stages of development on "smart contracts"

Stage 0 is the natural language traditional contract which has been used since the Middle Ages.

Stage I is the smart contract which is being used in the logistic industry. This applies to a relatively simple situation when all things go well, like the delivery of a parcel as explained before.

There is scope to develop the smart contract further from Stage I by way of introducing the concept of conditional logic. "Rule-based" functions are encoded into digital form and embedded into the natural language contract. The current status of smart contracts technology is reported in (Zou, et al, 2019). The reference presents the results of an extensive review and survey. In essence, there are two components in the emerging technology, which are (a) a legal contract component, which is represented by software, and (b) smart contracts as code scripts which execute certain tasks once pre-defined conditions are met. It is, therefore, the "Rule-based" functions can be code scripted and allow execution of certain clauses in a natural language contract once pre-defined conditions are met.

An example of such application is in the administration and management of supply chains in the construction industry. Delay is the most common cause of international construction disputes as revealed in a survey conducted in 2019 (Mistells and Hambury 2019). In an event of delay or performance below the agreed level, liquidated damages, as quantified in a sum of monies, are deducted from the payment. The principle and the process of calculating liquidated damages in the event of late delivery or delivery not meeting a service level agreement are well established (Furst and Ramsey, 2016). The perceived loss is estimated before the parties enter into contract. Once the amount of damages is agreed, parties will not consider the extent of the damages occurred, the payment deduction will apply automatically. This is a clear example that the blockchain-based smart contract can benefit businesses once it is developed beyond Stage I.

Stages III and IV show the road map to the ultimate destination of replacing the traditional natural language contracts by computer codes so that the advantages of the blockchain technology can be fully capitalised.

4.2 Blockchain platform

Blockchain requires a digital platform to store information, record transactions, drive the self-execution of the blocks and the distribution of ledgers to all users. In a closed environment, all users can be identified. Users are operating on mutual trust and co-operative nature. However, operating through a platform that multiple users can access and share data may lead to potential issues. Disputes and uncertainties can arise over the responsibility and control of the blockchain platform, performance assurance, and liability when the platform fails. Questions related to who provides the platform, who pays for it and who controls it, can be open to interpretation.

Indeed, the collaborative nature of using the platform, based on mutual trust and co-operation, is not recognised under English law with enforceable obligations as confirmed in a string of reported court's decisions, a recent example is given in Costain Ltd v Tarmac Holdings Ltd (Costain, 2017). If the parties wish to impose such a duty, they must do so expressly as emphasised in Astor Management AG & Anr v Atalaya Mining Plc & Others (Astor Management, 2017). In this case, the Judge commented: "*A duty to act in good faith, where it exists, is a modest requirement. It does no more than reflect the expectation that a contracting party will act honestly towards the other party and will not conduct itself in a way which is calculated to frustrate the purpose of the contract or which would be regarded as commercially unacceptable by reasonable and honest people. This is a lesser duty than the positive obligation to use all reasonable endeavours to achieve a specified result which the contract in this case imposed.*"

4.2.1 Building industry's BIM experience

Whilst the use of a digitalised platform where all parties are operating based on trust and cooperative is unfamiliar to many industries, this concept has already been adopted by the building industry under the UK government, in the construction strategy published in May 2011 (UK Government, 2011). The UK government requires all projects to use Building Information Modelling (BIM), to develop a 3-D model of a finished building before the commencement of a project and made available to every party involved in the project i.e. designers, builders, surveyors, certifiers, and also made available for the maintenance of the building.

Since the mandatory BIM requirements imposed by the UK Government, the building industry responded by agreeing on a BIM protocol that binds all interested parties in the building works (Construction Industry Council, 2018 and British

Standard Institute 2019). The BIM protocol has now been incorporated in all major standard forms of contracts nationally and internationally for building works as well as other engineering and construction work. The general opinion from the industry so far has been positive (Chevin, 2018).

Whilst not a blockchain example per se, the UK BIM case of Trant Engineering Limited v Mott MacDonald Limited (Trant, 2017) demonstrates how access (or lack of) to a common platform can lead to a dispute without appropriate agreement at the outset of the project. Trant was the main contractor for a new £55m power generation facility in the Falkland Islands. Trant had engaged Mott MacDonald to prepare and implement the BIM, which enabled the design teams to manage, share, and distribute design data on a single platform. A dispute arose between Trant and Mott MacDonald, who denied Trant's access to the servers hosting the design data by revoking the passwords that had been issued to Trant earlier. The court ordered an injunction for Mott MacDonald to release the password to allow the project to progress.

4.2.2 Blockchain governance

Lessons learned from the experience of BIM and the uncertainty as to the enforceability of mutual trust and collaborative obligations place greater importance in ensuring all parties are governed and bound by agreements from the outset. Simplicity should be a guiding principle in the structure and extent of the governance to avoid overburdening the project.

The user groups can be divided into two categories carrying out different functions. One category is those who set up the blockchain platform and decide who should be included in the platform. This category would include the EPC contractor and the Employer (for example, all the project board members). The other category is those who just participate in the network and do not interfere with other transactions, such as sub-contractors and sub-sub-contractors / suppliers. Their access to and within the network would be controlled by the first category users.

To cater for the two types of user groups, two additional agreements are required to be drawn up and agreed as supplemental to the chain of agreements between the Employer and the EPC contractor and the subsequent contracts between the EPC contractor and the sub-contractors/suppliers; and so on along the chains.

1) Consortium agreement:

This agreement includes the structure and governing principles for managing the blockchain platform. By way of example, it covers:

- agreement with the software provider in respect of its obligations, the performance level, availability of the network;
- appointment of an information manager who supports the team and provides a web service to carry all project information and control access and use. The information manager should be a standalone third-party with complete independence;
- participation and control of the blockchain platform, performance assurance and liability when the platform fails; and
- specify the intellectual property rights such that information loaded into the model remains the property of the party that developed it, or as agreed otherwise.

2) Participation agreement:

This agreement regulates the rules of joining the platform in respect of the operation and the use of the platform. It is essential that parties enter into an agreement that defines a number of issues including:

- allocation of responsibility for the operation of the platform and co-ordination of the data;
- allocation of liability, risk and responsibility for errors. This includes a reference to the software provider, the information manager in addition to the stakeholders and other participants;
- access to data in the system; and
- data privacy and cybersecurity

In an event of a conflict between various agreements, these agreements must set out clearly which terms and conditions take precedence over the others.

The risks arising from platform failure must be managed and the project All Risks Liability Insurance taken out by the EPC contractor should be extended to cover this risk element as part of the overall project risks and the benefits of the policy are passed down to all suppliers along the chains. As such, the EPC contractor should provide indemnity to all sub-contractors and suppliers based on the principle of fair allocation of risks to the party.

4.3 Multi-Jurisdiction

As blockchain nodes can be located in multiple locations around the world, there is often discussion and lack of clarity in relation to the laws that govern the platform regarding the multiple jurisdictions that may or may not apply. Transactions performed by parties within the blockchain platform could be subject to multiple laws and regulations that apply to the

blockchain (Emmanuel, 2019, McKinlay, 2018, Salmon and Myers, 2019). Likewise, transactions conducted along a chain may fall within more than one jurisdiction, and it is not clear which jurisdiction is applied to which issues arising from a transaction. These perceived blockchain difficulties mirror the issues that have occurred in traditional private international law and can be considered together under the subject of conflict of laws (Briggs, 2019). Conflict issues are broadly placed into three categories:

- Jurisdiction – whether a court of a particular country has jurisdiction to determine issues arising from a transaction where one or more of the parties may be foreign to the law of that particular country.

- Governing law – When an issue is to be determined in a particular country, whether to apply the local law of that country or foreign law or a combination of laws to deal with the matter.

- Enforcement and recognition of a foreign judicial decision in a particular country.

Rules and principles of private international law in dealing with conflicts of laws are well-established and have been developed over many years based on common law derived from previous cases. There is no clear reason why these principles could not also be applied to deal with multi-jurisdiction issues in blockchain.

Those who have been involved in international EPC projects are accustomed to multiple jurisdiction issues. A number of practices have emerged and developed as a solution for the industry and for the perceived blockchain's multi-jurisdiction issues.

4.3.1 Choice of Law

Standard forms of contracts have been widely used in the construction industry for some time and provide a degree of consistency. These standard contracts are drafted based on the principle that the contracts must provide a fair allocation of risk between the parties to a contract, and that risks should be borne by the party best able to control them.

One such common form of contract for use in the international construction project is known as FIDIC, Fédération Internationale Des Ingénieurs-Conseils (Udom, 2014). This contract form provides a range of standard conditions of contract for the construction, plant and design industries, the contract between the employer and the main contractor and the sub-contracts – designers and consultants. It is noteworthy that the BIM protocol is now integrated into the main body of FIDIC. Accordingly, blockchain governance (including both the consortium agreement and participation agreement) can be built into FIDIC.

Using FIDIC, parties are free to specify the governing law. The choice of law provision is specified in the bid documents before works go to tender. The governing law is chosen by having due consideration of the nature of the projects, the location of the projects, standard practices in the industry and financing mechanisms. The law choice is then negotiated between the employer and the EPC Main Contractor and agreed during the pre-contract stage. There are well-established rules under the private international law that parties are able to refer to and could form the basis of any negotiation. Once the governing law is agreed, the same law applies to all contracts belonging to the supply chain network that operates in the EPC contract.

4.3.2 Jurisdiction

As for the jurisdiction to determine issues arising from the blockchain, international arbitration could be used rather than commencing court proceedings in a particular country. Although there is no known case of arbitration of a blockchain dispute, there are a number of advantages to arbitration over litigation in courts. Arbitration allows the parties to choose a place where the arbitration takes place which may not be connected with the underlying contract and the location of any of the parties. International arbitration in a third party location is attractive because the parties would prefer to have the issues resolved on neutral territory.

As for the law that governs arbitration, the UNCITRAL Model form developed by the United Nations can be used (United Nations Commission on International Trade Law, 2008). It provides a model for countries to base their arbitration law upon. As for the procedure, parties can select institutional rules from one of several arbitration centres around the world. For example, London Court of International Arbitration in London, International Chamber of Commerce in Paris, China International Economic and Trade Arbitration Commission in Beijing, Hong Kong International Arbitration Centre in Hong Kong. These rules are similar to each other and the selection of an institutional rule is not dependent on the choice of jurisdiction. The arbitration process is flexible as long as parties consent to any chosen or modified procedure. There is no clear reason why Internet-based arbitration should not be used.

4.3.3 Enforcement

Finally, an arbitration award can be enforced in a local domestic court if the unsuccessful party refuses to comply with the arbitrators' award voluntarily. By virtue of the Convention on the Recognition and Enforcement of Foreign Arbitral Awards (1958) (the "New York Convention"), the courts of all of its signatory states have to recognise and enforce international arbitration awards made in another signatory state. Enforcement of a foreign award in a local

domestic court is a simple administrative procedure. The Convention has more than 160 state parties. This means that the convention covers most of the countries in the world (New York Arbitration Convention, 1958). The ability to enforce an arbitration award is the most attractive reason for international parties to choose arbitration as the dispute resolution procedure.

5. Discussions and Implications

Construction projects are of high value and high risk with complex supply chains. The efficient and effective operation and interaction of these supply chains are crucial for the successful delivery of the projects. In addition to the much-cited advantages of automation of documents/data management, immutable records of data, and improved security by reducing human errors, this paper identifies dispute avoidance and contract administration as further advantages of using blockchain in large-scale construction projects.

There is a cost element in setting up a blockchain platform with time and effort required to set up and govern. The benefits gained from using blockchain need to be balanced against these costs. As such, the use of blockchain is not suitable for every project and a cost/risk analysis needs to be undertaken. In the long run, projects can gain savings from not only the management of paperwork; but also intangible aspects like the early identification of issues and avoidance of disputes. It is also the case that as projects progress, technology development continues, in particular, if a project runs for years, and the benefits are to be realised throughout the project lifetime.

Blockchain technology has developed rapidly in recent years and will continue to develop as more and more industries embrace its application. Software engineers will find better ways and means to improve the technology; at the same time, availability and scale of computer processing power continue to increase. This is both an opportunity and a risk for infrastructure projects, which typically take years to design and build, as they need to be planned with the emergence of new technology and scaling of existing technology.

Solutions for three legal issues are discussed in this paper and summarised below. The results can assist the identification of any future technology development in blockchain for supply chains.

1. Smart contract utilises blockchain technology. However, the current status of smart contracts is limited only to being applied to a set of prescribed outcomes in (a) a simple contractual relationship, and (b) when all things go well. This paper explains a solution for relaxing the current limitations by encoding "rule-based" functions into digital form and embedded into the natural language contract.

2. The second issue identified is the requirement of a shared blockchain platform. Blockchain governance is introduced based on the lessons and experience of using Building Information Modelling learnt from the building industry.

3. As blockchain nodes can be located in multiple locations around the world, there is often discussion on the issue of multiple jurisdictions concerning uncertainties in identifying which is the governing law when blockchain is used. This is the third legal issue discussed in this paper. Rules and principles of private international law in dealing with conflicts of laws are referred to in dealing with the third issue.

6. Concluding remarks

A culture of claims and counter-claims between suppliers and buyers is deep-rooted in large-scale international construction projects. Blockchain technology offers advantages to improve efficiencies and effectiveness as set out in this paper. Indeed, this paper supports the view that blockchain technology is particularly suitable for use in supply chains in complex international construction projects. The demands for continuous development of the technology will continue and it will continue to grow rapidly. It is essential to tailor its future development with full consideration of issues from other disciplines, one of which is legal so that solutions to combat these issues can be identified and developed. As discussed in this paper, some of the potential legal barriers that have been raised by commentators can be overcome. Inputs in a collaborative manner from various disciples, such as law, are required for the technology to continue to advance and be adopted successfully.

REFERENCES

Astor Management AG & Anr v Atalaya Mining Plc & Others [2017] EWHC 425 (Comm)

Beale, H. (2018), "Chitty on Contracts", 33rd edition, Street & Maxwell, London

Briggs, A. (2019), "The Conflict of Laws", 4th Edition, Clarendon Law Series, Oxford University Press, UK

British Standard Institute, "Organization and digitization of information about buildings and civil engineering works, including building information modelling -- Information management using building information modelling", BS EN ISO 19650-1 and 2, 2019

Chevin, D (2018)," Revised CIC BIM Protocol meets industry demands". Industry news Chartered Institute of Building, 11 April, available at http://www.bimplus.co.uk/news/revised-cic-bim-protocol-meets-industry-demands-nb/

Construction Industry Council, Building Information Modelling (BIM) Protocol, 2nd Edition, Construction Industry Council 2018, London

Costain Ltd v Tarmac Holdings Ltd [2017] EWHC 319 (TCC)

Emmanuel, J. et al., (2019) "Blockchains uncut: risks, rewards & regulation", October, Bird & Bird, News Centre, London.

Fluor Ltd v Shanghai Zhenhua Heavy Industries Ltd [2017] EWHC 490 (TCC)

Furst, S. and Ramsey, V., (2016), "Keating on Construction Contracts", Street & Maxwell, London

McKinlay J., et al (2018), "Blockchain: background, challenges and legal issues". February, DLA Piper Publications, London.

McKinsey & Co. (2016), "Imagining construction's digital future", August 2016, available at: https://www.mckinsey.com/industries/capital-projects-and-infrastructure/our-insights/imagining-constructions-digital-future-infographic

Mistells L., and Hambury J., (2019) "International Arbitration Survey – Driving Efficiency in International Construction Disputes", November, Queen Mary University of London and Pinsent Masons LLP., London

New York Arbitration Convention (1958), "The New York Arbitration Convention on the Recognition and Enforcement of Foreign Arbitral Awards, New York, 10 June 1958", available at: http://www.newyorkconvention.org/

Salmon, J., and Myers, G., (2019) "Blockchain and associated legal issues for emerging markets", January 2019, Note 63, International Finance Corporation, World Bank Group.

Szabo, N. (1997), "Formalizing and securing relationships on public networks". *First Monday* 2(9), 1997.

Trant v Mott MacDonald [2017] EWHC 2061 (TCC)

Udom, K. (2014) "A brief introduction to FIDIC contracts" February, NBS, available at: https://www.thenbs.com/knowledge/a-brief-introduction-to-fidic-contracts

UK Government (2011) "Government Construction Strategy", May 2011, Cabinet Office, UK Government, available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/61152/Government-Construction-Strategy_0.pdf

United Nations Commission on International Trade Law, (2008) "UNCITAL Model Law on International Commercial Arbitration, 1985 with amendments as adopted in 2006" UNCITRAL secretariat, Vienna International Centre, Vienna.

Walport, M. (2016), "Distributed Ledger Technology: beyond blockchain", UK Government Office for Science, London, available at https://www.gov.uk/government/publications/distributed-ledger-technology-blackett-review

Yaga, D., *et al* (2019), "Blockchain technology overview", National Institute of Standards and Technology, U.S. Department of Commerce, NISTIR 8202, available at: https://nvlpubs.nist.gov/nistpubs/ir/2018/NIST.IR.8202.pdf

Zou, W., et al (2019), "Smart Contract Development: Challenges and Opportunities", IEEE Transactions on Software Engineering, DOI 10.1109/TSE.2019.2942301, September 2019.