# BLOCKCHAIN FOR CONSTRUCTION

## 1. Introduction

In the last 10 years, the hype over blockchain has gathered pace, but what is the reality for the construction industry about its role and can we really expect to carry out construction projects under smart contracts? Automation *promises to* increase efficiencies and lower costs, reduce the risk of human error, increase transparency and reduce the number of legal disputes.[1] But is it just hype?

Lawyers need to understand blockchain as it could transform their role: "*when the contract itself becomes centre stage then the lawyers' involvement is no longer at the periphery"*.[2]

## 2. Understanding the Terminology

Before we plunge into this world of automated contracts, it helps to simplify some of the jargon which is used to discuss smart contracts. This topic covers a wide range of fairly new technologies ('new' in the sense that their full potential is nowhere near being realised and many applications are still in the theoretical stage) including:

- *Distributed ledger technology* (DLT) allows all parties in a transaction to operate from a shared set of records (the distributed ledger); it reduces or eliminates the scope for false entries and unilateral changes.
- *Distributed ledgers* are databases, ways of storing and transmitting data,[3] which are both cheap (the cost is widely spread and based on simple software) and decentralized (spread across numerous stores or holders). In a distributed ledger network each participant can interact or transact with others in a peer-to-peer exchange. Because of the role of hashes (below) in distributed ledgers, any attempts to tamper with the ledger data are clearly shown (tamper evident, not tamper proof).
- *Nodes* are the participants who send and receive data to keep the ledgers up-to-date.
- *Blockchain* is a version of distributed ledger technology based on a series of blocks. It creates an 'immutable chain of records'.[4] It generally has five elements: cryptography, a peer-to-peer network, a consensus mechanism, a ledger made up of blocks, and validity rules and three features: distributed, consensus-based and requires trust.[5]
- 'Each *block* contains details of timestamped batches of validated data (typically representing a series of transactions'.[6] Before a block is added to a chain, the individual data entries are authenticated and validated.[7]
- *Hashes* are unique cryptographic identifiers (like digital fingerprints). The hashes convert inputs into a standard or fixed size output – this makes it extremely difficult to reverse engineer to determine the size of the input from the size of the output. The hashes also link the blocks into lists (chains) to prevent new blocks being

[1] EBRD (2018), Executive Summary.
[2] Mason (2017), p3.
[3] Data stored on a distributed ledger may be static (eg name of a person), dynamic (eg record of ownership of asset) or executable (ie a task to be completed).
[4] Blockchain Technology in the Construction Industry, ICE, p9.
[5] Dakhli (2019), p2.
[6] Dentons (2018), p10.
[7] Validation includes protection by private and public digital signatures, verification by the initiating node, and the process of creating chain adds a further lay of security. Only rarely can transactions be reversed. As the processes require consensus, it is considered that this adds trust into the transactions.

inserted or existing blocks being altered. The hashes are 'easy to verify and nearly impossible to falsify.'[8]

- *Cryptocurrencies* are encrypted digital currencies, where the encryption verifies the generation and distribution of funds, independent of a traditional or central bank.[9] "*In the absence of regulation to the contrary, there is no legal reason why, as a matter of private contract, two parties should not agree that payments between them are to be made in a cryptocurrency, or why the failure of one party to make a contractually required payment should not be enforceable as a debt claim through the courts or a contractually agreed alternative dispute resolution mechanism by the other party*."[10]
- *Bitcoin* is a specific form of cryptocurrency, which gained notoriety for its use in illegal transactions. It tends to be slower than traditional banking as all transactions need to be processed by miners (participants who charge fees to prove entitlement to the cryptocurrency). Bitcoin is not immune to hacking and customers have no recourse if this happens. Bitcoin is based on a public blockchain.

## 3. Smart Contracts

***'smart contracts'… the programs are typically not very 'smart', and are sometimes not used to execute or monitor legal contracts***[11]

A smart contract is "*a computerized transaction protocol that executes the terms of a contract*." Their design should "*satisfy common contractual conditions (such as payment terms, liens, confidentiality, and even enforcement), minimize exceptions both malicious and accidental, and minimize the need for trusted intermediaries*" and reduce loss, enforcement and transaction costs.[12]

EBRD (2018) breaks down this concept into:

- **Smart** because it refers to a transaction which is automatable (and not necessarily the code which automates the transaction)[13]
- **Contract** because it refers to an agreement based on legally enforceable rights and obligations between parties.

The issue for many commentators is whether a smart contract is fully or only partly automatable ie will it avoid the need for all human intervention once the transaction starts? As construction contracts are long (somewhere between the 20,000 words of NEC ECC and the 50,000 words of JCT 2016 SBC[14]) then this very length mitigates against automation as the general rule is 'the longer the contract, the less straightforward its automation.'[15]

Smart contracts and blockchain are not mutually dependent. A smart contract could replace a traditional hard-copy (or even electronic agreement) with a code that both

[8] Dakhli (2019), p2.
[9] Cryptocurrencies are a form of virtual currency which act as a medium of exchange based on the community users' agreement, rather than the acts of a state. They are not legal tender in any jurisdiction, although there are over 2000 currently invented and listed (source coinmarketcap.com).
[10] Dentons (2018), p**.
[11] Risks and Opportunities for Systems Using Blockchain and Smart Contracts, May 2017, Commonwealth Scientific and Industrial Research Organisation. Available from ResearchGate.
[12] Nick Szabo, 1994.
[13] There is little consensus on the use of the term smart contract with most authors citing Nick Szabo and then veering away from his definition to varying degrees.
[14] Each word count is without further amendments or any of their annexes or contract documents.
[15] Mason and Escott (2018), p3

records the agreement and automates some or all of its processes eg payment. Smart contracts could use blockchain or DLT for payment and audit trail functions.

Smart contracts *should* always include digital signatures – private cryptographic keys held by each party to verify and agree to the transaction. Smart contracts *should* include some degree of automated execution processes. Smart contracts *may* also use external agreed data providers (called oracles) to trigger specific tasks.

## 4. A Simple Blockchain Transaction

The process for a blockchain transaction is:

1. A transaction is agreed between two parties.
2. The transaction is created as a block of data and broadcast to the peer-to-peer network for validation. During validation, the nodes (participants in the ledger) check the sender/receiver and whether there are any duplicate transactions.
3. Once the network confirms consensus, the hashed transaction is included in a block of records, creating a tamper-evident transaction.
4. The blockchain is updated with the new block and distributed across the ledgers.
5. The transaction is concluded, digital assets/data/order are transferred and received – along with an immutable record of its origin and transfer/receipt.

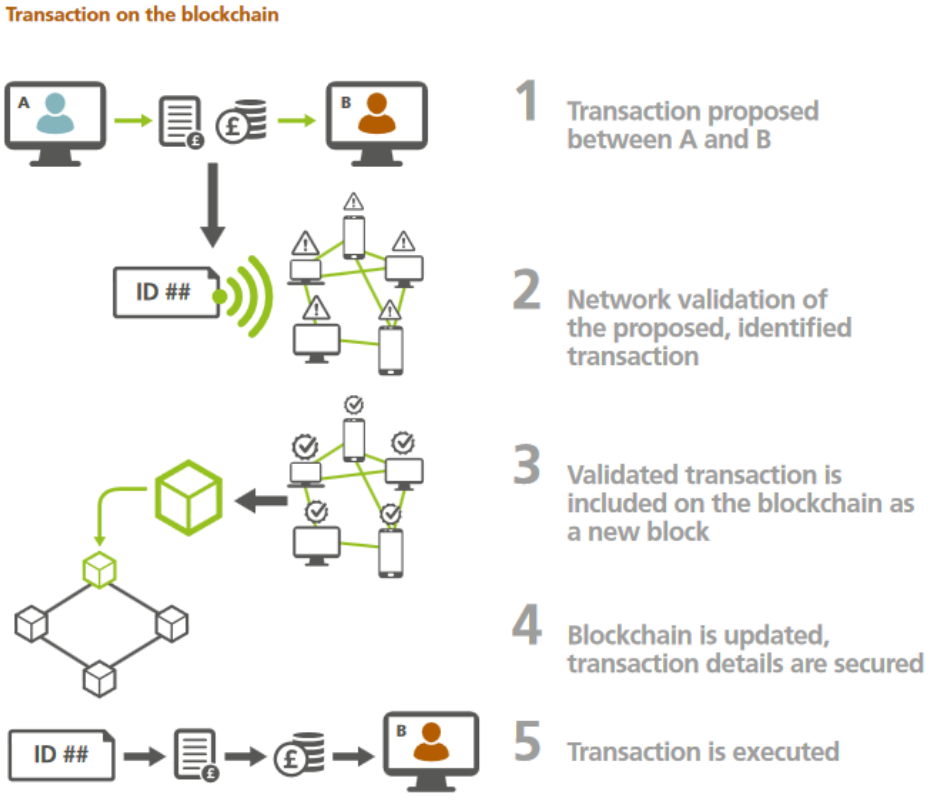



Image Source: ICE Report (2018)

## 5. Key Barriers

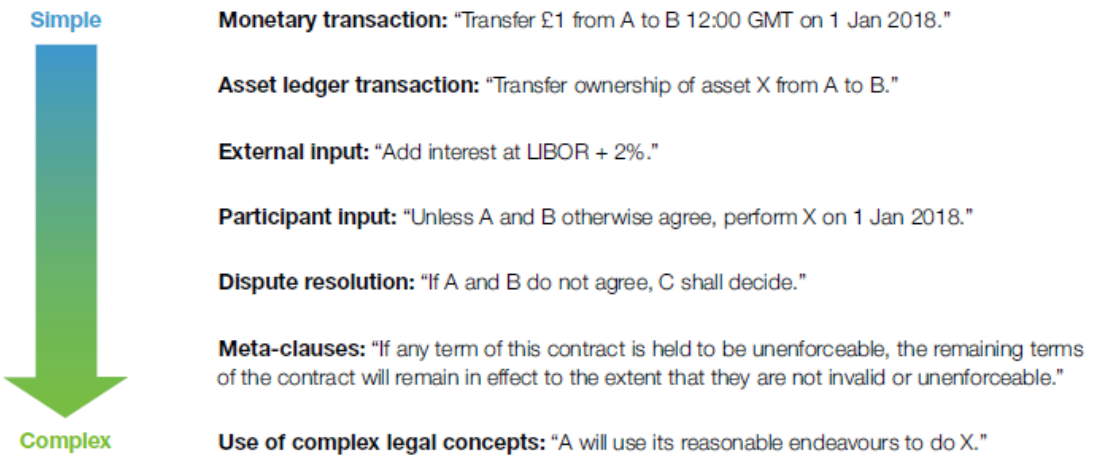
### Full Automation

One of the key proposed advantages of smart contracts is the reduced reliance on humans to administer contracts – a major source of global construction disputes.[16] Within construction contracts, payment remains a major source of contention for contractors and subcontractors. Whilst payment could be automated (fully or semi), our current construction contracts require monthly valuations based on subjective views as well as data and would need to be rewritten to create more objective inputs to trigger automated payments.

For many blockchain and smart contracts, commentators and innovators believe cryptocurrencies are central to the efficacy of distributed ledger technology and smart contracts – these currencies allow the contract to operate without the use of traditional payment arrangements and without the need for banks. This is, naturally, at odds with the way the vast majority of construction projects are funded, and the role of the funders will be critical to moving towards more automated processes.

In theory, a fully smart contract requires no administration or contract management, is self-monitoring for performance, and provides a clear audit trail.[17] Human input does not wholly undermine smart contracts - at present most smart contracts require humans (traditional) to undertake their planning, creation *and* use.[18]

The essence of automation is the use of conditional logic ie 'if X then Y' where X is a trigger and Y is a task that the computer then performs. Some of the Y tasks would have legal significance and others may be steps along that path.




Source: ERBD paper (Figure 2)

Although there are certain elements of a construction contract at the top (simple) end of this scale, many are more complex. With mostly complex clauses (in the sense of

[16] Poor contract administration has been the number 1 source of global construction disputes for the last 5 years of the Arcadis Global Disputes Survey.
[17] What the ERBD paper refers to as 'self-conclusion, self-performance or self-enforcement', p7.
[18] Intelligent contracts under the ERBD paper are those where the software relies of artificial intelligence to carry out more than simple 'if X then Y' operations. These are smarter than smart contracts!

requiring rich context) in construction contracts, it is hard to see how they can be fully smart. Perhaps the best we can hope for is semi-automated contracts.[19]

A number of aspects of existing construction contracts are hard to fully-automate in a smart contract:

- Subjective views of performance, completion or value
- Legal concepts such as frustration or force majeure
- Logical gaps such as governing law or jurisdiction
- The right of the contract administrator to issue instructions or decisions for the supply network to obey, as well as monitoring events and quality standards
- Provisions depending on layered or rich context such as extension of time mechanisms or those reliant on discretion and interpretation
- Mechanisms depending on external data inputs ie what is happening in the real world (which reduces the security of the contract)
- The resolution of uncertainties, claims and disputes
- The layering of statutes, case law and industry practice with written terms of the contract
- Transfers of tangible goods, as opposed to registering entries on a ledger or allowing digital transfers such as currency.

As Mason & Escott (2018) say "*Contracts usually require judgment and the use of discretion which requires subtlety and richness in the language which is extremely different to code*." Smart contracts simply cannot be coded for the wriggle room prevalent in various existing contract provisions.

**Payment**

Payment, where it is based subjective valuations and not objective data, is a paradigm of the issues that smart construction contracts face. Perhaps a contract "*could be comprised of... thousands of mini-contracts all self-executing and transferring data as they complete and generating payment once installed and the relevant online documentation such as performance attainment and continual monitoring have taken place*."[20]

Alternatively, smart contracts could adopt a more sophisticated form of the project bank account, enabling the entire supply network to be paid simultaneously (and automatically) based on data either recovered from a project database (eg a distributed ledger) or inputted from a single trusted external source (eg an oracle).

**Confidentiality**

A construction project invariably requires the sharing of data which is partly public (the identity of the landowner or funder), partly shared (eg object data in a BIM common data environment) and partly confidential (eg pricing information, designs). One issue to be resolved for a smart construction contract is what type of blockchain would support it.

There are different versions of blockchains with public (or permission-less) blockchains sometimes called 'trustless' systems – the parties trust the technology rather than each other.

The public blockchain results in an anonymous contract – this may not meet regulatory and governance requirements for UK organisations eg on money laundering. Moreover,

[19] Mason (2017), Intelligent Contracts and the Construction Industry, p1.
[20] Mason (2017), p5.

although the parties may be anonymous, the details of the transaction and its history are available to the public – which raises issues over privacy and confidentiality.

Private or permissioned blockchains allow stronger access controls, and – if spread across organisations – become a consortium blockchain, and suggested by ICE (2018) to cover the whole supply network.

**Irrevocability**

Since distributed ledger technology creates an immutable record, if the parties do not trust that the coding operates as they intended, there is virtually no opportunity to reverse or amend the transaction once it starts.

All construction contracts include mechanisms for changing the original programme (and completion dates), the scope or means of carrying out of the works (using variation or change provisions), and quality of the works (through inspection, testing and defects). Any smart contract will need to know how/how much to change the original data points to make allowance for a specific list of objective or measurable events, based on objective data (eg from a weather oracle)

The legal status of smart contracts is unclear –the Law Commission is currently reviewing their status under English law. A smart contract may become evidence for the existence of an agreement, although discovering its terms may not be simple (depending on the degree of integration between the code and the basics of the parties' agreement).

## 6. Key Enablers

According to Mason (2017), smart contracts in construction will require, as well as objective payment mechanisms and cryptocurrencies (noted in section 5 above), sophisticated BIM, the internet of things, and efficient liability insurance arrangements.

**BIM & Insurance**

Building Information Modelling relies on four aspects to make it efficient:

- Data sharing
- Collaboration
- Efficient processes
- Technology.

In terms of contracts, it may also create the push towards either interconnected bilateral contracts (with identical terms relating to these aspects to ensure coherent interoperability), or multi-party contracts. The creation of a single BIM model, which prevents an audit trail to the originator of any element of the design, requires integrated project insurance rather than the traditional single party professional indemnity or design liability insurance.

**The Internet of Things**

The ability to track goods, materials, labour, progress, defects, operation and even the use of copyright material through embedded codes, barcodes and censors would allow a project manager to maintain a database of project information that will enable the automation of further elements of a construction contract.

## 7. Uses of Smart Contracts or Blockchain in Construction

Although blockchain is not yet a mature technology and it will evolve substantially over the next few years, some proposed uses include:

- Reducing fraud and malpractice surrounding loans for construction projects;
- Site staff identification, training and security authorisation; for labour-only subcontractors this could also be linked to automated weekly payments based on hours spent on the project;
- Tracking assets (goods, materials, plant, equipments) through a supply network especially where provenance or sustainability criteria are essential to governance or legal requirements – deliveries could be linked to automated (stage) payments;
- Digital design rights management with the ability to manage, delegate or transfer access and rights, especially for BIM-enabled projects;
- Quality assurance could be tracked with digital signatures, approvals and steps during the design process recorded in a clear audit trail, creating accountability for errors; ideally this data would be shared with payment processes, project programme and KPI systems;
- Better risk management from identification, analysis, response and review; records will show exactly when a risk event occurred against an up-to-date programme and risk mitigation measures can be agreed and implemented (if not previously determined);
- Document management to enable multiple users to access, create and edit single a single source of project data eg in relation to health and safety (CDM) and to speed up its availability after completion;
- Supporting the processes, technology, data-sharing and collaboration that are key to different levels and dimensions of BIM maturity;
- Reducing errors caused by human contract administration – a major cause of global disputes by translating current processes into if/then schemes which can be implemented by a computer;
- Project accounting to facilitate more efficient use of project bank accounts and immediate payments across the supply chain; blockchain can improve transparency of payment;[21]
- Use of objective tests, digitally recorded and linked to automated (stage) payments to replace current subjective views of completion/take-over and to create a central system for test data;
- Simplify the exchange of data and records used in disputes to reduce their cost and length (and sometimes avoid claims altogether);[22]
- Storing and transferring validated accurate and up-to-date legacy data for future occupiers, users and owners of the project.[23]

[21] Cardeira (2015) argues that payments could literally be embedded into a web of linked contracts to provide security across the supply network as well as avoid insolvencies caused or contributed to by late and disputed payments.
[22] Respondents to a survey reported in Mason and Escott's paper showed an overwhelming contrary view with 80% stating that disagreements between people cannot be solved by a computer.
[23] This would build on COBie (Construction Operation Building Information Exchange) which collects data during design and construction in order to support operation and maintenance of the asset.

## 8. Benefits of Smart Contracts for Construction

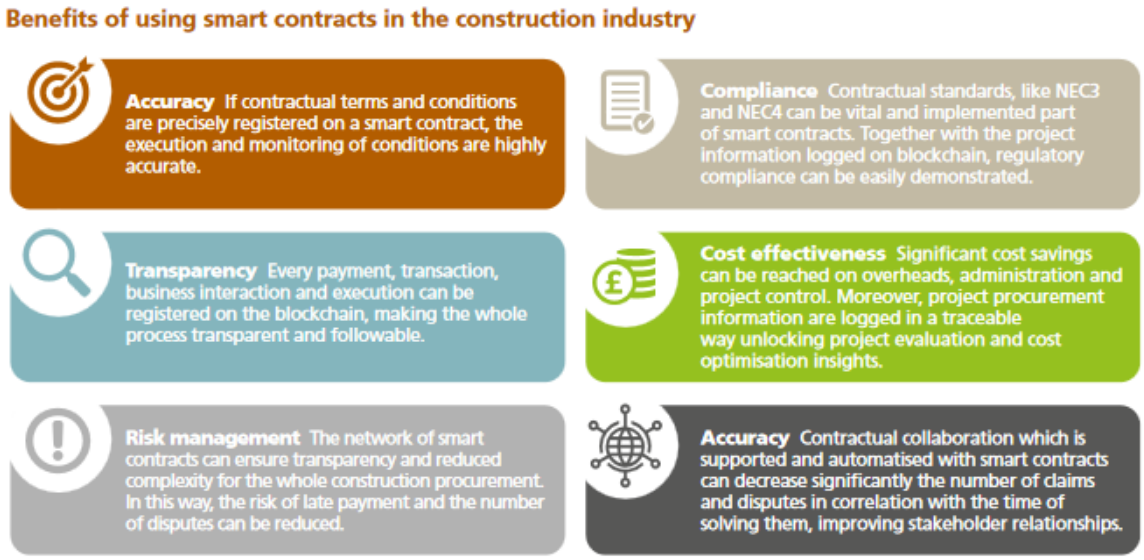



Image Source: ICE (2018)Report

## 9. Conclusion

***Smart contracts are… currently on the way to the peak of their inflated expectations buoyed by claims as to the benefits***[24]

Construction may account for 6% global GDP, but it has stagnant productivity levels, low levels of digitization, a huge impact on climate change, tight margins, fragmentation and lack of collaboration, and a wealth of costly disputes. Smart contracts are part of the solutions needed to improve efficiency and encourage collaboration across the industry for its long-term health and well-being.

## 10. Further Reading


1. *Blockchain and smart contracts: Binary solutions in a non-binary industry?* (March 2018), Winfield. Available here.
2. *Blockchain and Smart Contracts: What the AEC sector needs to know* (July 2018), Lamb at Centre for Digital Built Britain. Available here.
3. *Blockchain Technology in the Construction Industry, Digital Transformation for High Productivity* (December 2018), Institute of Civil Engineers. Available here.
4. *Blockchain for Construction/Real Estate* (2018), Thomson Reuters. Available here.
5. *Global Energy Game Changes* (2018, Issue 8), Dentons. Available here.
6. *Intelligent Contracts and the Construction Industry* (2017), Mason, UWE. Available here.
7. *Smart Contracts and Possible Applications to the Construction Industry* (2015, Cardeira. Available here.
8. *Smart contracts in construction: views and perceptions of stakeholders* (2018), Mason and Esctott, UWE. Available here.


[24] Mason and Escott (2018), p4

9. *Smart Contracts: Legal Framework and Proposed Guidelines for Lawmakers* (October 2018), European Bank for Reconstruction and Development/Clifford Chance. Available here.
10. *The Potential of Blockchain in Building Construction* (April 2019), Dakhli, Lafhaj and Mossman. Available here.