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SMART CONTRACTS
LEGAL AGREEMENTS FOR THE DIGITAL AGE

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LEGAL AGREEMENTS FOR THE DIGITAL AGE

Consider a world in which contracts are performed by computers and drafted in computer code by legal software engineers. What kind of efficiencies in terms of speed of execution, legal certainty and transparency could be gained? Conversely, what are the risks of trusting machines to execute contracts, and perhaps even to enter into contracts with other machines? These are some of the questions raised by smart contracts, an emerging technology that promises self-executing contracts implemented in computer code and performed by networks of computers, with minimal intervention from human agents after they have been "launched" by the parties.

Backers of smart contracts technologies believe they have the potential to revolutionise traditional contracting. Davos founder Klaus Schwab identifies smart contracts as one of the technologies that will unleash a "fourth industrial revolution" that will transform the world's economies. Despite this enthusiasm, the technology is still in development and it seems unlikely that digitised, self-executing contracts will replace all traditional legal contracts in the near future. However, there is real potential for smart contracts to flourish in certain sectors where the performance of process-intensive transactions has already been extensively automated.

What are smart contracts?

Smart contracts can refer to a number of different things, but what all smart contract technologies have in common is the idea that a smart contract is not only executed (in the sense of signed, agreed, or made binding) electronically but also performed electronically – ie the fulfilling of the obligations of the parties is not undertaken only by human agents reading and interpreting their obligations under the contract, but at least in part by machines running software code specifically designed to give effect to the contract.

The idea of computer-executed contracts has been around for decades, but one of the factors behind the recent wave of smart contract technologies is the emergence of blockchain technology. Blockchain is the technology underlying Bitcoin, the digital currency launched in 2009, that is based on a decentralised, networked model of self-executing transactions. Blockchain technology has applications well beyond the sphere of digital currencies and is widely seen as offering a model for how self-executing, autonomous smart contracts could be implemented.

Blockchain and smart contracts

A blockchain is a type of database, known as a distributed database, that is maintained and updated by a network of participating computers (called the "nodes" of the network). A blockchain can be used as an electronic ledger, recording who owns what assets, be it Bitcoin or real-world assets represented by electronic "tokens" on the blockchain, and transactions relating to those assets, such as a Bitcoin payment or the transfer of a tokenised real-world asset.

Blockchain demonstrates how a network could be set up so that once a transaction is set in motion, the network can produce outputs autonomously, without the direct intervention of any party. Because of this feature, the participants don't have to trust each other: they can rely on the system as a whole to carry out transactions, knowing that individual parties cannot frustrate or subvert the intended outcome.

For a smart contract implementation to be viable, the performance of the smart contract has to be similarly taken out of the hands of the contracting parties, otherwise a smart contract is no different from a traditional contract performed using a computer. Thus setting up a direct debit through an online banking interface does not make that arrangement a smart contract, because both the customer and the bank can interfere with, or prevent, the payment. Blockchain, which enables truly autonomous performance, may be the key to creating genuinely self-executing digital contracts.

Autonomous execution

There are three characteristics of blockchains that makes them particularly suitable to achieving autonomous execution:

- **Decentralised**: a blockchain is typically administered by multiple nodes who all

implement the rules governing how new data (ie new entries or new transactions) can be added to the blockchain ledger. This contrasts both with a centralised database that is controlled and updated by a single, central authority, and with a completely decentralised model where every participant maintains its own, separate ledger, which may or may not be consistent with other participants' ledgers. Achieving this distribution of the ledger means that the processing and implementation of transactions can be taken out of the hands of the parties and processed by a network that they do not directly control.

- **Immutable**: blockchain technology gets its name from the chain structure in which blocks of data forming the relevant ledger are recorded. Once a block of data (recording a number of transactions) is validated and written to the blockchain, it cannot be altered or removed. This tamper-proof feature is further strengthened by the decentralised architecture of the network: each of the nodes keeps a full, identical copy of the blockchain, so even if several participants conspire to modify it, unless they control a majority of the nodes in the network, they will not be able to impose their modified version of the blockchain. This characteristic of immutability reassures contracting parties that the delegation of performance to machine agents beyond their control does not mean that they are exposing themselves to those automated processes being interfered with or corrupted.
- **Cryptographically secure**: blockchains make use of tried and tested cryptographic technology to ensure that only authorised participants can submit valid transactions on the blockchain. Just as in the realm of traditional contracts where a unique signature identifies the person who has the authority to sign a contract and bind themselves or the entity they represent, on a blockchain only certain individuals can "sign" transactions using unique cryptographic keys. This cryptographic layer is a fundamental part of how blockchains work, deeply embedded in each step, making blockchains particularly reliable from a security point of view.

Why use smart contracts?

Smart contract technology is designed to have certain practical advantages over traditional "paper" contracts:

- **Certainty**: as smart contracts are implemented in computer code, the level of formalisation required to make this work should mean that the outcome of the performance of a smart contract should be clearly determined and easy to verify, unlike the potentially ambiguous natural language used in traditional contracts.
- **Speed**: as with other kinds of computer automation, self-executing smart contracts hold out the prospect of contracts that execute potentially near-instantaneously without being slowed down by human input.
- **Cost**: while developing the technology to implement smart contracts may represent a significant upfront cost, once working templates have been generated the technology should significantly reduce the costs of creating contracts and costs associated with performance of the contract by employees or agents who are "on the clock".

Who are the likely early adopters?

While there is clearly much interest in smart contracts from technologists keen to push the boundaries of traditional contract-making as an end in itself, the technology has also attracted much attention from more mature, typically more risk-averse businesses. The financial sector, for example, is developing and testing the technology as much of its activity is already automated (eg online payment systems) and mediated by computers. In addition, a number of the obligations in typical contracts are sufficiently simple and easy to implement technologically. For example, a contract which requires payments of certain amounts at certain time intervals based on specified quantitative inputs is easier to implement than one that requires the discretion of contracting parties or context-specific interpretation.

An example of a transaction that lends itself to a smart contract platform is the trading of simple derivative products such as options. The diagram on the following page demonstrates how an options contract could be automated through a smart contract on a blockchain. The contract terms, including the strike price, number of shares and expiry date of the trade, are agreed at the outset. Once these terms are translated into code and the underlying assets (cash and shares) are assigned digital tokens, they are recorded onto a blockchain-based smart contract platform. Each party is then given a private cryptographic key to access the contract. The purchaser is able to trigger execution by sending an option trigger message using this private key. The smart contract will perform the exercise of the option and transfer the digital token representing the assets provided that any encoded pre-conditions have been met, for example by checking that the trigger instruction is submitted before any option expiry date. In this way, trading, clearing and settlement

Smart Options Contract

could occur in an entirely decentralised manner, without an exchange or central counterparty. The smart contract and blockchain platform act as the ownership record-keeper, intermediary, custodian, and clearing and settlement system.

What are the legal implications of smart contracts?

Smart contracts raise a number of legal questions. These include:

- **Drafting**: Software languages are deterministic. This means that given an input, a piece of software should always produce the same output. Similarly, smart contracts will have to be implemented using structured, formal and unambiguous language. This, however, does not reflect the way traditional legal contracts are drafted. Contracts may include provisions which are easy to formalise – take "A shall pay B £100 on 1 January 2018." But typically contracts also contain legal expressions the meaning of which is less certain – consider, for example a clause that triggers certain consequences in the event of "material adverse change", a notoriously complex and context-specific expression. Such expressions are used to give contracting parties flexibility in respect of certain obligations by not determining in advance exactly what the obligation entails. Implementing contracts purely as self-executing software would mean losing much of the functionality of traditional legal language. This may be a worthwhile trade-off in certain contexts, but it will not be the right solution for all types of contracts.
- **Legal form**: The term smart contract is arguably a misnomer, as it implies that a contract will necessarily be established in the legal sense. This is not necessarily true of all implementations that go under the name of smart contracts, in particular implementations that focus on the technological self-execution part without specifically considering whether the initialisation of that self-executing process could be deemed to constitute the creation of a legally enforceable contract by a court of law. Although English law is generally flexible as to formalities, at a minimum a legal contract must include offer, acceptance and the intention of the parties that the contract should be legally binding. Recognition of a smart contract as legally binding is crucial to ensuring that the automated output from the smart contract (ie once the code self-executes) is legally effective and enforceable by the parties through a court of law. For example, is a particular smart contract effective to pass legal title to the asset that it purports to transfer? If the answer to this question is no, much of the potential utility of the smart contract would be lost. However, with appropriate attention being paid to the formalities pursuant to which the parties enter into a smart contract, it may in many cases be possible to ensure that the act that initiates the self-executing code always coincides with the creation of a legally enforceable contract. This could be achieved by ensuring that the "launch" of the smart contract is preceded by the participant accepting natural language terms that confer binding contractual effect on the transaction performed by the code (for example, by clicking "I agree" to a set of terms). Those natural language terms can be seen as a traditional legal contract "wrapper" around the smart contract, giving the smart contract the binding effect of a legal contract.
- **Risk of error**: While the implementation of smart contracts is designed to be predictable, just like any other software, smart contracts are likely to be prone to error and unintended

consequences, especially when deployed on a large scale. If code performs in a way that the parties did not expect, what remedies will they have and against whom? Are there terms in the legal contract "wrapper" that will override any erroneous outputs from the code? If so, would that not jeopardise much of the advantage of smart contracts by subjecting the autonomous execution processes to the same human intervention and ordinary language interpretation that smart contracts were meant to dispense with in the first place?

Smart contracts and financial sector regulation

While a wide range of legal and regulatory regimes may apply to smart contracts (prominent among which would be data protection and cyber security rules), the development of financial sector smart contract solutions raises some particularly complex regulatory issues, including the following:

- **Systems and controls**: Financial regulation requires that the governance, risk and compliance functions in financial institutions establish and maintain adequate systems of risk management. Large-scale adoption of smart contracts would therefore require a firm understanding of the risks inherent in those technologies, and how those risks can be mitigated. If the smart contract is going to rely on a decentralised network of nodes managing a blockchain, what governance arrangements will need to be put in place to manage that network? Beyond dealing with the purely technological issues, regulated financial institutions will also have to consider the technology from the perspective of ensuring the regulatory adequacy of its systems and controls.
- **Systemic risk exposure**: Regulators have encouraged and even mandated utility-like bodies to act as central counterparties for certain types of transactions, in order to centralise counterparty risk and better manage a profusion of bilateral arrangements. Smart contract models tend, in their basic architecture, towards decentralisation and individual bilateral arrangements. Smart contract implementations that undermine regulators' preferred approaches in this regard may attract adverse scrutiny. That being said, the fact that smart contracts are technologically decentralised does not necessarily prevent financial institutions from adopting industry – specific smart contract templates to achieve a level of coherence and uniformity that might achieve similar regulatory objectives.
- **Automation risk regulation**: The algorithmic trading rules in MiFID2 provide some insight into the regulatory response to the automation of transactional activities which put financial institutions on risk and have the potential to create market distortions. Large scale automation, and the concurrent acceleration of transactions, can lead to unexpected consequences and the emergence of new systemic risks, such as so-called "flash crashes." The mass automation of financial contracts through smart contracts might create similar systemic risks. Robust governance arrangements and hard controls, such as kill functionality (so-called "red buttons"), may need to be implemented to ensure compliance with these rules – although it will be readily apparent that there is a tension between the idea of obligations that are performed autonomously and on a tamper-proof basis, on the one hand, and an "emergency brake" that enables one or more parties to suspend the operation of the network, on the other.

What's next?

Automation and digitisation is spreading to all sectors of the economy. The legal industry has already seen the emergence of a wide range of technologies to automate and accelerate various aspects of the work lawyers have traditionally done. Yet, while computer-mediated execution is commonplace, the performance of contracts has only been automated in mostly ad hoc, application-specific ways. The creation of self-executing contracts therefore represents a new frontier, but one for which the long-term potential to change how businesses contract is clear. That transformative potential brings with it the possibility of new risks and disruption to tried and tested business models. For technology innovators starting out with no baggage, that is an alluring prospect. But even for mature businesses, that do not have the luxury of being able to take big gambles on new technologies, smart contracts may present opportunities to steal a march on competitors. Smart contract technology looks like it is approaching viability, and businesses that move first in using smart contracts may gain a valuable head start. A careful balancing of the potential of smart contracts and the many aspects of regulation that may apply will be required. That means that the key will be to start with small steps: trialling the technology in simpler contexts that are well understood and where performance is easy to automate using existing systems and deploying on a small scale but building the system so that it can scale up. Once businesses get comfortable with those simple smart contract models, it won't be long before the technology gains traction and the full automation of contracts kicks off in earnest.

CONTACTS

Amsterdam

Marian Scheele
Senior Counsel
T: +31 20711 9524
E: marian.scheele@cliffordchance.com

Tommy Hurley
Associate
T: +31 20711 9156
E: tommy.hurley@cliffordchance.com

Beijing

Tiecheng Yang
Partner
T: +86 106535 2265
E: tiecheng.yang@cliffordchance.com

Hong Zhang
Counsel
T: +86 106535 2256
E: hong.zhang@cliffordchance.com

Jack Hardman
Senior Associate
T: +971 4503 2712
E: jack.hardman@cliffordchance.com

Frankfurt

Marc Benzler
Partner
T: +49 697199 3304
E: marc.benzler@cliffordchance.com

Oliver Kronat
Partner
T: +49 697199 4575
E: oliver.kronat@cliffordchance.com

Hong Kong

Francis Edwards
Partner
T: +852 2826 3453
E: francis.edwards@cliffordchance.com

Mark Shipman
Partner
T: +852 2825 8992
E: mark.shipman@cliffordchance.com

Brian Harley
Senior Associate
T: +852 2826 2412
E: brian.harley@cliffordchance.com

London

Rocky Mui
Senior Associate
T: +852 2826 3481
E: rocky.mui@cliffordchance.com

Kate Gibbons
Partner
T: +44 20 7006 2544
E: kate.gibbons@cliffordchance.com

Jonathan Kewley
Partner
T: +44 20 7006 3629
E: jonathan.kewley@cliffordchance.com

Stephen Reese
Partner
T: +44 20 7006 2810
E: stephen.reese@cliffordchance.com

Peter Chapman
Senior Associate
T: +44 20 7006 1896
E: peter.chapman@cliffordchance.com

London

Nikhita Suria
Lawyer
T: +44 20 7006 6214
E: nikhita.suria@
cliffordchance.com

Luxembourg

Steve Jacoby
Partner
T: +352 485050 219
E: steve.jacoby@
cliffordchance.com

Madrid

Eduardo García
Partner
T: +34 91590 9411
E: eduardo.garcia@
cliffordchance.com

New York

David Felsenthal
Partner
T: +1 212 878 3452
E: david.felsenthal@
cliffordchance.com

Allein Sabel
Associate
T: +1 212 878 3371
E: allein.sabel@
cliffordchance.com

Paris

Frèdèrick Lacroix
Partner
T: +33 14405 5241
E: frederick.lacroix@
cliffordchance.com

Sébastien Praicheux
Counsel
T: +33 14405 5156
E: sebastien.praicheux@
cliffordchance.com

Singapore

Paul Landless
Partner
T: +65 6410 2235
E: paul.landless@
cliffordchance.com

Lena Ng
Partner
T: +65 6410 2215
E: lena.ng@
cliffordchance.com

Lijun Chui
Senior Associate
T: +65 6506 2752
E: lijun.chui@
cliffordchance.com

Shanghai

Yin Ge
Counsel
T: +86 212320 7202
E: yin.ge@
cliffordchance.com

Lance Sacks
Partner
T: +61 28922 8005
E: lance.sacks@
cliffordchance.com

Sydney

Alastair Gourlay
Counsel
T: +61 28922 8043
E: alastair.gourlay@
cliffordchance.com

Washington

Megan Gordon
Partner
T: +1 202912 5021
E: megan.gordon@
cliffordchance.com

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www.cliffordchance.com

Clifford Chance, 10 Upper Bank Street, London, E14 5JJ

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