Financial Technology: Opportunities and Challenges to Law and Regulation

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In recent years four important technological developments have created new opportunities in many walks of life. What are they? First, there has been a huge increase in the computational and data processing power of IT systems. Secondly, data have become available on an unprecedented scale. Thirdly, the costs associated with the storage of data have fallen. And, fourthly, increasingly sophisticated software services have come onto the market.

Changes on the supply side of technology have given rise to the development of Artificial Intelligence ("AI"), which I define as the development of computer systems able to perform tasks that traditionally have required human intelligence or tasks whose completion was beyond the boundary of human intelligence. Within AI, there is machine learning, which involves the designing of a sequence of actions to solve a problem, known as algorithms, which optimise automatically through experience and with limited or no human intervention.[1]

Computers can now find patterns in large amounts of data from many and diverse sources, in a process which is often called "big data analytics".

Between 2010 and 2015 global investment in AI start-up businesses increased almost ninefold and there has been a marked increase in mergers and the acquisition of AI start-up companies by established technology companies in recent years. I am also aware that China has invested heavily in AI projects.

There are many beneficial uses for the new processing capacity and storage infrastructure. To give but a few examples, there are the diagnosis of diseases, the translation of foreign languages, and the development of driverless vehicles. There are interesting initiatives by a United Nations organisation on the use of machine learning in combination with natural language processing to

[1] The definitions are taken from the FSB paper, document (7) in the bibliography.

analyse material on the web, in social media, in newspapers and other sources to detect and anticipate emerging socio-economic or political problems.[2]

In the financial sphere, the new technology can be used to form digital identification records to give access to the financial system to those who are currently excluded from it. It can assist central banks in making economic forecasts, and private sector financial institutions have invested very large sums of money in the development of new products and services.

Changes have not been confined to the supply side. On the demand side of the equation, there are many younger, computer-literate consumers and investors who want an improved and less expensive experience as consumers of financial services. Regular users of the financial system expect to gain when the cost of completing cross-border payments diminishes and when lending and investment decisions become more tailor-made to fit their needs.

AI and machine-learning can contribute to a more efficient financial system, for example by allowing lenders better to assess the credit quality of borrowers, by enabling insurance companies to price and market their insurance contracts more efficiently, and by assisting customers of financial institutions to transact and solve problems at a lower cost by interacting which "chatbots".[3] Banks are using AI and machine-learning to maximise the profits from scarce capital, to improve their models for risk-management and stress-testing, and to carry out market impact analysis, by creating "trading robots" which evaluate the impact of the business's own trading on the market in which it operates. Asset managers and trading firms can use machine learning to devise trading and investment strategies, and in portfolio management by using data to predict price movements, for example. The technology is also used by regulated institutions to assist them to comply with regulations. It is used by public sector regulatory authorities to supervise that compliance, to detect fraud, money-laundering and the financing of terrorism. Natural Language Processing may help supervisory authorities assess textual sentiment to detect and anticipate such things as market volatility, financial stress, liquidity risks, housing prices and unemployment.

Consumers and investors may benefit from lower fees and borrowing costs if the new technology reduces the costs of financial services. The technology also has the potential to make

[2] United Nations Global Pulse.
[3] Chatbots are computer programs which simulate conversations with human customers in natural language.

financial services available to consumers who are currently excluded from or have only limited access to such services. This could be a significant benefit as access to reasonably-priced credit can do much to alleviate poverty in our societies. And there is potential for the creation of more customised or personalised financial services.

Innovation can bring benefits; but it can also create risks. The Financial Stability Board[4] ("FSB") has published several useful papers on AI, machine learning and financial technology[5] in which it identifies developments in the market and their implications for financial stability. The FSB warns, at the micro-financial level, of the danger of "herding" in financial markets, by which traders adopt similar machine learning strategies and so amplify financial shocks. The FSB also identifies the risk that insiders and cybercriminals who identify predictable patterns in the behaviour of automated trading strategies may use that knowledge to manipulate market prices.

There is a danger that financial institutions and regulators will not understand how machines have come to make trading and investment decisions, or how undesired events have occurred. There may be a lack of clarity about who is responsible for causing financial losses and legal uncertainties, which I will discuss shortly. Financial institutions and regulators will need people who understand and can supervise AI and machine learning so that financial institutions using such technology can establish adequate standards of internal governance and outside bodies can audit their businesses. There is also a danger that financial institutions may, over time, become too dependent on a few large technology firms for the provision of AI and machine learning services in specific areas of the financial market. If a large technology firm with a large market share were to face a major disruption or insolvency, its difficulties could adversely affect the financial system more widely.

There are ethical questions about the use by financial institutions of the available data and the new technology to build profiles of people's behaviour, including their spending or consumption patterns, when deciding whether to lend.

These risks must be analysed and addressed if we are to maximise the benefits of the new technology.

[4] An international body which monitors and makes recommendations about the global financial system
[5] See FSB papers, documents (7) and (8) in the bibliography.

An element within financial innovation which has aroused great interest is the development of distributed ledger technology. Ledgers have been used in commerce since ancient times to record the existence and transfer of assets such as money and goods. In the past and currently, businesses would maintain their own ledgers, or a trusted intermediary would control the ledger or record of the ownership of property. Now, innovation has resulted in the development of algorithms to enable the collaborative creation of digital distributed ledgers by which a database of assets is shared across a network of multiple sites, geographies or institutions and in which all participants have their own identical copy of the ledger.

The European Securities Markets Authority[6] has described Distributed Ledger Technology ("DLT") systems as:
(a) records of electronic transactions which are maintained by a shared or "distributed" network of participants (known as "nodes"), thereby forming a distributed validation system, that
(b) make extensive use of cryptography - that is computer-based encryption techniques such as public keys and private keys and hash functions which are used to store assets and validate transactions on distributed ledgers.

DLT systems are diverse and are still evolving. There are systems which are fully decentralised and have no central point of control or central validation system. There are others in which particular participants within the system control the system and validate transactions.

For the purposes of this talk I wish to point out two further important distinctions between "permissioned" and "permissionless" systems and between "on-platform" and "off-platform" tokens.

There are "permissioned systems" on which only authorised participants or a single authorised person can create records and verify changes to the ledger. A permissioned system is by definition less decentralised. "Permissionless systems", on the other hand, are open to the public and members of the public can effect and verify changes to the ledger. The system's architecture ensures that no user has full control of the ledger and incentives are offered to users to give consent and validate transactions.

[6] FMLC paper, document (6) in the bibliography p 61; document (9) p 4.

The second distinction is between DLT systems which circulate and transact in "off-platform asset tokens", which represent or are pegged to underlying assets in the real world, on the one hand, and, on the other hand, DLT systems which circulate and transact in "on-platform asset tokens", which are assets created within and have value derived entirely from the sphere of the DLT system. "On-platform asset tokens" do not represent and are not linked to any underlying asset in the real world.

DLT systems have a potential far beyond the field of financial services. The United Kingdom Government's Chief Scientific Adviser has recorded his view that such systems "have the potential to help governments to collect taxes, deliver [social welfare] benefits, issue passports, record land registries, assure the supply chain of goods and services and generally ensure the integrity of government records and services".[7] The systems have the potential to improve the delivery of health care services though the authentication and sharing of medical records according to exact rules and it should be possible for the systems to enable individual consumers to control access to their personal records and to know who has obtained access to them.

The origin of this technology is the blockchain which a person or persons under the pseudonym "Satoshi Nakamoto" developed in about 2008 to create the peer-to-peer crypto-currency, Bitcoin. In his paper on Bitcoin,[8] Nakamoto emphasised the attraction of a decentralised payment system by which electronic cash could be sent from one party to another without going through a financial institution or other trusted intermediary and which would make the payments irreversible or at least impractical to reverse, thus removing the need for a merchant to trust his customer to pay for his goods or services.

I am not qualified to discuss the technology behind blockchain which was used to create Bitcoin.[9] It is sufficient to say that Bitcoin is an on-platform asset token on a permissionless system which is open to the public. Blockchain uses cryptographic and algorithmic methods to create and verify a continuously growing data structure that takes the form of a chain of transaction blocks. The database can be extended only by appending a new block onto the most recent of the blocks on the chain. Each block typically contains a cryptographic hash of the

[7] Document (11) in the bibliography, p 6.
[8] Document (18) in the bibliography.
[9] For a useful, short and non-technical description of the process I recommend chapter 3 of the World Bank's publication, document (10) in the bibliography.

previous block, a timestamp and transaction data. The system prevents an owner of a digital coin from spending it more than once by creating a publicly available and verified chain of transactions which shows that the digital coin has been transferred from Owner A to Owner B and then to Owner C and so on. It is not the only form of distributed ledger technology as other forms and many other digital currencies have since been developed.[10]

Bitcoin and other digital currencies have proved to be controversial and trading in cryptocurrencies and cryptocurrency exchanges have been banned in some countries, including China and South Korea. China has also banned initial coin offerings because they have so often been vehicles for fraud. Some countries have made Bitcoin and other crypto-currency exchanges subject to anti-money laundering laws and rules to counter the financing of terrorism. In some other countries regulators have issued warnings to consumers about the risks of the use of such cryptocurrencies. This should not surprise as one of the most striking consequences of the development of Bitcoin and of other cryptocurrencies has been the extent to which they have become the subject of speculative short-term investment.

It is not unusual for innovation to result in speculative bubbles. In the seventeenth century Netherlands, the tulip, a flower which had been introduced into Europe from Turkey for the first time in about 1554, became very fashionable as growers produced new colour combinations to satisfy a rapidly growing demand for the flower which was then a luxury item. Prices of tulip bulbs soared in the 1630s and a futures market developed in Amsterdam in which people paid very high prices for the following year's crop. When the price collapsed in 1637, those who had bought tulip futures for high prices lost their money. The Dutch tulip mania did not seriously damage the economy of the Netherlands but the event is interesting as an early example of an asset bubble; and some commentators have compared the recent Bitcoin speculation with the tulip mania.

Asset bubbles, which have caused much more economic damage, have included "the Mississippi bubble" in France in 1717-1720, in which the so-called "Mississippi company"[11] obtained a monopoly right to trade in the Louisiana territory, a vast expanse of land from the Mississippi delta to the West, which was equivalent to about one-quarter of the modern United States. Wealthy citizens invested heavily in the company's paper in a scheme developed by an ingenious

[10] The most significant other digital currencies are currently Ethereum and Ripple. The latter is a public permissioned ledger.
[11] It was actually called the 'Compagnie des Indes' or the Company of the Indies.

Scotsman with a chequered record, John Law, in the belief that great riches would be won from the development of the Louisiana territory. The price of the shares issued by the company soared by a factor of over nineteen as the controller of the company manipulated the market for its shares with the assistance of the absolutist and heavily-indebted French monarchy, which hoped that the scheme would be able to wipe off the government debt. Unsurprisingly, it was at this time that the French first came up with the word "millionaire". But fortunes were not made; they were lost. The share price collapsed in 1720, ruining many investors and turning the French against paper money and stock markets for several generations. A similar bubble but on a smaller scale occurred in England at about the same time. The South Sea Company was set up to exploit a monopoly of trade with the Spanish in South America. Market manipulation was rife. Irresponsible marketing and incautious investment caused its stock to rise by a factor of 9.5 before it fell back sharply when the so-called "South Sea Bubble" burst. One market participant described the situation at the time as follows:

> "A mighty bubble of wealth is blown before our eyes, as empty, as transient, as contradictory to the laws of solid material, as confuted by every circumstance of actual condition, as any other bubble which man or child ever blew before."

And he concluded:

> "The additional rise above the true capital will only be imaginary; one added to one, by any rules of vulgar arithmetic will never make three and a half; consequently all fictitious value must be a loss to some person or other, first or last. The only way to prevent it to oneself must be to sell out betimes, and so let the Devil take the hindmost."[12]

Many investors were ruined by the bursting of the bubble. Commentators at the time spoke of the "vast fund of stupidity in human nature".[13] This bubble did not have as serious consequences as the Mississippi bubble in France, but legislation passed at the time (the Bubble Act) restricted the establishment of new joint stock companies for many years.[14]

In the twentieth century, unwise responses by governments and central banks to the stock market crash on October 1929, itself the result of a mixture of stock market fraud and the madness of crowds,[15] caused the worst depression in world history and world trade shrank by two-thirds as countries tried to protect themselves by introducing trade barriers and import quotas. More recently still, the boom in housing prices particularly in the United States which

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[12] An anonymous pamphleteer quoted in John Carswell, "The South Sea Bubble" (2011) p 120.
[13] "Cato's Letters" January 1721 written by John Trenchard and Thomas Gordon.
[14] See, more generally, Niall Ferguson, "The Ascent of Money: A financial history of the world" (2008) ch 3; E. Chancellor, "Devil take the Hindmost: a history of financial speculation" (1988) ch 3.
[15] Chancellor, op. cit. chapter 7.

was fuelled by cheap credit played a significant role in the financial crisis of 2008 which led to the great recession. What has accurately been called the "irrational exuberance"[16] of investors has repeatedly caused serious economic damage.

It seems that crypto-currencies risk creating bubbles if they are not brought under governmental regulation. It can surely be stated that the novelty of Bitcoin has generated irrational exuberance by speculators. Before it became popular with speculators in about 2017, it had shown considerable volatility, with crashes in 2011, 2013 and 2014. But in 2017 the cryptocurrency rose in value on a speculative bubble from about US $ 1,000 to over US $ 19,000 before falling back to its price at the time of writing this lecture of about US $ 6,400. Such a performance does not bode well for an unregulated cryptocurrency in a permissionless system to be an effective unit of account or a store of value.

Other concerns have been expressed about Bitcoin and similar cryptocurrencies. Digital currencies which are on-platform asset tokens have no intrinsic value. There is no guarantee that they can be converted into fiat currency or that they can be used as a means of payment for goods and services. The "proof of work" validation method used by Bitcoin, which involves the use of large quantities of computing power, is extravagant in its use of electricity. It has been estimated that Bitcoin already uses as much electricity per year as the annual consumption of the Republic of Ireland (which has a population of 4.8 million) and that by 2020 it will consume as much as Denmark, which has a population of 5.7 million.[17]

The world's most important central banks, including the Bank of England, have dismissed the notion that cryptocurrencies are money since their high volatility makes them unsuitable as a store of value and high transaction costs make them impossible to use in retail payments. But several central banks, including, I understand, the People's Bank of China, have plans for digital currencies with central bank approval. It is likely that such digital currencies can avoid such volatility and costs.

In addition, the relatively anonymous nature of the blockchain makes it difficult to identify who is transacting on a permissionless system. Thus, digital currencies such as Bitcoin appear to be

[16] Alan Greenspan on 5 December 1996, cited by Niall Ferguson op. cit. p168.
[17] The records of Bitcoin transactions are thought to be almost impossible to falsify because the collective computer power required to validate transactions is so great: World Bank paper document (10) in the bibliography, p 6.

attractive to criminals who need to launder money.[18] Concerns have also been expressed at the use of Bitcoin in tax evasion, drug-trafficking and the funding of terrorism. Digital currencies such as Bitcoin have been demanded by the controllers of Ransomware, which is malicious software preventing users from accessing their computer system unless a ransom is paid. But the anonymity is incomplete. More accurately a cryptocurrency can offer pseudonymity (that is a state of disguised identity), and it may be possible to identify people trading in cryptocurrencies by studying their dealings and other information on the internet. The US Federal authorities were thus able to identify Ross Ulbricht as the controller of the notorious dark web market place of illegal goods and services, called Silk Road, in 2013. He is now serving a life sentence in prison for money laundering, computer hacking and conspiracy to deal in narcotics.

Concerns have also been expressed about the lack of regulation of Bitcoin exchanges at which the digital currency can be exchanged for real world fiat currency. Further, there are worries about the vulnerability of software which has been built on top of the distributed ledger technology of cryptocurrencies which has resulted in the theft of large amounts of cryptocurrency.[19] Thus the Tokyo-based Bitcoin exchange, Mt Gox, which grew to handle 70% of the world's Bitcoin trades, had to be closed down in 2014 after it was discovered that there had been thefts of over US $450 million worth of Bitcoin.[20] And, in August 2016, US $72 million worth of Bitcoin were stolen in a hack of another Bitcoin exchange, called Bitfinex.

Since Bitcoin came onto the scene there have been attempts to establish many other cryptocurrencies. These attempts have concerned public authorities because of the high level of misrepresentation in initial coin offerings and the lack of a robust system for regulating such offerings.

There is therefore a pressing need to answer questions about how to protect investors and how to protect financial stability if cryptocurrencies are to have a significant role in the financial system in future.

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[18] For example, in July 2017 a Russian, Alexander Vinnick was arrested in Greece and charged by a Grand Jury in the USA of money laundering of over US $ 4billion over several years.

[19] There is a theoretical possibility of a fundamental breach of the DLT ledger supporting a cryptocurrency if a malicious organisation managed to get control of more than 50% of the computer processing power for the ledger but to date the vulnerabilities appear to have been linked to exchanges rather than the operation of the DLT itself.

[20] The US Department of Justice allege that Alexander Vinnick, whom I have mentioned (fn 15), was responsible for laundering many of the stolen Bitcoin.

Whatever problems have been associated with cryptocurrencies, many governments and financial institutions see great potential in the development of distributed ledger technology in the future financial system. The Bank of England operates a FinTech hub, which it established after it introduced the FinTech accelerator project, and has offered a proof of concept service to innovators since 2016.[21] The United Kingdom Government has expressed an enthusiasm for developing the technology. It has suggested that permissioned ledgers with smart contracts added on are likely to be more appealing than permissionless ledgers. By "smart contracts", I mean contracts whose terms are recorded in a computer language and which are automatically executed by a computing system. I will discuss them shortly when I address the legal challenges of the technology. The UK Government supports research to establish whether DLT can operate effectively if it is built up in scale, and whether it can be secure, provide proof of the correctness of the contents of the ledger, and be energy efficient. It recognises the need for a regulatory framework for the technology including both legal rules and a technical code. It calls for collaboration between government, the universities and industry to set standards for the integrity, security and privacy of ledgers and their contents and to implement identification and authentication protocols. And it recognises the need for the development and implementation of internationally agreed standards.[22] I will return to the need for international cooperation at the end of this talk.

For financial institutions, as well as for governments, distributed ledger technology has at least seven strengths. First, it has the benefit of transparency. You can trace on blockchain the things that are being transferred as it can provide a record of who owns and who has owned the asset in question. This may be valuable as it can assist in stamping out illegal trading in, for example, conflict diamonds. Secondly, the relative difficulty of altering the distributed ledger is likely to preserve its accuracy as a record of prior transactions. This is because it requires the collusion of a very large number of participants in a permissionless system and the cooperation of a group of trusted institutions in a permissioned system to change the ledger. The preservation of an accurate historical record would be an important weapon in holding people accountable for the performance of their fiduciary and other duties.

Thirdly, a distributed ledger is less open to cyber-attack than a single centralised digital ledger as there is no one single point of failure. Fourthly, as technology develops the distributed ledger

[21] https:www.bankofengland.co.uk/research/fintech.
[22] See UK Government Office for Science report, document (11) in the bibliography.

can be operated at lower cost than the initial distributed ledgers. Enthusiasts for DLT argue that it offers the prospect of giving financial services to those who have been excluded from such services. Fifthly, it has the potential to remove the significant costs of having to use paper documents in banking transactions and international trade. Cross-border payments may be simplified. Sixthly, the removal – or at least the reduction in the number of intermediaries in financial transactions – offers the prospect of increased speed and lower costs. The World Bank quote an estimate of annual savings in the financial sector alone in the range of US $ 15-20 billion per year.[23] And, seventhly, there is the potential to enhance the protection of a consumer's privacy and personal data. Pseudonymous transactions in permissionless systems make it difficult to identify who is transacting. In permissioned systems, smart contracts can control which institutions can have access to private data and which cannot.

Nonetheless, achieving all or any of these benefits poses a serious challenge to the legal systems and regulators in countries which are exploring the potential of distributed ledger technology and other forms of financial innovation.

It is generally said that the purposes of financial market regulation are threefold, namely the protection of investors and consumers, the promotion of market integrity and the preservation of financial stability. But financial innovation tends to outstrip regulation so that regulators are having to catch up with the work of financial institutions. It is imperative that both the financial institutions and the public regulators understand where the technology will lead us before it is applied widely in the financial system.

Regulators face a significant challenge because of the complexity of FinTech. To perform their roles properly they will have to understand the transactions which the technology will create. Regulators will also have to address the risks to financial stability if the new technology expands the shadow banking sector[24] in a major way by creating peer-to peer lending platforms and crowd-funding facilities. The support of a central bank to maintain liquidity in a crisis, which is available to the regulated banking sector, is not available to this form of funding. This raises also an important question of consumer protection.

[23] Document (10) in the bibliography, p 16.
[24] My understanding of shadow banking system is that it is a collection of financial intermediaries which facilitate the creation of credit outside normal regulatory oversight. I am aware of concerns in China about the size of its shadow banking system.

Options include the licensing of platforms which offer FinTech products to retail consumers in order to protect such investors from risky products. It should be possible to restrict access to certain platforms to sophisticated investors. There appears to be considerable scope for financial institutions to use DLT in permissioned systems in ways which to not pose a risk to consumers such as for cross-border payments, correspondent banking, clearing and settling transactions in securities and derivatives, syndicated loans and trade finance, with the use of tokens as mirrors of fiat currencies and securities. In fact, a trial of the use of blockchain technology for the processing of trade finance documentation by a consortium of Hong Kong and Singapore-based banks has proved successful in pushing down both the costs of processing relevant documentation and potentially cutting down the time required to complete a transaction from five days to a single day.

But if (contrary to my intuition) digital currencies in permissionless systems eventually succeed in playing a significant role in commercial life, there will be a need to regulate the exchanges which convert digital currencies into fiat currencies.

It will be necessary for regulators to formulate their requirements as to the information which providers of FinTech must disclose to those who seek to use their services. Measures to counter money laundering and to check the financing of terrorism, including "Know Your Client" requirements, will have to be adapted to the forms of FinTech transactions which are to be authorised if permissionless systems gain acceptance.

The use of "big data" by financial institutions poses a risk of unacceptably discriminatory behaviour, for example in the insurance industry if insurance were withdrawn from, or made available only on relatively adverse terms to, certain groups of people on unlawfully discriminatory grounds.

The increasing use of cloud computing technology raises important issues of privacy, the security of personal data and the protection of intellectual property which regulators and legislators in different jurisdictions are having to grapple with. The availability of so much data and the increased capacity to process combined data from various sources have made it easier to identify individuals who are data subjects. Re-identification technology may require regulators to adopt an expanded view on what is personal data. Preventing unauthorised access to and use or loss of

data stored "in the Cloud" will remain a major concern for cloud service providers and regulators if financial services are provided in this way.[25]

Given the diversity of the innovations in FinTech, including the many potential applications of DLT in financial services, and the potential benefits which FinTech may create, it is important not to stifle innovation. One method by which innovation can be promoted but regulatory control maintained is the "regulatory sandbox". This concept, which was invented by the UK's Financial Conduct Authority (FCA) in 2015, refers to a framework set up by a financial services regulator to allow small-scale live testing of innovations by private firms (operating under a special exemption or limited temporary exception) under the regulator's supervision.[26] Collaboration between the private firm and the regulator allows the former to test products and services and the latter to assist in identifying consumer protection safeguards to build into such products and services to enable them (if the testing is successful) to be released onto the market promptly. By 2017 over 20 countries have adopted the concept of the regulatory sandbox. Very recently, the FCA and 11 other regulators, including the Hong Kong Monetary Authority, announced the creation of a "Global Financial Innovation Network" to create a "global sandbox" which would allow firms to trial new products in several countries at the same time and to allow regulators to share policy ideas.[27] There is potential for such cooperation to lead to the introduction of international regulatory standards for the providers of Fintech services which operate across borders.

FinTech poses challenges on a similar scale to legislators, judges and lawyers who seek to apply or adapt commercial law. A successful system of commercial law promotes rather than hinders honest commercial activity. A legal system which offers a high degree of legal certainty will tend to reduce the cost of transactions and so encourage commerce. In the eighteenth century, Lord Mansfield, whom many would regard as the father of English commercial law, stated:

> "In all mercantile transactions the great object should be certainty: and therefore, it is of more consequence that a rule should be certain, than whether the rule is established one way or the other."[28]

Similarly, more recently, Lord Goff stated in an extrajudicial writing:

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[25] See Cheung and Weber , document (4) in the bibliography, especially chapters 1-4 and 8.
[26] I have derived this definition form Jenik, Ivo and Kate Lauer. 2017. "Regulatory Sandboxes and Financial Inclusion." Working Paper. Washington, D.C.: CGAP.
[27] Financial Times 7 August 2018.
[28] *Vallejo* v *Wheeler* (1774) 1 Cowp 143, at 153.

> "[Judges] are there to give effect to [businessmen's] transactions, not frustrate them; we are there to oil the wheels of commerce, not to put a spanner in the works, or even grit in the oil."[29]

How can a legal system promote that certainty and oil the wheels of commerce when its traditional structure has not been adapted to accommodate the novel forms of transacting which financial technology offers?

I start with contract law. "Smart contracts" are contracts which can be partially or fully executed or enforced without human intervention. At their simplest, they involve an instruction to the computer that if X happens then the computer is to act to make Y the result. This process of "if-then" instructions can be compared to the operation of an automatic a vending machine. If you wish to buy a snack, you put money in the machine, select the product and the machine takes the money and delivers you your snack.[30] In such a simple form, there should be no problem in upholding the existence of a contract in legal systems such as the common law, which assess the intention of the contracting parties objectively, so long as the parties were aware, when contracting, of the nature of the arrangement which they were entering into.

But the law has to address how to provide a remedy if contractual consent has been vitiated, for example, by misrepresentation or fraud. Smart contracts are self-executing as the terms of the agreement between a buyer and a seller are written into lines of code which exist in a blockchain. When the coded conditions are met, a product is released or a payment made. No-one, including a court, can stop the performance of a smart contract. The courts will not be able to cancel the performance of the contract. But a remedy may lie in the law of unjust enrichment in both common law and civil law jurisdictions to compel the parties to re-transfer the property or money which was the subject of the transaction.

If the use of FinTech in contract, which goes beyond the smart contract[31] and uses artificial intelligence to optimise the arrangements between contracting parties on the occurrence of contingencies, becomes widespread, contract law will have to be developed to address this. If machines make independent decisions, how will the law attribute those decisions to the intention of the contracting parties?

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[29] Lord Goff of Chieveley, "Commercial contracts and the commercial court", [1984] LMCLQ 382 at 391.
[30] The example of the vending machine was the chosen illustration of the idea behind a smart contract which Nick Szabo used when he coined the term "Smart contracts" in his 1997 paper "The Idea of Smart Contracts".
[31] The "smart contract" in the sense used by Nick Szabo involves no machine learning but simply implements "if-then" instructions.

Similarly, the law will have to address the existence of civil liability outside the field of contract law. AI may also come to have many uses in financial systems such as the optimisation of the balance between assets and liabilities, portfolio management, the execution of trades and the detection of fraud. In the law of tort or delict, liability can result from the combination of a wrongful intention to harm another or foresight of harm to another and a causal link between the individual's action (or inaction) and the harm which the other suffers. If an adverse outcome is the result of a decision by a computer, to whom will the law attribute fault? How will the law see a causal connection between a human individual's acts and that outcome? Who is to be responsible for the machines' decisions? Will there have to be legislation to impose liability on the developer of AI devices in Fintech as one might in relation to the manufacturer of driverless cars? Or should legislation impose liability on those who choose to use such devices?

These are matters which need to be addressed as the practicable uses of FinTech become clearer.

Another area of doubt is in property law. For example, if digital currencies are developed and become widely used in cross-border commercial transactions, it will be necessary to achieve a degree of international legal consensus on their nature as property rights. Should such currencies, if they were to achieve a stability so far absent and were accepted widely in exchange for goods and services, be regarded as money or are they to be seen as securities and regulated as such?[32] If computers using AI generate intellectual property, who owns that property? Rules will be required to define the nature of assets held on distributed ledgers and to identify when such property passes from one owner to another.

If financial courts are to give justice in disputes arising from the use of FinTech, they will need personnel who understand the basics of finance, of investor and consumer protection principles and the mechanics of FinTech which is in issue. Judges and arbitrators will have to understand or have access to independent experts to enable them to understand the potentially complex technical evidence which parties may present in such disputes if they are to reach a reliable conclusion as to liability. The creation of the Financial List in London and the establishment of the Financial Court in Shanghai are important initiatives in this direction and both can contribute to the preservation of financial stability.

[32] In London the FMLC has suggested that virtual currencies which are pegged to "real world" currencies could be regarded as e-money and be negotiable. They suggest that the traditional categories of the common law might be extended to recognise virtual choses in possession as a new form of property: document (6) in the bibliography pp 30 & 38.

If FinTech is to contribute significantly to international commerce and financial services, there is a pressing need for international cooperation to establish agreed rules of private international law. It is a fact that many distributed ledger structures operate across borders. This gives rise to uncertainty as to the governing law in relation to contracts executed and property held in the distributed ledger. There needs also to be agreement on jurisdiction and enforcement to enable court judgments and arbitration awards to be enforced in several jurisdictions as the nodes controlling such a distributed ledger will operate in several jurisdictions. The Standing International Forum of Commercial Courts, in which both the United Kingdom and China participate, is working on enforcement of commercial judgments for money and might be a suitable body to seek agreement on rules of jurisdiction and enforcement in FinTech.

What is the way forward? I suggest that we should seek to extend the cooperation between regulators, such as the Global Financial Innovation Network of which I have spoken, to achieve a greater harmonisation of regulation. Also, countries with a major interest in financial services, including China and the UK, should cooperate to promote new rules of private international law which could be promulgated by an international body, such as the Hague Conference or Unidroit. More ambitiously, if we were to develop internationally accepted laws on those FinTech operations which can promote international trade in goods and services, so as to make the consequences of those operations as familiar as those of a bill of lading or a banker's letter of credit, we would enhance the prospect of spreading the gains of the new technology to benefit more people internationally.

In all this, ethical considerations, the interests of the consumer, and the need for privacy and data integrity will have to be balanced carefully against the potential benefits the new technology brings in terms of lowering transaction costs, broadening access to the financial system, increasing market efficiency and enhancing consumer choice. It will be a most challenging task with important ramifications for the well-being of our societies in the years to come.

Thank you.

Endnote

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