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The Potential for Blockchain Technology in Corporate Governance

Vedat Akgiray

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The Potential for Blockchain Technology in Corporate Governance

by

Vedat Akgiray*

Beyond bitcoin, blockchain technology has acquired attention and importance in its own right. Today, it is conceptually accepted that blockchain stands out as a disruptive technology that will change a number of processes in financial services and could in turn impact corporate governance. This paper explores the recent applications of blockchain technology in financial services and outlines regulatory responses, to set the scene for future work in this area on corporate governance. This paper provided background for the Corporate Governance Committee's roundtable discussion on blockchain technology and the implementation of the G20/OECD Principles of Corporate Governance on 10 April 2018. A subsequent presentation of the paper was given at the OECD Workshop on Digital Financial Assets on the 16 May 2018, and at the OECD-Asian Roundtable on Corporate Governance in Malaysia on 7-8 November 2018. This work also provides a contribution to the work of the OECD Blockchain Policy Centre.

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* This paper was developed by Vedat Akgiray, Professor of Finance, Bogazici University.

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I. Historical and Conceptual Perspective

Blockchain is an example of a distributed ledger technology (DLT) which has attracted a lot of attention in recent years. This interest was first due to the growing popularity of Bitcoin, which is based on a peer-to-peer electronic money system suggested by "Satoshi Nakamoto" in 2008.[1] However, beyond bitcoin and other cryptocurrency models, blockchain technology has acquired independent importance. Developers and researchers worldwide arenow investigating its potential. Today, it is conceptually accepted that blockchain stands out as a disruptive technology with the potential to transform the foundations of our societal and economic systems. Using terms like "new internet", "internet of trust" or "internet of value", some authors claim that blockchain technology is the most transformative technology since the creation of the World Wide Web. This technology, however, is not well understood by many. A survey by HSBC in 2017 found that 80% of those who have heard of 'blockchain' do not have a clear understanding ofwhat it means. The street is crowded by "only cryptocurrency enthusiasts" and governments by "sworn technology sceptics." Therefore, it is important to develop a clear and well-informed perspective of the technology and its probable foundational implications.

To help better imagine the potential social and economic impact of blockchains, Lansati and Lakhani (2017) and Waldman (2018) recall the history of the Transmission Control Protocol and Internet Protocol (TCP/IP), the communication technology which made the internet possible and part of our everyday life. First introduced in early 1970s as the emailing protocol for ARPA net users, TCP/IP was first met with scepticism by telecom companies, who continued to invest heavily in traditional physical lines and dedicated communication equipment. In the 1980s, new technology firms started using TCP/IP technology to build local peer-to-peer networks of emailing, first within their own organisations and then for localised use in other industries. Communication speed and capacity were increased almost infinitely and, as a result, there were huge gains in productivity. Dedicated lines, circuit-switching equipment, fax machines, telex machines and the like quickly became obsolete. In 1990s, the start of the World Wide Web based on HTTP and HTML protocols opened TCP/IP-based technologies to global public use and this marked the start of disruption and transformation.

Enabled by the development and commercialisation of internet applications by companies such as Netscape, Sun, and Microsoft, information and the number of users on the internet grew very fast. The low cost of connectivity coupled with powerful application development tools started to disrupt and eventually replace existing business models. Napster, eBay, Priceline, Google, Amazon, Facebook, Apple, Alibaba, Baidu, Weibo and Tencent, to name a few, became the new multinational platform-based business models on the internet. Brand names and physical scale were no longer commercially as important as before. Business models that could not keep up with this new internet-driven world were forced to leave the stage. The single most important driver of this fundamental transformation in the economy was the ever decreasing cost of connectivity made possible by TCP/IP technology. It would be fair to hypothesise that only very few people in the 1970s and even in the 1980s could have imagined this huge transformation in our business models.

It is easy to find conceptual parallels between TCP/IP and blockchain technologies. Both can be used over local and wide area networks. The development and maintenance of blockchain is open and shared—similar to TCP/IPs. Volunteers around the world maintain the core software. And just like e-mail, bitcoin

first caught on with an enthusiastic but relatively small community. TCP/IP dramatically reduced the cost of connectivity (and hence the cost of information) and enabled global access to information. Continuing on the same axis of progress, blockchain may be expected to dramatically reduce the cost of transactions. As a case in point, the full process of trading a financial asset may take days to clear, settle and finalise. The same transaction under a blockchain setup has the potential to be done in a fraction of a second. This paper explains how this is possible. If TCP/IP-based peer-to-peer networks are to transfer "information about assets", blockchain networks are to transfer "values of assets." (It is important to note that, blockchain is not an alternative to TCP/IP but a technology running on network protocols like TCP/IP.)

To complete the historical perspective, the 2008 financial crisis left a populace distrustful of centralised ("systemically important") financial firms and markets, and also showed the danger of hiding financial ledgers from public scrutiny. Today, the world is exposed to data breaches, hacking, fraudulent use of private information, fallible financial institutions, and high costs of intermediation. It is claimed by some that the popularity of bitcoin was partly a people's response to these problems and an act of defiance.

A decade after the start of the global financial crisis and despite countless analysis of the reasons, some of the factors that led to the crisis are still very much alive today. Unimagined advances in computing and communication technologies are constantly giving rise to new risks related to cybersecurity, privacy protection, and oligopolistic concentration in information control. Whatever the potential tangible value of blockchains, businesses and policy makers will benefit from keeping abreast of the opportunities and challenges presented by new technologies. Emerging technologies like blockchain may help fill in gaps that cannot be handled with laws and regulations alone.

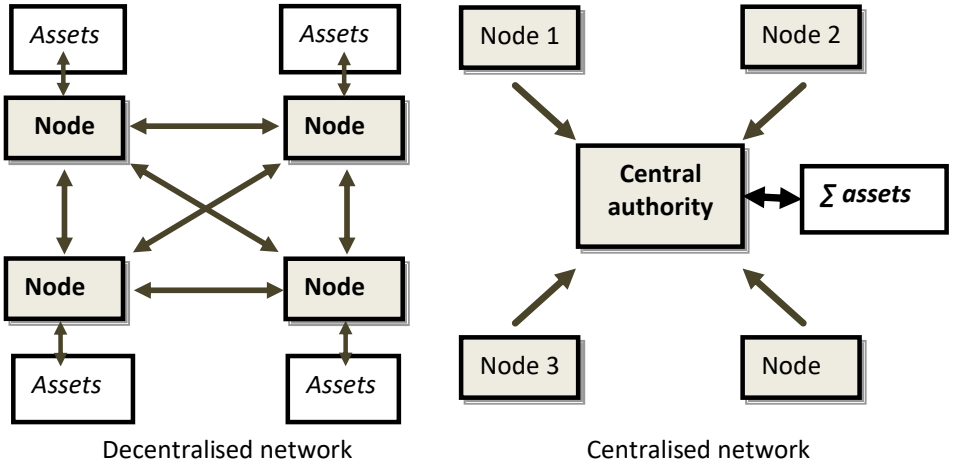
II. Basic Concepts in Blockchain Technology

Before discussing blockchain technology as a business model, two points need to be clarified. First, although most of the studies on blockchain are centred on the presence of a cryptocurrency such as Bitcoin, cryptocurrencies are mere applications of blockchain. The essence of blockchain is related to a certain method of processing information and it does not have to be directly related to any monetary platform. Cryptocurrencies are powerful applications of the blockchain and their use has revealed much about the current and potential weaknesses and strengths of the technology. Bitcoin is in fact the first real applied example of a blockchain although a similar idea was first envisaged in a paper by Haber and Stornetta (1991). Nonetheless, "thinking bitcoin only" carries the risk of swaying the topic away from technology and implementation issues, and towards cryptocurrency-specific issues such as sovereignty and legal tender. That is not the subject matter here. Blockchains can be designed without any application of their use as a cryptocurrency per se.

Secondly, given access to network like the internet, blockchain is a combination of three basic technologies: cryptography, smart contracts[2], peer-to-peer networks and distributed ledger design. These are all independent technologies which can be used independently in stand-alone applications, or jointly with in any combination with the others. Indeed, these technologies date back a few decades before the name blockchain was first heard. Blockchain is best interpreted as a business model assembling these component technologies (and others, as needed) under a novel design. The success or failure of a given blockchain design should not be attributed to that of either one of its component technologies, or vice versa.

A blockchain is essentially a decentralised peer-to-peer (P2P) network of transactions, confirmations and ownership transfers, without a central authority or intermediary. Computers on the network ("the nodes") use cryptographic algorithms and smart contracts to confirm the transactions, which are then written into "blocks". "Chains" of such blocks form a transaction log which can then be summarised into a ledger. When transactions occur, records of ownership (assets and their values) are permanently logged into the ledgers, there being as many identical ledgers as the number of related nodes. This makes corrupting the ledger extremely difficult, giving blockchains a high level of "immutability" - which is what makes them a strong alternative to traditional centralised databases. In theory, there is no need for an authorised centralised intermediary to confirm the transactions and hence there is no need for a central database or repository of transactions and records. This mechanism results in a decentralised / distributed database of ledgers with a continually growing record of transactions. As illustrated in Figure 1, this is in sharp contrast to a traditional centralised network, where all transactions are verified and ownership records kept by a central authority. (In what follows, the term "blockchain" is used synonymously with "distributed ledger.")

Figure 1. Decentralised versus centralised network



Decentralised networks may be customised for any degree of decentralisation with respect to user access and usage rights. A blockchain network can be in one of two formats:

- Public ("permissionless") blockchain: There is no one owner / operator and anyone is able to enter and exit freely. Everyone on a ledger has access to the same copy of the ledger and hence there are as many identical copies of a ledger as the number users. (Bitcoin is a typical example of a public blockchain.)
- Private ("permissioned") blockchain: There are one or multiple owners / operators, who grant access to permissioned users. Only permissioned users hold a copy of a given ledger. Financial institutions seem to prefer this type of setup (two examples are RippleNet and NASDAQ LINQ).

Table 1. The main types of blockchain segmented by permission model

			READ	WRITE	COMMIT	EXAMPLE
Blockchain types	OPEN	Public permissionless	Open to anyone	Anyone	Anyone	Bitcoin, Ethereum
		Public permissioned	Open to anyone	Authorised participants	All or subset of authorised participants	Supply Chain ledger for retail brand viewable by public
	CLOSED	Consortium	Restricted to an authorised set of participants	Authorised participants	All or subset of authorised participants	Multiple banks operating a shared ledger
		Private permissioned ("enterprise")	Fully private or restricted to limited set of authorised nodes	Network operator only	Network operator only	External bank ledger shared between parent company and subsidiaries

Source: Hileman and Rauchs, 2017

Beyond a binary choice between public and private blockchains, a continuum of setups is also possible. Indeed, any format between public and private blockchains may be envisioned as a "hybrid blockchain". As a future case in point, a fully public blockchain with multiple nodes on the blockchain (or, on a "side chain" linked to the blockchain) dedicated to regulatory authorities / operators may be imagined. As all other users, the authority will have an identical copy of the public ledger and no special user rights. However, via transparent and live "smart contracts", the authority may exercise its oversight power and intervene in case of non-compliance.

In non-technical terms, the steps of a standard blockchain proceed as follows:

1. A transaction request by a user is transmitted to all related users on a P2P network and it is verified by consensus algorithms such as "Proof of Work" (PoW) and "Proof of Stake" (PoS).[3] The security and accuracy of verification are based on two algorithmic technologies: (i) private / public key infrastructure and (ii) cryptographic hash.
2. Verified transactions are combined with other related transactions to build a new block and the new block is then "chained" to previous related blocks. The chain of blocks is the distributed ledger of all transactions in chronological order and is shared among all related nodes.
3. Transaction is confirmed and finalised.

At a first reading, the above descriptions may not sound spectacular. But blockchains really introduce very fundamental powerful capabilities for business models and beyond. Compared to traditional centralised databases, blockchain is a superior database design for a number of reasons:

1. It is decentralised and immutable: In any network on the Internet, it was not previously possible to maintain the accuracy of transactions without a "trusted" central authority / intermediary and hence the need for centralised networks. Blockchain allows for secure transactions and ownership transfers in a P2P model without a trusted intermediary. Using private/public key cryptography and hash algorithms[4]:
    a. Access to data (who can do what with the ledger) and data in the ledger (who did what and when) are both encrypted,
    b. Hence, data is "immutable" and no one can tamper with historical records.

    Data accuracy and immutability are two features that have shaped blockchain as an alternative trust-reinforcing mechanism in our societies and economies. They allow for transactions to be made without a trusted intermediary to establish trust between the parties who may not know or trust each other. The Economist magazine calls the blockchain the "Trust Machine" and Finck (2017) describes it as "trustless trust, which makes it possible to trust the outputs of a system without trusting any actor within it". However, it still seems that when blockchains have to connect with the real world to get information about assets, a trusted authority may be required to make that connection. A recent example is Thomson Reuters' BlockOneIQ. A complete elimination of the need for trust does not seem to be possible, at least for now.
2. It is secure: Since the blockchain design produces multiple shared copies of the ledger, it is inherently more resistant to cyber-attacks than centralised networks where the master ledger is kept at one node only. This is because there is no single point to attack and also because the built-in consensus mechanism can easily recognise malicious attacks and isolate them. In this regard, public blockchains are more resilient to cyber risks than private blockchains, which in turn are more resilient than centralised databases. However, there may be a new type of cyber risk unique to blockchains and it is the collusion of a sufficient number of nodes that control

the network. This would effectively reverse immutability. Although several solutions are being developed, such collusion could result in events like the LIBOR crisis.

3. Provides a platform for a myriad of applications: Blockchain can serve an efficient platform on which new applications such as "smart contracts" ("digital agreement"), "tokens" ("value carrier" or "value container"), decentralised applications (dApps) and "Decentralised Autonomous Organisations" (DAOs) can be developed. The concept of token is related to "currency" and "tokenisation" is the process of digitally representing an off-chain real-world asset (currency, commodity, security, property etc.) on a distributed ledger. Tokenisation can also be viewed as a type of smart contract. A smart contract is basically a software program to execute certain tasks if certain conditions are met. The program code comprises the initiation, verification, execution and enforcement of the terms and conditions of a contract between two or multiple parties. The code itself and all of its executions in chronological order are recorded in the blockchain using the same consensus and security mechanisms as other transactions. In theory, if a code of law or any regulation can be embedded as a smart contract in a blockchain, then breaking the law is tantamount to breaking the code. In other words, the only way to infringe the law is to "crack" the computer code. This is potentially a very powerful tool not only to automate contractual transactions but also to automate legal supervision and some kinds of enforcement. After the popular term FinTech, new terms like RegTech (Regulatory Technology) and LegTech (Legal Technology) have entered our vocabulary. Examples of using smart contracts on a blockchain are applications developed on Ethereum and Codius on public blockchains, and HyperLedger on private blockchains.

Despite the known and expected superior aspects of blockchains, the technology, as of today, still has some shortcomings and weaknesses:

1. **Scalability** seems to be a widely recognised challenge in blockchains with continually expanding ledger sizes. The problem seems to be more obvious for public blockchains where every user on the network has to store a full immutable copy of the ledger, which is the basic mechanism of integrity in blockchains (that is, full global verifiability). This, in turn, demands continually increasing storage capacity for all users and can become a serious barrier to entry, which is against the basic promise of decentralisation. Expanding ledgers eventually cause both a storage capacity and also a computing power problem. There are several developing software solutions such as "sharding", where users need to verify only relevant transactions, and "certificate transparency", where there is no need for consensus by the whole network of users. Examples are Corda by R3, IOTA, Stellar and Hyperledger. The nature of soft solutions would seem to depend on the area and nature of application. Decreasing throughput and increasing latency are actually problems of hardware limiting software, and therefore a complete solution may have to wait for quantum computing to commoditise.

2. **Privacy** comprises people's identities and activities. Ever since the start of the Internet, privacy has been challenged, both legally and technologically. Personal data, exclusively and centrally stored on the servers of big technology companies and financial institutions has become a valuable asset. Big data analytics and artificial intelligence are widely studied new technologies to develop commercial models leveraged by personal data. Today individuals play a greater role in disseminating personal data – raising new issues on the impacts they are having on the privacy of others and themselves. This is an inherent problem with centralised networks, which seems impossible to solve by laws and regulation alone. As mentioned before, the blockchain with a distributed ledger setup can produce an acceptable solution to problems caused by the centralised control of data.

However, full "privacy control" is yet far from being realised on most blockchains. On a blockchain, users can have "pseudonymous" identities and hence their real-world identities can be largely protected via public key cryptography. However, details on transactions may be still fully transparent, which is in particular the case on public ("permission-less") blockchains where ledgers are shared by all. As in the case of scalability, some solutions such as sharding, side-chains and time-based filters are proposed. (These are all methods to split a big ledger into many smaller ledgers across multiple machines. The criteria may be based on dates, relevance and types of data in the ledgers.) Again, all imply some degree of compromise from the basic promise of blockchains. That said, privacy enhancing algorithms are being adopted on some blockchains such as Monero, where algorithms such as Ring Signatures and Confidential Transactions are used to obfuscate the information provided on the ledger.

3. **Governance** of (public) blockchains is often cited as a critical issue as the technology achieves wider use in different industries. The issue attracted closer attention after the Ethereum DAO incident where a token holder used a software-bug to funnel about one-third of the total value in the network to her own account. (The bug was fixed later via a "forking" solution but the issue is still an open question.) Governance problems in cryptocurrency platforms have become clear after widely-advertised platform collapses. Recently, the heist of more than half a billion dollars' worth of digital currency from the Coincheck exchange in Japan was largely due to a weak governance structure, which in turn was related to a lack of standardisation to enable timely regulatory action. Governance is about who makes the rules and who enforces them. It is not only about who controls the blockchain but also about having the right resolution mechanisms in place in case of technological collapse, contractual default and crime. Similar technology solutions as in scalability and privacy issues have been proposed but again all seem to require "some degree of centralisation" of governance authority as in a "Masternode." As blockchain has the potential to become a foundational business model, technological solutions should be paired with appropriate standardisation and regulation mechanisms to ensure that its benefits outweigh its risks.

III. Blockchain technology and the Financial Industry Landscape

The market for blockchain development is still relatively small but it has been growing very fast since Bitcoin gained popularity in 2012. Some current industry trends since then are:

- According to a global market survey by Juniper Research (2017), 40% of all businesses and 60% of large corporations are considering blockchain deployment during the next 2 to 10 years. Reports by the World Economic Forum (2016, 2017) reveal that more than 30 national governments and 90 central banks are currently investing in blockchain solutions, and more than 80% of banks planned to initiate blockchain projects in 2017 and 2018. More than 2,500 blockchain-related patents have been filed since 2013 and currently there are more than 20 consortia of blockchain development, including many financial firms.
- A benchmarking study at the Cambridge Centre for Alternative Finance (2017) shows that the cumulative number of "pure" blockchain start-ups (excluding cryptocurrency-focused firms, consulting firms, and firms which were not engaged in non-blockchain development before 2012) has reached 115 between 2013 and 2017 worldwide. About 30 cryptocurrency-focused firms also pivoted to blockchain in 2014 and 2015.

Blockchain models are being developed and tested in many different sectors, such as governments, media, healthcare, agriculture, manufacturing, supply chain management, energy and finance. About half of identified blockchain use cases are in the finance industry including capital markets, banking and insurance. Financial institutions are currently the biggest customers of blockchain technology providers.

Although the term "blockchain" is not mentioned in Nakamoto's original paper, bitcoin is the oldest cryptocurrency and a textbook-style implementation of blockchain. Its structure has not changed in any significant way since 2008 and it is still up and running. Whatever the use verdict may be, bitcoin can be seen as the "killer app" that triggered the work on blockchains and other DLT formats. Each new cryptocurrency brought in a new dimension and probable improvement in blockchain algorithms. Litecoin, launched in 2011, was forked from bitcoin with four-times faster block generation. Ripple in 2012 designed a private-permissioned blockchain for the verification of payments and settlements. Unlike other cryptocurrencies, issuance of Ripple coins is controlled by the company, not by the users and hence there is no mining process and no proof of work. Ethereum, founded by Vitalik Buterin in 2013, introduced smart contracts, dApps and DAOs in blockchains, which later became the basic concept underlying many blockchain projects in finance. IOTA, founded in 2016, is based on a different format from standard blockchains and offers significant improvement in scaling. The underlying technology of IOTA is a graph data structure called "tangle" instead of blockchain. Technology companies seem to be diverting from pure cryptocurrency focus and towards a broader blockchain focus.

As a note, according to data on www.coindesk.com, as of March 2018, there are 1,565 cryptocurrencies, a great majority of which are more like "hobby trials" with no material trade and market value. The total market capitalisation of cryptocurrencies is about USD 260 billion, where Bitcoin has a share of 45%, Ethereum 15%, and Ripple 8%. Largest 20 cryptocurrencies make up more than 90% of total value. The trade volume in 2018 is estimated to be around USD 3.5 trillion. An extrapolating guess from the

Cambridge survey is that more than 900 companies worldwide accept cryptocurrencies as a payment method for real-world assets and more than 300 million transactions have been recorded to date. In 2017, CBOE and CME started trading futures contracts on leading cryptocurrencies. In 2018, NASDAQ and NYSE issued ETFs of blockchain technology companies. Beyond cryptocurrencies, it is interesting to note that a number of central banks (European Central Bank, Bank of Canada, Bank of Japan, Swedish Riksbank, Banco de Brazil, Central Bank of Turkey and others) have started to investigate whether they should issue their own cryptocurrencies (or, as they often prefer to say, "digital currencies" on blockchain).

Initial coin offering (ICO) is a new model of public offering, where the initial offer price is either in a cryptocurrency (mostly) or a traditional currency and where investors do not acquire any shareholder rights. (As a case of regulatory blackhole, Telegram corporation filed a Form D disclosure with the U.S. SEC stating that the funds raised were "purchase agreements for cryptocurrency." Telegram has raised about USD 1.7 billion through its ICO this year.) Again based on data from www.coindesk.com and www.coinschedule.com, cumulative ICO funding has grown from nothing in 2014 to USD 5 billion in 2017, USD 8 billion to date, and it is expected to close 2018 at about USD 12 billion. These figures are to be compared with about only USD 1 billion of blockchain equity funding in 2017, via IPOs or private equity. Venture capital in blockchain development companies has reached a cumulative level of about USD 2.5 billion in 2017. Due to lack of regulation in most countries, ICO business seems to move in the few countries like Estonia where regulation is more supportive and rules of compliance are easier.

ICOs and venture capital aside, the big picture is where banks and financial market institutions invest in blockchain testing and deployment. An incomplete story of the last three years is given here. It is necessarily incomplete because industry is moving very fast and results of success or failure are not public knowledge because results of test deployments and regulatory responses are not visible yet.

Examples of securities exchanges and clearing houses testing blockchain applications:

- In 2015, Nasdaq launched its LINQ blockchain platform to trade private stocks and bonds. The first client was Chain.com, a blockchain developer, and later in 2017 Nasdaq LINQ and CitiConnect announced an integrated payments system using Chain's technology. In 2018, Nasdaq is also preparing for blockchain deployments in its subsidiaries like the Tallinn Stock Exchange in Estonia. Toronto's TMX Group has announced the development of a blockchain platform for its Natural Gas Exchange (NGX). The Depository Trust and Clearing Corporation (DTCC) has been working with IBM to develop a blockchain platform to process global CDS trading (worth about USD 12 trillion). Deployment is expected at the end 2018. DTTC is also active in a number of different blockchain projects.
- In 2017, Australian Stock Exchange (ASX) decided to replace its well-known clearing and settlement platform CHESS by using the blockchain technology provided by Digital Asset Holdings. Deployment is expected in two years.
- Japan Exchange Group (JPX) and IBM are testing blockchain technology for trading in low liquidity securities. Korea Startup Market (KSM) in the Korea Exchange was launched in 2017 and it is based on Blocko's blockchain platform to trade shares of start-up companies. In 2017, India's National Stock Exchange (NSE) conducted a blockchain trial of a KYC (know-your-customer) data protocol involving many of the country's leading banks. NSE is also a member of the consortium working on digital identity in India. Moscow Exchange (MOEX), a member of the Hyperledger consortium, has been evaluating a blockchain platform for the National Settlement Depository (NSD).
- Deutsche Börse and Deutsche Bundesbank have been testing prototypes of a blockchain platform for settlement of securities since 2016. The London Stock Exchange is evaluating

blockchain to improve the post-trade space. Luxembourg Stock Exchange has introduced a security system where digitally signed documents and related code are on a blockchain.

All of the above applications and trials of blockchain in securities exchanges are in the format of private permissioned blockchains. Most are still in early trial stages. There are also a few successful applications of blockchain in Over the Counter (OTC) offerings of fixed income securities. However, they are all "small" applications of blockchain but their number is expected to grow fast:

- In July 2017, Daimler used blockchain technology to issue a €100m bond in partnership with four savings banks. The entire transaction from origination, distribution, allocation and execution to confirmation of repayment and interest payments was carried out by its blockchain.
- After Daimler's bond issue, the Japanese data company Fisco followed with a Bitcoin bond.
- Megafon company of Russia issued RUB500mn worth of bonds on a blockchain platform developed by the National Settlement Depository (NSD).
- The Commonwealth Bank of Australia announced a plan to issue a bond over a blockchain system, possibly in 2018.
- In 2018, Lomard Odier IM of Switzerland announced it has completed its first CAT bond transaction using blockchain.

It seems that technology companies and financial institutions need to cooperate to figure out what blockchain can do for them. For this purpose, several blockchain consortia have been formed. In addition to technology issues and standardisation, these groups work on finance-specific issues such as data security, compliance, operational efficiency and cost reduction. Major consortia as of today are:

- Enterprise Ethereum Alliance (EEA): This is a group of more than 200 members including J.P. Morgan, Santander, BBVA, DTCC, SWIFT, CME Group, Mastercard, Cisco, Intel and Microsoft. Design strategy is largely based on smart contracts and forking technologies of Ethereum.
- Hyperledger: Founded in 2015 by the Linux Foundation, some group members are Wells Fargo, J.P. Morgan, BBVA, Deutsche Börse, State Street, SWIFT, DTTC, American Express, Cisco, Intel and IBM. It is an open-source platform focusing more on scalability and the interoperability of different blockchains.
- R3: A group of more than 100 members including Bank of America, Wells Fargo, Citigroup, DTCC, Amazon and Intel. R3 is also a Hyperledger member, especially works on issues of compliance (such as KYC and AML) and cross-border payment systems.
- B3i: Blockchain Insurance Industry Initiative including 15 leading insurance companies such as Aegon, Allianz, Munich Re, Swiss Re, and Zurich, working on blockchain opportunities in the insurance industry.
- The Blockchain Alliance: a public / private forum for dialogue between industry and governmental agencies in order to help fight criminal activities on blockchains. Some members are Chamber of Digital Commerce, Bitfury, Ripple, Coin Base, MIT Media Lab and recently law enforcement agencies from countries outside the U.S.
- Global Blockchain Business Council: Formally launched during the 2017 Davos meeting of WEF, it is an organisation with founding members from over 30 countries to "advance global understanding of blockchain technology."

To date, after Bitcoin and other leading cryptocurrencies, one of the first full scale deployments of a blockchain is the RippleNet, a permissioned blockchain of a global payments system. It uses smart contracts and a token called XRP as a value carrier. Banks, payment providers, corporates, and exchanges (with digital asset capabilities) are the permissioned users of the system. RippleNet processes cross-border payments in real time with end-to-end tracking and payment certainty at minimal transaction costs.

RippleNet is a good case to imagine how blockchain technology can be transformational and possibly disruptive in the finance industry. In 2018, the global cross-border B2B money transfers is estimated to total USD 155 trillion, most of which will be through traditional wire transfers between banks. This volume will generate a fee revenue of about USD 320 billion. The average speed of a transaction under ideal conditions is 4-5 days, and it may take weeks to back-wire a wrong transfer. In RippleNet (or a similar blockchain), on the other hand, the average cost of a money transfer is negligible and the average speed is under 5 seconds. Moreover, due to instant two-way messaging, the probability of a wrong transaction and fraud is practically zero.

It is also instructive to present some of the other related applications of blockchain:

- In Africa, companies such as BitSpark and BitPesa developed blockchain platforms to bring banking services to the unbanked population.
- The Everledger blockchain provides diamond certification to combat "blood" diamond.
- New York City is testing a smart-energy system (where consumers buy and sell electricity from each other) based on a blockchain, much like an energy exchange with free entry.
- The Republic of Georgia implemented a state-of-the-art blockchain-based property registry system developed by the Bitfury Group. Ukraine is working on a full-service e-Governance platform on the blockchain, including digital identity and property registry. Governments in the UAE, Australia, Japan, Denmark, Estonia and Sweden are all looking into blockchain solutions for better public governance. Dubai plans to transfer all governmental systems on the blockchain by 2020.
- Credit Mutuel Arkea, the BankChain consortium and Infocommunications Media Development Authority of Singapore are some examples of blockchain for "uniform source of data" for Know Your Customer (KYC) and Anti-Money Laundering (AML) compliance.

Even within the boundaries of limited understanding of a new evolving technology and despite the high probability of many potential failures, the current industry landscape shows that the following financial applications are imminent:

- Capital markets: The full ecosystem from trade execution to clearance and settlement can be efficiently modelled as a blockchain.
- Payment systems: Both global (B2B) payment systems and also domestic (B2C, P2P) payment systems (also covering the unbanked population and rural banks) are candidates for cook-book application of blockchains.
- OTC trading: The full trading cycles of bonds, syndicated loans, derivatives, commodities, private equities, and other illiquid assets can be directly modelled as blockchains.
- Trade finance: The traditional trade finance process takes about 3-5 weeks to finalise. There are unnecessary intermediaries, much redundant work, and it is still largely paper-based with emails and faxes to communicate. Instances of fraud and illicit activity are common. Again, the full trade finance process also seems to be a cook-book application.

- Some decentralised "cryptoexchanges" such as Bitshares Asset Exchange, Openledger, Etherdelta, Counterparty and Kyber are based on blockchains themselves while they trade blockchain based cryptoassets.

In all of these cases, significant gains in productivity are expected through increased transaction speed, lower transaction costs, enhanced transparency, reduced fraud, automated and synergistic compliance with KYC and AML rules. In order to have an informed prediction of the future of block chains in finance, it can be said that blockchain as a business model is appropriate if:

1. Disintermediation is technically and economically feasible;
2. Transaction and data verification is required;
3. Multiple users need to share the data;
4. Business processes needs trust in transactions and certainty in results.

These criteria imply a long list of applications, only limited by imagination. However, regulatory clarity is lagging and technology is still evolving.

IV. The Regulatory Landscape for Blockchain

Blockchain technology is still in early stages of development but there is a fast growing genuine interest in its potential. The number of use cases is continually increasing and, unlike in previous disruptive technologies such as the TCP/IP and the internet, there seems to be a more global dialogue between relevant parties from different countries. The general mood of policy makers on blockchain as a technology is positive (see Annex A). On the banking side, Mark Carney (Chair of the FSB and Governor of the Bank of England) has commented:

"New technologies could transform wholesale payments, clearing and settlement. In particular, distributed ledger technology could yield significant gains in the accuracy, efficiency and security of such processes, saving tens of billions of pounds of bank capital and significantly improving the resilience of the system." (2017)

Similar ideas have been expressed by other central banks. On capital markets, Greg Medcraft (then Chair of the IOSCO and Australian ASIC) urged market regulators to act:

"… digital disruption has enormous potential to reconfigure and radically improve the efficiency of global capital markets. I see this happening because digital disruption will give investors, and businesses looking for capital, more direct, more immediate and cheaper access to each other. And what this means, for us as regulators, is reconfiguring our toolkit around the end users of our markets – businesses and investors – and how they behave. Given the speed of change, we need to think about that toolkit now." (2015)

Regulators have also started evaluating and acting on the emergence of blockchains. However, almost of all of the tangible regulatory responses to date relate to components of blockchain such as cryptocurrencies, ICOs and on specific legal issues such as KYC and AML. Currently, a comprehensive regulatory response to blockchain as a whole does not exist.

A non-exhaustive list of regulatory responses from different jurisdictions and institutions is presented in Annex A. The landscape is complex and regulatory responses are often limited in scope. There seem to three types of regulatory positioning:

- **Study-and-Wait-and-See:** Considering blockchain as a comprehensive new business model, most regulators are in this position. Like most people and institutions, regulators are also trying to conceptualise and understand the potential foundational and transformational implications of blockchains for economies and societies. This approach is both good and also bad. It is good because hasty regulation without due deliberation of its consequences can become an obstacle to technological development and deployment. It is bad because industry players would benefit from regulatory clarity to try new business models and stay away from risks of doing "unregulated" business.
- **New legislation and regulation:** Some jurisdictions have started to enact new laws and regulation. For example, Russia has announced a regulatory framework for ICOs, and France allows crowdfunding records to be kept on blockchain ledgers. Several states in the USA have enacted state laws on smart contracts, blockchain-based digital signatures, and

legal admissibility of blockchain ledgers as evidence. Since the technology is still evolving, there is a risk that new legislation may backfire and necessitate eventual amendments. Moreover, regulating a business without adequate comprehension of its true nature is often possible via complex and hence costly regulation, which in turn becomes a barrier to entry for innovative start-ups. Finally, without a common global interpretation of a new technology, independent local or national regulation may also cause legal confusion.

- **Guidance and sandboxing:** Considering the shortcomings of the above positions, some jurisdictions have concluded that it is both premature to bring in new regulation and also risky to just wait and see. They have chosen to provide regulatory guidance of how new technologies fit into existing legal frameworks and to provide sandboxing opportunities for new models. Sandboxing means a legally safe environment (often through some regulatory exemptions) for blockchain developers to test their products. Products are implemented on a controlled scale for a limited period of time and under close supervision. This approach is expected to be mutually beneficial for both sides. In 2016, FCA in the UK started to allow sandboxes for certain FinTech products including blockchains. Canada and Australia have also announced similar sandboxing initiatives. Singapore, Switzerland and Luxembourg have followed suit. In 2017, the European Commission issued a statement recognising sandboxing in FinTech services as an acceptable regulatory tool.

Needless to say, the purpose of financial regulation is to regulate the business on the blockchain in the form of financial flows and not the underlying technology itself. However, due to its properties, notably cryptography, it will be a challenge to regulate "blockchain finance" and it is therefore critical that policy-makers and regulators should understand the technology. The establishment of global standards is needed. Technical specifications aside, standardisation should cover three critical areas:

- **Terminology:** Currently, different people use different terms for the same event. For example, even the name of the technology differs from people to people. Terms like blockchain, distributed ledger, shared ledger, public ledger and various others are used to mean the same. Another example is when terms like cryptocurrency, virtual currency, token and digital money are used (often incorrectly) interchangeably. There is confusion and it should be sorted out.
- **Architecture:** In order to implement effective network governance and external supervision (when needed), the system architecture of a blockchain should be clearly defined and suitable to audit. This includes protocols of data storage (which data and whether on-chain or off-chain), data diffusion and access rights (whether global as in public blockchains or selective as in private permissioned blockchains), consensus (what needs consensus, what constitutes a consensus, and who votes how), and smart contract capabilities (how and whether executed internally or linked to off-chain legal contracts, or hybrid "smart legal contracts").
- **Governance:** Governance is about how a blockchain is initiated and managed. It defines the rules and procedures about network membership, management of permissions, transaction validity, issuance of new assets and their tokenisation, dispute resolution, software updates, regulatory reporting, and protection against cyber risks. Conceptual parallels between blockchain governance and "corporate governance" should be obvious.

Led by Standards Australia, the International Organisation for Standardisation (ISO) has set up a task force working on these internal blockchain standards and also on standards about the interoperability of separate blockchains.

Given proper standards, the second step for regulators is to have a transparent multi-stakeholder dialogue in a non-supervisory atmosphere. This is beneficial for regulators for two simple reasons. First, it will prevent hasty regulation with potentially unintended consequences, the most damaging of which is hindering technological advance. Secondly, familiarity with existing technologies and foresight about future trends will enable timely and effective regulation and supervision. Dialogue is also good for technology companies because awareness of public policy and regulatory concerns will prevent waste of resources on developing potentially unusable products.

If blockchain technology is to have a transformational impact on financial markets and institutions, methods of regulation must also be able to adapt. And this cannot be accomplished by trying to regulate and oversee new business models with traditional methods. Since early 1990s, most jurisdictions have successfully digitalised their existing "analogue" (paper based) processes and hence the term RegTech. Considering the big challenge posed by blockchain, this is no longer adequate and a new paradigm is called for. Regulators must now explore the possibility of using blockchain technology for their own purposes ("RegTech 2.0"), where monitoring and supervision of financial markets is done using blockchain-based platforms. Quoting Andy Haldane of the Bank of England (www.bankofengland.co.uk):

"I have a dream. It is futuristic, but realistic. It involves a Star Trek chair and a bank of monitors. It would involve tracking the global flow of funds in close to real time (from a Star Trek chair using a bank of monitors), in much the same way as happens with global weather systems and global internet traffic. Its centrepiece would be a global map of financial flows, charting spill-overs and correlations." (Maxwell Fry Annual Global Finance Lecture, 2014)

This is a realistic expectation today and deserves serious attention. The final picture will naturally depend on how widely blockchains are adopted globally and how they interoperate. In any case, regulatory multi-stakeholder dialogue, including with technology companies, will certainly be beneficial in this regard too.

Challenges of fast advancing technologies aside, the most difficult and time-consuming problem facing public policy makers and financial regulators will be redefining the financial regulation system. The current practice of regulation is heavily based on the presence of intermediaries (banks, exchanges, brokers, audit firms, investment funds, clearing houses, insurance companies, trade repositories, etc.) and much of regulation is done by regulating the intermediaries. For regulators, intermediaries are the sources of data about market activity and investor behaviour. Historically, the current financial system has evolved as such. Blockchain technology, however, promises to disintermediate all or some of these intermediaries. The big question is then how regulation will redefine and reshape its traditional intermediary-dependent model in the new financial markets with fewer intermediaries. In 1994, when the Internet was still very new, Bill Gates of Microsoft had said, "We need banking, but we don't need banks." How can banking be regulated without banks? This is a fundamental question and much worth pondering on.

V. The Potential Complementarities of Blockchain Technology on Corporate Governance

Below is a non-exhaustive list of trend changers in financial services over the last two decades:

- Policy changes such as the Payment Services Directive (PSD2) in Europe supports open sharing of data, which in turn supports "platform banking."
- Mobile banking channel's share increased from 10% in 2013 to more than 35% in 2017.
- Share of eWallets (such as AliPay, WeChat, Tenpay, PayPal and ApplePay) in the e-commerce market reached 40% from almost negligible levels 5 years ago.
- P2P lending platforms did not grow as much as expected but they provide access to credit for the unbanked and subprime customers. New platforms such as AmazonLending and Tradeshift have recently entered the market.
- Growth in "sharing economy" models such as the Airbnb has been remarkable (from £2b in 2013 to more than £8b in 2016 in the UK alone).
- Crowdfunding has not been as successful as expected but there is huge international demand, yet untapped. Electronic crowdfunding (ECF) platforms are going international.
- Robo-advisory and robo-distribution algorithms in investment management are fast spreading (for example, Vanguard and Blackrock have already deployed such platforms).
- Non-financial firms like Facebook and Amazon are moving into simple financial services and disintermediate the traditional intermediation channel.
- The global cost of default was more than USD 4 trillion in 2016 and most cases were made possible due to loopholes in outdated technologies.

The trend is towards open platforms of financial services. Legacy platforms are fast becoming outdated and technology firms are beginning to offer simple but often disruptive financial services. As a response, big financial firms are cooperating with tech firms to maintain their market power. The fact of the matter, however, is that "benefits of scale" is losing value relevance and "quality of service" is becoming more valuable.

It is relatively easy today to imagine various blockchain applications in finance as long as transactions are all denominated in real currencies (euro, dollar etc.) or in digital currencies (Alipay, Apple Pay etc.) expressed in terms of real currencies at transaction finality. In other words, when currency as we know is around, thinking blockchain is easy. The concept of a token may be more confusing. As Innes (1913) wrote a century ago about the concept of money:

"The use of money does not necessarily imply the physical presence of a metallic currency, nor even the existence of a metallic standard of value. We are so accustomed to a system in which the dollar or the sovereign of a definite weight of gold corresponds to a dollar or a pound of money that we cannot easily

believe that there could exist a pound without a sovereign or a dollar without a gold or silver dollar of a definite known weight."

Economists attribute three basic functions to money: medium of exchange, unit of account, and storage of value. By this reasoning, if a token on a blockchain can fulfil these functions, questions can be raised as to whether it is money. Of course, the producer of tokens is not a central bank and it is not exchanged through banks. In the logic of Innes, this may be the puzzle that is presented by these new technologies.

This paper has intentionally not yet mentioned the potential of blockchain for corporate governance. Yermack (2017) and Lafarre and Van der Elst (2018) show that blockchain technology is a powerful tool for stakeholder engagement, a much desired aspect of corporate governance. In particular, blockchainenables:

- Greater transparency of ownership and changes in ownership: All users on the network can see trading by managers, activists and corporate raiders. Legal insider trading channels are redundant. Disguised derivatives hedging, backdating and similar undesirable actions are almost impossible on a blockchain network.
- Efficient and fair shareholders meetings: An AGM under a blockchain design will have several material benefits such as easier voting (not mere electronic but "digital voting"), certainty in tabulation of votes and harder to manipulate board elections. Most importantly, proxy firms may be disintermediated, or they will have to assume more of an advisory role rather than simple "vote collecting".
- Real-time accounting: Distributed ledger technology in accounting is often touted as the next big step in bookkeeping after the introduction of double-entry bookkeeping. Blockchain accounting systems will significantly reduce the need for traditional auditing and hence audit firms will have to redefine their roles. With proper implementation of smart contracts, the need for litigation and expected costs of financial stress will be reduced.

These are all useful potential applications. However, the most important implication of blockchain for corporate governance is much further reaching. Bad corporate governance can be a major factor in corporate scandals and financial crises. The inefficiency and ineffectiveness of some corporate governance systems, in turn, may be due to the current complexity of the investment chain. The distance between households (owners of money) and corporations (users of money) has increased as a result of the complex web of intermediaries (managers of money and providers of services). Since blockchain technology's biggest promise is the elimination of some forms of intermediation, it presents a great opportunity for better corporate governance. This take on the potential of blockchain for improving corporate governance may be worth exploring further.

In the future, it could be of interest to map the basic purposes of corporate governance against the basic properties of blockchain technology:

Table 2. Potential complementarities of blockchain for corporate governance

Purpose of Corporate Governance	Properties of Blockchain
Transparency	Shared distributed ledgers
Accountability	Irreversibility of records
Responsibility	Peer-to-Peer communication
Fairness	Smart contracts (?)

Conceptually, the sharing of information by all relevant parties and the irreversibility of recorded (shared) information can be thought of as maximally effective mechanisms for ascertaining transparency and accountability in corporate affairs. Clarity and accessibility in channels of communication on peer-to-peer network architectures can help identify responsibility and its fulfilment. Fairness, which often requires human judgement and involvement, is probably the most difficult property of corporate governance to seek in practice and technology may not be of much help in this regard. However, it is still imaginable that smart contracts can be designed to observe certain corporate actions (such as related party transactions) which require fairness for those who are outside of the decision making process. Along similar lines of reasoning, it is clear that purposes of corporate governance can also be a useful guide in reconceptualising financial regulation and revising public policies to adapt to new technologies such as blockchain.

Notes

[1] Bitcoin is a cryptocurrency; decentralised digital currency without a central bank or single administrator and can be sent from user to user on the peer-to-peer bitcoin network. Bitcoin was invented by an unknown person or group of people using the name Satoshi Nakamoto and was released as an open-source software in 2009.

[2] Smart contracts are self-executing contracts that include the terms of an agreement between a buyer and seller being directly written into lines of code. The code and the relating agreements contained therein exist across a distributed, decentralised blockchain network. Smart contracts permit trusted transactions and agreements to be carried out among disparate, anonymous parties without the need for a central authority, legal system, or external enforcement mechanism at the time of execution.

[3] Proof of stake (PoS) is a type of algorithm by which a cryptocurrency blockchain network aims to achieve distributed consensus. In PoS-based cryptocurrencies the creator of the next block is chosen via various combinations of random selection and wealth or age (i.e., the stake). In contrast, the algorithm of Proof of Work (PoW)-based cryptocurrencies such as bitcoin uses mining; that is, the solving of computationally intensive puzzles to validate transactions and create new blocks. PoW is a piece of data which is difficult (costly, time-consuming) to produce but easy for others to verify and which satisfies certain requirements.

[4] Public and private keys are not unique to blockchain technology and are used in cryptography as a cryptographic protocol that is used to confirm the identity of each party in a transaction, thus allowing users to both send and receive transactions. Public keys can be made public and are often used as an identifiable method by which recipients can receive transactions and use as unique identifiers. Private keys are secret keys used by individuals in the network and work as a private digital signature for encryption.

References

Ahmet Usta and Serkan Doğantekin (2017) "*Blockchain 101*" Kapital Medya, Istanbul

Arner, Douglas W, Jànos Barberis and Ross P Buckley (2017) "*FinTech, RegTech and the Reconceptualization of Financial Regulation*" Northwestern Journal of International Law and Business (37 - 3)

Arslanian, Henry, Rebecca Lee and Grainne McNamara (2018) "*Understanding the ICO*" www.pwc.com/NextinTech

Australian Securities Exchange (2017) "*Blockchain: An Overview*" (pp. 1 -24 of a report by Deutsche Bank AG / Sydney)

Atzori, Marcella (2015) "*Blockchain Technology and Decentralised Governance: Is the State Still Necessary?*" Journal of Governance and Regulation

Bank For International Settlements (2015) "*Digital Currencies*" CPMI, www.bis.org

Bank For International Settlements (2017) "*Distributed Ledger Technology in Payment, Clearing and Settlement: An Analytical Framework*" CPMI, www.bis.org

BBVA (2016) "*The Advance of Bitcoin and Virtual Payments*" Fintech Series by Innovation Edge

Berentsen, Aleksander, and Fabian Schär (2018) "*A Short Introduction to the World of Cryptocurrencies*" Federal Reserve Bank of St. Louis Review.

Blemus, Stéphane (2017) "*Law and Blockchain: A Legal Perspective on Current Regulatory Trends Worldwide*" Revue Trimestrielle de Droit Financier (Corporate Finance and Capital Markets Law Review) RTDF N°4-2017

Brito, Jerry, Houman Shadab, and Andrea Castillo (2014) "*Bitcoin Financial Regulation: Securities, Derivatives, Prediction Markets and Gambling*" The Columbia Science & Technology Law Review 16: 144–221.

Brühl, Walker (2017) "*Virtual currencies, distributed ledgers and the future of financial services*" Intereconomics 6

Catalini, Christian, and Joshua Gans (2017) "*Some Simple Economics of the Blockchain*" MIT Sloan Research Paper (5191-16)

Cermeño, Javier Sebastian (2016) "*Blockchain in Financial Services: Regulatory Landscape and Future Challenges for Its Commercial Application*" BBVA Research (16/20)

Chang, H (2017) "*Blockchain: Disrupting Data Protection*" The University of Hong Kong WP

Chapman, Chris (2018) "*Blockchain basics: Crypto-currencies, bonds and the blockchain*" Citi Research

Chohan, Usman (2017) "*Blockchain and Securities Exchanges: Australian Case Study*" University of New South Wales working paper

Crosby, Michael and et al (2015) "*Blockchain Technology beyond Bitcoin*" Sutardja Center Report, University of California, Berkeley

Decker, C. and Wattenhofer, R (2013) "*Information Propagation in the Bitcoin Network*" IEEE Symposium on P2P Computing

Depository Trust and Clearing Corporation (2016) "*Embracing Disruption: Tapping The Potential Of Distributed Ledgers To Improve The Post-Trade Landscape*" (white paper)

English, Erin, Amy Kim and Michael Nonaka (2018) "*Advancing Blockchain Cybersecurity: Technical and Policy Considerations for the Financial Services Industry*" Microsoft and Chamber of Digital Commerce Report

European Banking Authority (2017) "*Regulatory Sandboxes: A Proposal to EBA by the Banking Stakeholders Group*" (July)

European Securities and Markets Authority (2017) "*The Distributed Ledger Technology Applied to Securities Markets*" (February report)

EY Research (2018) "*Initial Coin Offerings (ICOs)*" www.ey.com

Financial Conduct Authority (2017) "*Discussion Paper on Distributed Ledger Technology*" DP 17 / 03

Financial Conduct Authority (2017) "*Distributed Ledger Technology: Feedback Statement on Discussion Paper 17/03*" FS 17 / 4

Financial Stability Board (2017) "*Financial Stability Implications from FinTech: Supervisory and Regulatory Issues that Merit Authorities' Attention*" (No: 65)

Finck, Michèle (2017) "*Blockchain Regulation*" Max Planck Institute for Innovation and Competition Research Paper (17-13)

Fink, Michèle (2018) "*Blockchains and Data Protection in the European Union*" Max Planck Institute for Innovation and Competition Research Paper (18-01)

Government Accounting Office (2017) "*Financial Technology: Information on Subsectors and Regulatory Oversight*" Report to U.S. Congressional requesters

Giancarlo, Christopher. 2016. "Cryptocurrency: The Policy Challenges of a Decentralised Revolution." The Cato Institute

Global Blockchain Business Council (2018) "*Global Challenges: Blockchain Solutions*" Annual Report 2018

Gupta, Vinay and Rob Knight (2017) "*How Blockchain could Help Emerging Markets Leap Ahead*" Harvard Business Review (May)

Haber, S. and Stornetta, S (1991) "*How to time-stamp a digital document*" https://link.springer.com/article/10.1007/BF00196791

Halaburda, Hanna (2018) "*Blockchain Revolution without the Blockchain*" Staff Analytical Note 2018-5, Bank of Canada.

Harvey, Campbell (2014) "*Cryptofinance*" ssrn.com/abstract=2438299.

Hassan, Samer and Primavera De Filippi (2017) "*The Expansion of Algorithmic Governance: From Code is Law to Law is Code*" The Journal of Field Actions

He, Dong, R Leckow, V Haksar, T Mancini, N Jenkinson, M Kashima, T Khiaonarong, C Rochon, and H Tourpe (2017) "*Fintech and Financial Services: Initial Considerations.*" International Monetary Fund (SDN/17/05)

Hernandez, Guillermo (2017) "*Blockchain entrepreneurship opportunity in the practices of the unbanked*" Business Horizons 60

Hileman, Garrick, and Michel Rauchs (2017) "*Global Blockchain Benchmarking Study*" Cambridge Centre for Alternative Finance, University of Cambridge

Hongjiang, Zhao and Cephas Coffie (2018) "*Economic Force of Smart Contracts*" ssrn.com/abstract=3138063.

Iansati, Marco, and Karim R. Lakhani (2017) "*The Truth About Blockchain*" Harvard Business Review (Jan - Feb)

Innes, A (1913) "*What is money?*" The Banking Law Journal (May)

International Financial Corporation (2017) "*Blockchain: Opportunities for Private Enterprises in Emerging Markets*" www.ifc.org/thoughtleadership

International Swaps and Derivatives Association (2017) "*Smart Contracts and Distributed Ledger – A Legal Perspective*" ISDA Linklaters whitepaper

Jaccard, Gabriel Olivier Benjamin (2018) "*Smart Contracts and the Role of Law*" www.jusletter-it.eu and in ssrn.com/abstract=3099885

J. P. Morgan (2018) "*Decrypting Cryptocurrencies: Technology, Applications and Challenges*" Global Research report

J. P. Morgan (2018) "*China Financials: Cryptocurrencies in China*" Asian Pacific Equity Research

Kaal, Wulf (2018) "*Initial Coin Offerings: The Top 25 Jurisdictions and Their Comparative Regulatory Responses*" ssrn.com/abstract=3117224

Kosba, Ahmed et al (2016) "*HAWK: The Blockchain Model of Cryptography and Privacy-Preserving Smart Contracts*" IEEE Symposium on Security and Privacy

LabCFTC (2017) "*A CFTC Primer on Virtual Currencies*" U.S. Commodity Futures Trading Commission

Lafarre, Anne and Christoph van der Elst (2018) "*Blockchain Technology for Corporate Governance and Shareholder Activism*" ECGI Law Working Paper (390/2018)

Liao, Nancy (2016) "*A Brief Introduction to Blockchain*" Yale Law School Center for the Study of

Corporate Law

Lu, Lerong (2018) "*Decoding Alipay: mobile payments, a cashless society and regulatory challenges*" Journal of International Banking and Financial Law

Maupin, Julie (2017) "*Mapping the Global Legal Landscape of Blockchain and Other Distributed Ledger Technologies*" CIGI Papers (149, October)

McKinsey&Company (2015) "*Beyond the Hype: Blockchains in Capital Markets*" (No: 12)

Medcraft, Greg (2015) "*The Future of Capital Markets in a Digital Economy*" keynote speech at Carnegie Mellon University (Australia)

Meiklejohn, Sarah (2017) "*Top Ten Obstacles along Distributed Ledgers' Path to Adoption*" R3 Report

Muhammad, Marjan (2017) "*Shari'Ah Analysis of Cryptocurrency: Bitcoin*" Shariah Fintech Forum, ISRA

Murck, Patrick (2017) "*Who Controls the Blockchain*" Harvard Business Review (April)

Nakamoto, Satoshi (2008) "*Bitcoin: A Peer-to-Peer Electronic Cash System*" an email

Niforos, Marina, Vijaya Ramchandran, and Thomas Rehermann (2017) "*Blockchain Opportunities for Private Enterprises in Emerging Markets*" International Finance Corp.

Nolting, Chrsitian and Markus Müller (2017) "*CIO Insights Reflections: Cryptocurrencies and Blockchains - their Importance in the Future*" Deutsche Bank Wealth Management

OICV-IOSCO (2017) "*IOSCO Research Report on Financial Technologies (Fintech)*" report by the International Organisation of Securities Commissions

Peters, Gareth W., Efstathios Panayi, and Ariane Chapelle (2015) "*Trends in Cryptocurrencies and Blockchain Technologies: A Monetary Theory and Regulation Perspective.*" The Journal of Financial Perspectives: Fintech (www.ey.com)

Pilkington, Marc (2015) "*Blockchain Technology: Principles and Applications"* ssrn.com/abstract=2662660

Pilkington, Marc (2018) "*The Emerging ICO Landscape: Some Financial and Regulatory Standpoints*" working paper, Université de Bourgogne Franche Comté

PricewaterhouseCoopers (2017) "*Top financial services issues of 2018*"

Reijers, Wessel, Fiachra O'Brolcháin and Paul Haynes (2016) "*Governance in Blockchain Technologies and Social Contract Theories*" Ledger (Volume 1: 134–51)

Robleh Ali, John Barrdear, Roger Clews, and James Southgate (2014) "*Innovations in Payment Technologies and the Emergence of Digital Currencies*" Bank of England Quarterly Bulletin

Roubini, M. and Preston, B (2018) "*Bitcoin is based on the blockchain pipe dream*" The Guardian newspaper

Silverberg, Kristen, C French, D Ferenzy, and S Van den Berg (2015) "*Banking on the Blockchain. Reengineering the Financial Architecture*" Institute of International Finance

Standards Australia (2017) "*Roadmap for Blockchain Standards*"

Starkie, Heather (2017) "*Usage of Blockchain in the UN System: A Desk Review*" UN Office of Information and Communications Technology

Stiphout, Mees van, and Mélisande Mual (2017) "*Payment Methods Report 2017: Insights into the E-Wallets Landscape*" The Paypers

Swanson, Tim (2015) "*Consensus-as-a-Service: A Brief Report on the Emergence of Permissioned, Distributed Ledger Systems*" R3 Cev Whitepaper, 66

Symons, Paul and et al (2016) "*Blockchain Settlement: Regulation, Innovation and Application*" Euroclear in cooperation with Slaughter and May

Tapscott, Alex and Don Tapscott (2017) "*How Blockchain is Changing Finance*" Harvard Business Review (March)

Walch, Angela (2017) "*The Path of the Blockchain Lexicon (and the Law)*" Review of Banking & Financial Law, Vol. 36 pp.713–66.

Waldman, Jonathan (2018) "*Blockchain Fundamentals*" msdn.microsoft.com

Weiss, Michael and Corsi, Elena (2018) "*Bitfury: Blockchain for Government*" Harvard Business School Publishing (9-818-031)

Williams, Robert Crane (2017) "*Prospects for Blockchain-Based Settlement Frameworks as a Resolution to the Threat of de-Risking to Caribbean Financial Systems*" ECLAC, United Nations

World Bank Group (2017) "*Distributed Ledger Technology (DLT) and Blockchain*" FinTech Note / No.1

World Economic Forum (2015) "*The Future of Financial Services*"

World Economic Forum (2016) "*The Future of Financial Infrastructure: An ambitious look at how blockchain can reshape financial services*" (in cooperation with Deloitte)

World Economic Forum (2017) "*Beyond Fintech: A Pragmatic Assessment of Disruptive Potential in Financial Services*" (in cooperation with Deloitte)

World Federation of Exchanges (2016) "*Financial Market Infrastructures and Distributed Ledger Technology*" a survey of member exchanges

Yaga, Dylan, Peter Mell, Nik Roby, and Karen Scarfone (2018) "*Blockchain Technology Overview*" NIST, U.S. Department of Commerce

Yermack, David (2017) "*Corporate Governance and Blockchains*" Review of Finance (21)

Zsykind, Guy and et al (2015) "*Decentralizing Privacy: Using Blockchain to Protect Personal Data*" IEEE CS Security and Privacy Workshops

Annex A. Regulatory Response to Cryptocurrencies and Blockchain

	Crypto-currencies	Blockchain	Approach
Europe			
European Parliament	Neutral	Positive	Report / Taskforce
European Commission	Neutral	Positive	Amendments to the AML Directive / Taskforce
ESMA	Neutral	Positive	Consultations on applications to securities markets
EBA	Negative	Neutral	Recommendation against c-currencies and amendments to include virtual currency traders in the AML Directive
ECB	Negative	Positive	Reports / Declaration / Joint work with BoJ on blockchains in post-trade activity
National central banks	Neutral	Positive	Reports / Declarations / Some interest in own c-currency
National regulators	Neutral	Positive	Reports / Weak guidance / Sandboxing
United States			
US Senate/Congress	Neutral	Positive	Request to regulators / Taskforce
Several states	Positive	Positive	Reports / Some regulation
FinCEN / CFPB	Negative	Neutral	Reports / Guidance against illicit trade
OCC	Neutral	Positive	Reports / Statement on blockchains
CFTC	Neutral	Positive	Statement on blockchains / Supervision of contracts on c-currencies
SEC	Neutral	Neutral	Warnings on c-currencies and spoofing
Federal Reserve	Positive	Positive	Declaration / Reports
Selected Countries			
China	Negative	Positive	Prohibition of c-currencies / Taskforces on blockchain
India	Positive	Positive	Reports / Statements of intent to regulate
Japan	Positive	Positive	Reports / Declarations / Taskforce
United Kingdom	Neutral	Positive	Reports / Taskforces / Sandboxing
France	Neutral	Positive	Reports / Support of blockchain use

	Crypto-currencies	Blockchain	Approach
Australia	Neutral	Positive	Reports / Taskforces / Sandboxing
Russia	Negative	Neutral	Prohibition of c-currencies / Taskforce on blockchains
MENA	Positive	Positive	Reports / Declarations of intent to regulate
Turkey	Neutral	Positive	Taskforces on blockchains
Singapore	Neutral	Positive	AML regulation on c-currencies/ Taskforce on blockchain
Canada	Neutral	Positive	Reports / Taskforces / Sandboxing
International Organisations			
FATF	Negative	Neutral	Report about illicit trade with c-currencies
FSB	Neutral	Positive	Reports on c-currencies / ICOs
IOSCO	Neutral	Positive	Reports
BIS	Negative	Neutral	Reports
IMF	Positive	Positive	Reports
World Bank	Neutral	Positive	Reports
ISO	Neutral	Neutral	Taskforce on blockchain technology standards
WFE	Positive	Positive	Reports

Source: Authors analysis, based on publically available information from national regulator websites and public press releases.

Note: Information as of April 2018. The table is indicative and based on the author's interpretation of information in official publications and web sites, media reports and news, and several related studies listed in the Bibliography. Since the writing of this paper, some of this information may be out of date as regulators are actively exploring the issues and may have changed their stance. The term "neutral" may mean either that regulator has clearly expressed neutrality, or that regulator has not expressed any position whatever, or that the regulator has given mixed signals.

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www.oecd.org/daf/corporateaffairs/wp

N°20	28 July 2016	Corporate Governance of Financial Groups Takahiro Yasui
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