
Blockchain and the reshaping of investment management

By Dave Dowsett and Heather Wied



In brief

In this article, we cover various aspects of the blockchain phenomenon, with a focus on capital markets. Our central argument is that the blockchain will transform the capital markets by speeding up settlement and clearing, enabling “smart contracts”, making data delivery faster and encouraging disintermediation. We also cover possible threats to this development, especially regulatory issues, and discuss potential risks arising from the new technology.

Blockchain initially gained prominence as the revolutionary technology underpinning high-profile cryptocurrencies like Bitcoin. Now it is attracting significant attention on its own as a viable stand-alone infrastructure for executing and recording transactions. In this article we examine how the investment management industry could be transformed by the widespread adoption of smart contracts, digital identities and other innovative blockchain components.

Throughout history, one sees evidence of technology's capacity to reshape markets and ways of doing business. Today's internet serves as a digital marketplace, a platform for economic activity and a storehouse for virtually all of human knowledge. Facebook and other social networks have redefined human interaction, recast the idea of "connectedness" and altered how people share information. The smartphone put a staggering array of information and direct access to the social networks at the fingertips of billions of people. In short, each of these innovations has fundamentally affected the structure of social and economic systems by altering how we exchange information, goods and services. What's more, none of these technologies existed 25 years ago.

So where will the next new technological paradigm emerge? We believe that blockchain will have a transformative effect on the capital markets. Blockchain offers the possibility of drastically redefining transactions, the structures and protocols of which remain largely inefficient. Professor Bryan Zhang, co-founder of the Cambridge Centre for Alternative Finance (CCAF) observes that: "Blockchain is beginning to rewire our digital infrastructure and

challenge our thinking on how data, information, assets and even governance can be organized and reimagined." Earlier this year, in a Risk & Reward article exploring the various aspects of cryptocurrencies, we provided a broad overview of blockchain's capabilities.¹ Here, we will concentrate more on blockchain's likely impact on investment management, examining in more detail some of its applications in this space. We cover both those that are already being adopted and those that - for now at least - are somewhat further from implementation. Lastly, we survey not only the opportunities that the blockchain phenomenon presents but also the hurdles that must be overcome if its promise is to be fully realized.

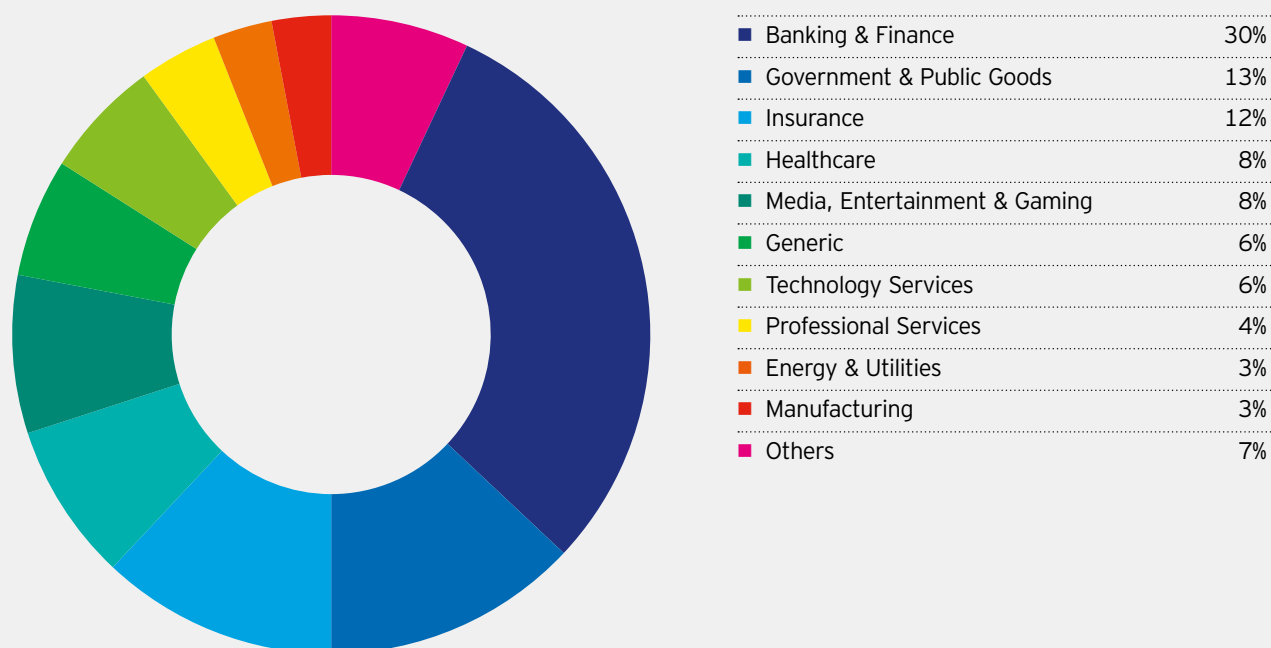
Understanding blockchain technology

Simply defined, blockchain is a decentralized, distributed digital ledger system that records transactions in a secure, verifiable and permanent way. This technology holds the potential to radically transform a wide variety of practices and products throughout the global economy due to the three overarching benefits that it can offer: reduced costs, enhanced risk mitigation and greater efficiency. Astute organizations are already identifying which elements of their business models could be enhanced, or disrupted, by blockchain. According to Deloitte's *2018 Global Blockchain Survey* of more than 1,000 global executives, 39% of respondents indicated that their organizations will invest USD 5 million or more in blockchain technology within the coming year. Perhaps more strikingly, only 5% reported that no investment in blockchain is planned.² As demonstrated in figure 1 below, the banking and finance sector has been leading the way in the development of blockchain applications.

Figure 1

Finance leads the blockchain revolution

According to the Cambridge Centre for Alternative Finance's inaugural Global Blockchain Benchmarking Study, the banking and finance industry is by far the largest user of blockchain technology.



Source: Cambridge Centre for Alternative Finance: Global Blockchain Benchmarking Study, 2017; based on 132 use cases frequently mentioned in public discussions, reports and press releases.

The blockchain concept first came to light in Bitcoin: A Peer-to-Peer Electronic Cash System, a white paper published in 2008 by the mysterious figure known as Satoshi Nakamoto,³ where it was presented as the basis for a public ledger system designed to track transactions in Bitcoin. Its importance lay in its unique approach to the problem of “double-spending” - the scope for a digital currency to be duplicated or falsified and thus spent more than once.

The notion of a distributed database or ledger is fundamental to addressing this issue. In a traditional centralized system, a single participant stores and maintains all the data. A decentralized system eliminates the need for a hub-and-spoke-style setup, allowing data to be shared on a peer-to-peer basis. A distributed system takes this a step further by allowing every participant to host a copy of the ledger and independently verify the integrity of the data at any time (see figure 2).

This “data democracy” requires a consensus mechanism to approve changes to the ledger. The underlying assumption is that the system operates within an adversarial environment and that malicious actors might supply it with incorrect information. Following a shared set of rules, every participant within a blockchain system validates all changes (new transactions) and recreates the ledger independently. Transactions are accepted only after validation by a majority of participants, which mitigates the risk of a single point of failure in the system.

Transactions are batched into blocks, which are cryptographically linked to produce a chain that contains the ledger’s entire history. The result is

what is known as an “append-only” database, which effectively prevents any deletion or alteration of data entered into earlier blocks.⁴ It is the append-only nature of a blockchain ledger that distinguishes it from other types of distributed databases.

Trading, settlement and clearing

A snapshot of the history and likely future of trade settlement affords a striking insight into blockchain’s potential for “creative destruction”. It also underscores the critical point that blockchain opens the door to doing things not just better - but altogether differently.

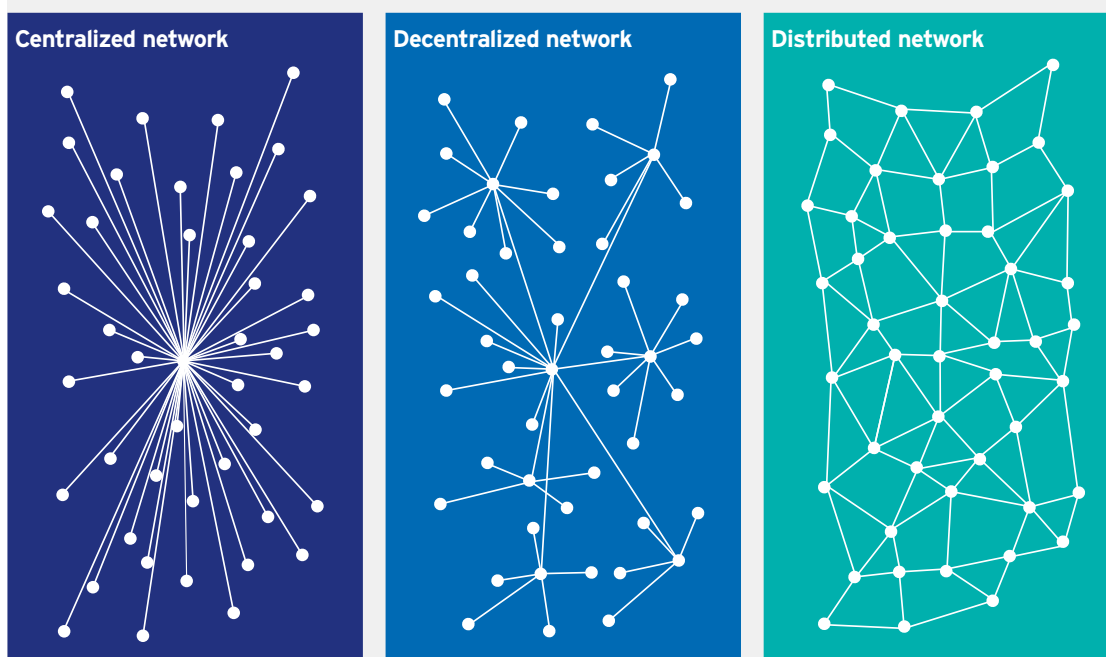
Going nearly as far back as their inception, most stock exchanges favoured a period of 14 days for the completion of trades. In the 1970s and 1980s, this was cut to five and then three days with the advent of new technology. Today, the standard settlement cycle for many investment vehicles is two days. However, by limiting the need for intermediaries - central counterparty clearing and central securities depositories foremost among them - blockchain enables near-real-time settlement, making T+0 a reality.

Invesco has already participated in post-trade settlement clearing experiments that validated the concept using gold bullion and equities. The company we partnered with for this proof-of-concept work secured USD 65mn in series B funding earlier in 2018. We continue to study and test the best way to scale and implement blockchain for settlement purposes, actively preparing for potential future developments in this area. In addition to minimizing risk exposure, shorter settlement times create more liquidity for asset managers, freeing funds to be

Figure 2

Three network paradigms

Blockchain technology uses a distributed network - in which every participant holds and can independently verify all data. This concept is different from both the traditional hub-and-spoke approach and the decentralized methodology used for more simplistic peer-to-peer networks.



Source: Paul Baran (1962), “On distributed communication networks”, <https://www.rand.org/content/dam/rand/pubs/papers/2005/P2626.pdf>.

reinvested in shorter amounts of time. Kevin Cronin, Global Head of Trading for Invesco, observes: “We see great potential for blockchain in the post-trade settlement arena. While the promise of near real-time settlement is exciting, we believe we are approaching this emerging technology with the right amount of diligence and caution. We are most excited about the liquidity for reinvestment that near real-time settlement affords. Markets move on their own time, and the difference between days versus minutes can have real impact on trading strategies.”

Many clearing houses and depositories are also conducting their own blockchain proofs-of-concept, developing relationships with (or buying) blockchain startups and evaluating how the technology could impact their business models and operations. Breaking down the functions of central counterparty clearing performs helps to demonstrate blockchain’s potential. Broadly speaking, central counterparty clearing manages the operational tasks of settlement to reduce risk and maintain market integrity. The central counterparty monitors the individual credit risks of individual trade participants, addresses

defaults and it oversees systemic risks in the market. Blockchain can streamline these management, monitoring and oversight functions through protocols known as “smart contracts”, which we discuss further in the next section. The reduction of manual tasks and the operational efficiencies gained from the execution of smart contracts allows financial market participants to reexamine and reallocate scarce resources.

Work towards using blockchain to increase the efficiency of capital markets has been underway for well over two years. For example, in response to regulators’ criticisms of settlement delays, a well-respected financial data vendor recently unveiled blockchain-based software designed to affect “seamless integration and straight-through processing” in the trading of syndicated loans, which have traditionally had settlement times far in excess of the T+0 potential of blockchain.⁵

Other proof-of-concept projects are analyzing how blockchain can expedite settlement of cross-border payments. For example, XRP, the architecture behind cryptocurrency Ripple, has been billed as, “built for enterprise use” and able to offer “a reliable, on-demand option to source liquidity” – and many companies are currently testing its viability.

The inaugural *Global Blockchain Benchmarking Study*

The fintech space moves quickly, however, in September 2017, in collaboration with Ernst & Young and Visa, the Cambridge Centre for Alternative Finance published a major report into the spread of blockchain and distributed ledger technology (DLT). Drawing on online surveys and publicly available data sources, the study’s findings are representative of more than 200 private and public sector organizations engaged with DLT.

*The key findings include the following:**

- *The number of DLT startups has tripled since 2014, from 37 to at least 115.*
- *Around 47% of all DLT startups are based in North America, followed by Europe (28%) and Asia-Pacific (19%).*
- *The banking and finance industry accounts for 30% of publicly reported DLT use cases, followed by government (13%), insurance (12%) and healthcare (8%).*
- *“Immature” technology is still considered a key challenge to the broader adoption of DLT.*
- *Only limited network and application deployment has been observed to date.*

*To illustrate the speed at which blockchain technology and the blockchain investment space is moving, since publication of the CCAF’s 2017 report, Coindesk – a leading digital media source for cryptocurrency and blockchain news – published findings that approximately 300 blockchain startups are located in the United States alone, with funding totalling approximately USD 4.5B.***

* Data as of September 2017. ** The State of Blockchain Q2 2018 report summarizes key happenings in the world of blockchain up to date and illustrates the rapid pace at which the blockchain startup environment is changing. (<https://www.coindesk.com/research/state-of-blockchain-q2-2018/?slide=63>).

Smart contracts and digital identities

In late 2013, teenage programmer Vitalik Buterin drew public attention to the idea of “smart contracts” in a white paper introducing Ethereum, his own blockchain platform. Smart contracts are code that automatically executes a transaction or other protocol when triggered by an event or an absence of sufficient inputs. For example, one can specify that funds cannot be transferred until required information is provided, or that a payment cannot be made unless an asset has been transferred within an allocated amount of time. The benefit of smart contracts is that they are governed by programmatic rules and their execution is recorded on the blockchain, providing a transparent and auditable accounting trail.

Although pioneering computer scientist Nick Szabo coined the term “smart contract” almost a decade previously, the 2015 debut of Ethereum gave the concept greater prominence by creating a decentralized platform that replaced Bitcoin’s more restrictive scripted programming language with one that developers could use to write their own smart contracts or “autonomous agents”. Today, fulfilling Buterin’s prophecy that they would become an essential component of “systems... that we have not yet imagined,”⁶ smart contracts are firmly at the heart of blockchain’s ever-widening appeal: two thirds of CCAF’s Global Blockchain Benchmarking Study respondents – made up of blockchain startups, established corporations, central banks and various public sector institutions – indicated that their solutions included some sort of fully functional smart-contract capability.

With consumer preferences in investment management lowering barriers to entry and fees, smart contracts can offer clear benefits. They arguably improve almost any situation that necessitates a contractual arrangement to establish trust and security. This is why financial institutions of all kinds are investigating

how best to use them in an array of settings where counterparty risk is a feature. Given their potential to eradicate delays, minimize inefficiencies and encourage transparency, it is easy to see how they might help to facilitate, for example, the instant calculation and payment of fund managers' performance fees - as well as upending the settlement and clearance procedures already discussed. Invesco has experimented with smart contracts for the accounting of client fees in order to digitize the client lifecycle. The objective is to transform a complex process into a more transparent and verifiable record.

Derivatives represent another area where longstanding inefficiencies could be mitigated through smart contracts. Here, the manual processing of trades can be extremely complex and time-consuming, which tends to be reflected in the fees charged by brokers and intermediaries. Blockchain's advocates say that it could bypass many, if not all, of these problems - although the International Swaps and Derivatives Association (ISDA) last year published a report claiming that smart contracts are not yet sufficiently

Smart contracts and the "oracle" problem

According to skeptics, smart contracts - at least in their current guise - are not really very smart. This criticism is based on the premise that smart contracts cannot answer questions about the world beyond their blockchain, which means they must rely on outside help.

Help usually comes courtesy of what are known as "oracles". The name is well chosen: like those of Greek mythology, the oracles that inform smart contracts serve as a connection between two realms. As a provider of data, an oracle effectively determines what a smart contract sees - and, by extension, what a smart contract does.

This gives rise to a paradox: the distributed nature of blockchains is intended to eliminate the threat of a single point of failure within a network, yet oracles usually operate on a centralized basis and therefore reintroduce the very same risk. So, the price of connecting with the outside world is to sacrifice the decentralization benefits that are fundamental to blockchain's appeal.

One of the most promising proposed solutions to this dilemma is to create an oracle that is itself decentralized, by making several oracles retrieve data from multiple sources and then aggregating the results. Any contributing oracle that deviates significantly from the mean would be excluded from the aggregation and imbued with less influence in the future. Other potential responses, such as subjecting an oracle service provider to due diligence, would substantially increase transaction costs - again undermining a foundational reason for using blockchain in the first place. Many supporters of blockchain are not troubled by the oracle problem, arguing that blockchain protocols can naturally defend against bad oracles by identifying and recording their activity. Moreover, the oracle problem can be further mitigated through the use of private or permissioned blockchains, as opposed to public blockchains.

"smart" to deal with legal clauses that may be subjective or in need of interpretation.⁷

"Know your customer" (KYC) and "anti-money laundering" (AML) requirements constitute a particularly difficult challenge within financial services. At present, with regulatory obligations often taking weeks to satisfy, the onboarding and monitoring of clients is time-intensive and expensive. Blockchain startups specializing in the "tokenized" securities discussed below are currently paving the way for improvements by embedding KYC and AML information requirements into smart contracts. By granting real-time access to any changes in a client's status, a smart contract-enabled distributed ledger could automate the onerous task of detecting and reporting fraud and enable institutions, regulators and other relevant agencies to react immediately to suspicious behavior.⁸

Fund data and trading

Blockchain is also driving moves to revolutionize how investment managers process mutual fund index data. The goal is to use distributed ledgers to underpin a single source of real-time, immutable data from a range of providers.

Since the distribution of index data usually relies on a variety of parties and transmission channels, disintermediation is once again key. Tests have shown that blockchain increases the speed of data delivery and can cut out the errors that can occur when information - for instance, the names and share prices of companies - are inputted manually. Major institutional investors are actively experimenting in this space. Invesco participates in several blockchain consortiums, among them an index data consortium that includes major industry participants, providers of institutional blockchain solutions and the Center for Research in Security Prices - part of the University of Chicago's Booth School of Business.

Yet this is in many ways only a first step. Attention is already turning to the question of how blockchain could impact index funds more generally, and it is here that some of the biggest changes could be witnessed.

Exchange-traded funds (ETFs), which were first developed in the early 1990s, have become an acknowledged engine of both disintermediation and disruption. Their ability to bypass third parties, and thus lower costs, has proven key to the sector's massive growth.⁹ However, it has been suggested that a new generation of ETFs, dubbed blockchain-traded funds or BTFs, might further elevate disintermediation - and perhaps disruption.

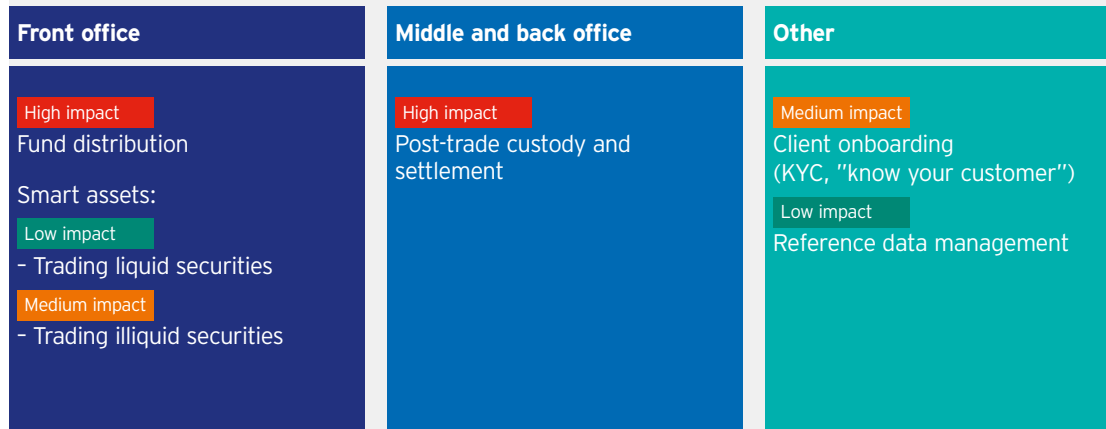
BTFs could allow trading to occur without the involvement of custodians, exchanges, banks and other trusted third parties traditionally pivotal to the process, thus opening up a 24x7 trading cycle. This would further reduce the costs associated with "middlemen" and reconciliation. Proponents say that such a shift could be achieved if indices were "tokenized" - a potentially significant development that we will address next.

"There are clear benefits [to blockchain technology] such as the access to real time or 24x7 trading. It's still in the early stages but these investment vehicles

Figure 3

Blockchain's likely impact on investment management

A recent report released by Gartner entitled *How Investment Management CIO's Can Identify Practical Blockchain Use Cases* observes that, "The greatest current opportunity for blockchain is acting as a trust protocol to coordinate untrusting entities."



Source: Gartner: How Investment Management CIOs Can Identify Practical Blockchain Use Cases, 2018.

are in a similar stage of development as tradeable index funds in the 1990s, when Vanguard was the only firm active in this area. This is also similar to the development of ETFs," says Colin Fitzgerald, Head of EMEA Institutional at Invesco.

Tokens and the democratization of investment

"Tokens" are a vital component of the blockchain thesis. Some public blockchain cryptocurrencies incentivize the creation and maintenance of networks by providing a means for designers and "miners"¹⁰ to profit from the growth of these networks, effectively turning them into markets. Tokens also enable new ways of fundraising, with over USD 13bn raised in ICOs in the first half of 2018.¹¹

Now, the influence of tokenization looks set to become even further-reaching thanks to a growing recognition that the concept can serve as a model for digitally representing physical assets that can then be traded via the blockchain.

The thinking is straightforward enough. The investment world is replete with illiquid assets that are difficult to transfer or subdivide, and these have historically been beyond the reach of many investors. Tokenization could make the buying, selling and trading of relatively illiquid alternative assets, such as direct real estate, diamonds and fine art - and even intangible assets such as financial indices, patents and copyrights - a relatively simple task for investors of all kinds.

Tokenization could bring about a seismic shift in democratizing investment, as well as driving portfolio diversification and lowering administrative costs. Numerous fintech companies are now developing means of deriving liquidity from ostensibly illiquid assets through tokenization and related techniques on private and public blockchains. Invesco is currently developing proof-of-concept tokenized assets on the Ethereum blockchain. Potential impediments to the progress of tokenization include transaction costs and the computer processing power required to confirm transactions on the blockchain.¹²

In essence, tokenization represents a new take on an old idea: securitization. "Illiquid assets, such as real estate, can offer a great opportunity for tokenization," says Colin Fitzgerald. "This is because tokenization creates liquidity and, potentially, a secondary market for such assets. Also, there aren't many existing investment vehicles that enable the average investor to invest directly in asset classes like real estate."

Sandy Kaul, Global Head of Business Advisory Services at Citi, argues that investment managers must take note of these novel ways of considering "ownership" of real assets and seize the chance to adjust and adapt. "The impact on business models could be significant," she says. "There could be an arms race over deal sourcing and a need to partner with a new set of specialized players - anything from market-makers and administrators to realtors and art curators. There's no doubt that distributed ledgers and smart contracts, along with big data and artificial intelligence, offer the potential to transform the industry."

Risks, regulation and the road ahead

Blockchain offers no exception to the rule that new technologies involve some degree of risk and disruption. The road ahead is unlikely to be smooth, and the consequences will not be uniformly positive.

Regulation may pose the greatest threat to blockchain's widespread adoption in the short term. This was certainly the consensus among CCAF's Global Blockchain Benchmarking Study respondents, who deemed extant legal frameworks "unclear". The fact that distributed ledgers, by their very nature, have neither a specific location nor a centralized source of administration raises substantive hurdles in terms of jurisdiction and applicable law. Obtaining a framework that recognizes blockchains as genuinely tamper-proof is likely to prove a contentious affair, as is the task of persuading multiple agencies to reach consensus on global standards: at present, for instance, the US Securities and Exchange Commission and Commodity Futures Trading Commission do not even

agree on what constitutes final settlement of a transaction. How regulators will eventually come to view the likes of cryptocurrencies and tokenized assets is an open question, as is the issue of how to reconcile supposedly immutable public ledgers with legislation such as the EU's Global Data Privacy Regulation (GDPR), which grants individuals the "right to be forgotten".

With governments and investors increasingly focusing on environmental considerations, it may also be hard to disregard the environmental effects of the intense computational power needed to confirm blockchain transactions at scale for mining. At least in countries such as China and Russia, the sheer size of "mining farms" is an emerging cause for concern. According to data from Digiconomist, an online platform dedicated to the analysis and discussion of cryptocurrencies, a single Bitcoin transaction uses enough energy to power an average US household for eight days. It has been estimated that Bitcoin has the same environmental impact annually as more than 2.38 million cars.¹³

Finally - and inevitably - disintermediation driven by the adoption of blockchain is bound to be felt in the jobs market. While it should not be forgotten that new roles - most obviously in the fields of computer security and encryption - will be created, there will undoubtedly be casualties. Just as driverless cars are poised to remold the labour landscape in the transport industry, so too are positions revolving around reconciliation, authentication and the processing of mountains of paperwork unlikely to escape blockchain's march. What remains to be seen is whether those affected will be rendered as superfluous as buggy whip manufacturers, or whether they might be able to develop new skills aligned with the blockchain business model. For example, in light of the aforementioned regulatory issues, it could be that not everything is left to machines: auditors and agents might still need to scrutinize the actual contents of a distributed ledger, even if computer programs handle the order in which entries are processed.

The history of innovation has repeatedly demonstrated that wheels are not easily stopped once they are in motion - and often with good reason. Radical advances invariably bring about winners and losers, and the cost of ignoring novel technologies is frequently higher than the cost of embracing them. All things considered, this is likely to be the case when it comes to blockchain. The genie is well and truly out of the bottle, and it seems foolish to deny or overlook the likely long-term impact - even if nobody can presently say with absolute confidence precisely what that impact might be.

The "leapfrogging" phenomenon

A curious feature of modern-day innovation is that countries at or near the cutting edge of technology are not always the swiftest in adopting a novel concept. Consider, for example, India's recent move towards smartphone technology.

According to a Credit Suisse analysis, India's market for mobile phone payments is the fastest-growing in the world and could increase five-fold over the next five years - reaching approximately USD 1 trillion in 2023. Although demonetization policies and the government's Digital India Initiative have undoubtedly fuelled this shift, the fact is that India - unlike more developed nations - has not been held back by legacy issues: in effect, it is in the process of "leapfrogging" an entire generation of technology.*

By bringing about further disintermediation, blockchain is likely to further accelerate this process. There is little reason for a country like India to invest in systems such as ATMs, or even contactless credit cards, when it could be easier and more cost-effective to adopt a far faster and more seamless method of transacting. Since any street merchant with a QR code and any consumer with a smartphone can already engage in digital payments, the future is likely to lie in embracing the state of the art rather than in regressing to technologies that are even now being superseded.

The Blockchain Council, which seeks to, "raise awareness among businesses, enterprises, developers and society by educating them in the blockchain space," supports this view. It argues: "The lack of existing infrastructure in developing countries is a good thing when it comes to further development. It allows developing countries to skip a few iterations of technological progress, to jump to the most advanced iteration directly. Developing countries like India, Kenya and South Africa already have a massive network of active smartphone users, thanks to the low-cost data services in these countries... and this provides a unique opportunity for blockchains."

* Digital Payments: Trends, Issues and Opportunities, National Institution for Transforming India (NITI) Aayog.

Notes

- 1 'The latest frenzy: the rise of the token', published in the Q1 2018 edition of Risk & Reward, noted that "Most speculative bubbles have something real and potentially transformative underpinning them, and crypto is no exception."
- 2 Breaking blockchain open-Deloitte's 2018 global blockchain survey, Deloitte (<https://www2.deloitte.com/us/en/pages/consulting/articles/innovation-blockchain-survey.html>).
- 3 "Satoshi Nakamoto" is widely acknowledged as a pseudonym. Some have speculated that *Bitcoin: A Peer-to-Peer Electronic Cash System* encapsulated the work of a team of developers rather than a single visionary - notwithstanding reports that the US's Department of Homeland Security has managed to identify the author (allegedly through the use, fittingly enough, of highly sophisticated data analysis).
- 4 As the Cambridge Centre for Alternative Finance's first *Global Blockchain Benchmarking Study* points out, absolute immutability does not exist. In theory, blocks could be reversed if sufficient network participants were to collude.
- 5 Markit noted that loan trades were still taking an average of 19.3 days to complete in 2015. This striking statistic can be found in Markit's Q3 2016 Loan Market Data Snapshot, which reveals only a slight improvement - to 18.7 days - during the ensuing 12 months.
- 6 Buterin's paper, *A Next-Generation Smart Contract and Decentralized Application Platform*, represented one of the earliest attempts to look beyond cryptocurrency and recognize the enormous potential of its underpinning technology.
- 7 Co-authored with London-based law firm Linklaters, ISDA's *Smart Contracts and Distributed Ledger - A Legal Perspective* observed: "Certain operational clauses within legal contracts lend themselves to being automated. Other non-operational clauses - for instance, the governing law of a contract - are less susceptible to being expressed in machine-readable code."
- 8 Deloitte envisioned a similar future in a report published about digital identity. The preface reads: "Imagine a world where customers carry a trusted digital identity that is linked to their financial records and transaction history. The customer's digital approval of a new account registration triggers a smart contract to execute a search of the records and return an authorization to open (or not) the kind of account proposed by the financial institution. Upon completion of the eligibility review, digital account-opening documentation is securely presented to the new customer on a personal smartphone app... The app then secures the funding for the new financial relationship through an automated payment system or an automated securities transfer..." Deloitte observed that the use of blockchain in investment management is currently "a few steps behind [this] vision" but added: "Many firms are actively exploring development, signalling significant change on the horizon." *Investment Management Firms: Getting started with blockchain*, Deloitte (<https://www2.deloitte.com/content/dam/Deloitte/us/Documents/financial-services/us-fsi-im-firms-getting-started-with-blockchain.pdf>).
- 9 According to EPFR, a leading provider of fund-flow data, the ETF sector experienced record growth in 2017, attracting USD 460 billion worth of inflows worldwide, and is set to hit USD 5 trillion in funds invested in 2018.
- 10 "Miners" is the term used to describe those who validate blockchain transactions. It is intended to compare the process, which earns or "unearths" cryptocurrency tokens, with the act of digging for gold.
- 11 CoinDesk ICO Tracker.
- 12 For example, Ethereum imposes charges (known as "gas limits") in order for the blockchain miners to confirm the transaction. The amount of these charges is determined with reference to the computational effort needed to execute the smart contract. Thus, the more complex the smart contract terms are, the more "gas" is required to execute the transaction.
- 13 Digiconomist publishes the Bitcoin Energy Consumption Index, which suggests that Bitcoin is now responsible for more energy consumption than most individual countries. It claims that the Bitcoin network would rank 39th, between the Philippines and Austria, if it were included in the International Energy Agency's rankings of nations' energy use.

About the authors



Dave Dowsett

Global Head of Strategy, Innovation and Scenario Planning, Invesco

Dave Dowsett is Global Head of Technology Strategy, Disruptive Technology, Innovation and Scenario Planning for Invesco. Dave Dowsett and his team use an innovative and emerging technology approach to drive maximum return on investment for Invesco.



Heather Wied

Advanced Business Analyst, Invesco

Heather Wied is responsible for researching, analyzing and communicating external emerging technology trends in the asset management industry and beyond, as well as socializing knowledge about the activities of the Invesco Technology Strategy, Innovation and Scenario Planning team to Invesco and wider audiences.

About risk

The value of investments and any income will fluctuate (this may partly be the result of exchange rate fluctuations) and investors may not get back the full amount invested.

Important information

This document has been prepared only for those persons to whom Invesco has provided it for informational purposes only. This document is not an offering of a financial product and is not intended for and should not be distributed to retail clients who are resident in jurisdiction where its distribution is not authorized or is unlawful. Circulation, disclosure, or dissemination of all or any part of this document to any person without the consent of Invesco is prohibited.

This document may contain statements that are not purely historical in nature but are "forward-looking statements", which are based on certain assumptions of future events. Forward-looking statements are based on information available on the date hereof, and Invesco does not assume any duty to update any forwardlooking statement. Actual events may differ from those assumed. There can be no assurance that forward-looking statements, including any projected returns, will materialize or that actual market conditions and/or performance results will not be materially different or worse than those presented.

The information in this document has been prepared without taking into account any investor's investment objectives, financial situation or particular needs. Before acting on the information the investor should consider its appropriateness having regard to their investment objectives, financial situation and needs.

You should note that this information:

- may contain references to amounts which are not in local currencies;
- may contain financial information which is not prepared in accordance with the laws or practices of your country of residence;
- may not address risks associated with investment in foreign currency denominated investments; and
- does not address local tax issues.

All material presented is compiled from sources believed to be reliable and current, but accuracy cannot be guaranteed. Investment involves risk. Please review all financial material carefully before investing. The opinions expressed are based on current market conditions and are subject to change without notice. These opinions may differ from those of other Invesco investment professionals.

The distribution and offering of this document in certain jurisdictions may be restricted by law. Persons into whose possession this marketing material may come are required to inform themselves about and to comply with any relevant restrictions. This does not constitute an offer or solicitation by anyone in any jurisdiction in which such an offer is not authorised or to any person to whom it is unlawful to make such an offer or solicitation.