1

Blockchain Technology

> [Blockchains] will be the biggest disruptor, not only causing every single back office for every single corporation to be re-thought but also leading to the emergence of new business models and new companies. Smart contracts, in particular, will turn into an invention on par with the invention of written laws and with the emergence of corporations.[1]

This monograph sets out to examine blockchains and other forms of distributed ledger technology (DLT) from a legal and governance perspective.[2] A blockchain is, essentially, a database that is replicated across a network of computers updated through a consensus algorithm. Whereas innovations in database design may once have appeared bland and uninspiring, they no longer are in an age in which the economy and close to all aspects of life have become datafied. Blockchains promise to constitute a profound paradigm shift regarding data collection, sharing and processing and to trigger related revisions of socio-economic and political arrangements.

Much hype currently surrounds the potential of DLT, as it is hailed as a solution to 'virtually every human problem in existence'.[3] Distributed ledgers are widely considered to be 'radically disruptive'[4] and 'to fundamentally shift the way in which

[1] Wilson, 'Interview With Emin Gun Sirer, Professor And Cryptocurrency Researcher At Cornell, And His Thoughts On Smart Contracts' (*CryptoMeNow*, 18 March 2018) <http://insider.cryptomenow.com/interview-with-emin-gun-sirer-professor-and-cryptocurrency-researcher-at-cornell-and-his-thoughts-on-smart-contracts/> accessed 28 March 2018.

[2] From a technical perspective, 'blockchains' cannot necessarily be assimilated with other forms of DLT that do not group data in blocks. For the sake of simplicity, I use this terminology interchangeably and also occasionally rely on 'distributed ledgers' as a synonym.

[3] Angela Walch, 'The Fiduciaries of Public Blockchains' (2016) <http://blockchain.cs.ucl.ac.uk/wp-content/uploads/2016/11/paper_20.pdf> accessed 20 March 2018.

[4] Mark Walport, 'Executive Summary' in Government Office for Science, 'Distributed Ledger Technology: Beyond Block Chain. A Report by the UK Government Chief Scientific Adviser' 14 <www.gov.uk/government/uploads/system/uploads/attachment_data/file/492972/gs-16-1-distributed-ledger-technology.pdf> accessed 3 April 2018.

society operates'.[5] It has been argued that the technology's eventual impact 'on British society may be as significant as foundational events such as the creation of the Magna Carta'.[6] Blockchains are thus seen as an entirely novel socio-economic paradigm.[7]

While many are profoundly optimistic about the technology, others are deeply sceptical. It is striking that most observers either venerate or condemn the technology, with little middle ground in between these camps.[8] Indeed, many caution that blockchains are the most inefficient of all databases and susceptible to trigger environmental disaster through the high-energy consumption required to power some of them.[9]

Hype is an unavoidable component of each technological revolution.[10] Further, according to Clayton Christensen, we must distinguish between 'sustaining innovations', which simply improve the performance of established products, and 'disruptive technologies', which typically perform poorly at first but bring an entirely different value proposition, resulting in subsequent large-scale adoption.[11] Blockchains might fall into the latter category. There can be no certainty regarding the technology's eventual impact, however. Right now blockchains are inefficient by design and need to be upgraded to be functional at scale. The technology suffers from technical limitations that must be resolved to match expectations. The starting point of my analysis, and of any policy-maker compelled to engage with the blockchain phenomenon, must therefore be that this is an area in full development and that the outcome of current innovation processes cannot be predicted.

In a climate of fast-paced development and extreme opinions, objective and timeless analysis proves challenging. Referring to the first blockchain, Bitcoin, Andreas Antonopolous notes the following: 'I wrote a book that answers the question

[5] Aaron Wright and Primavera De Filippi, 'Decentralized Blockchain Technology and The Rise of Lex Cryptographia' (2015) 2 <https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2580664> accessed 28 February 2018 (hereafter Wright and De Filippi, 'Lex Cryptographia').

[6] Catherine Mulligan, 'Applications in Government' in Government Office for Science, 'Distributed Ledger Technology: Beyond Block Chain. A Report by the UK Government Chief Scientific Adviser' (n 1) 65 <www.gov.uk/government/uploads/system/uploads/attachment_data/file/492972/gs-16-1-distributed-ledger-technology.pdf> accessed 3 April 2018.

[7] Jason Potts, Ellie Rennie and Jake Goldenfein, 'Blockchains and the Crypto-City' (2017) 1 <https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2982885> accessed 3 April 2018.

[8] According to the Gartner hype cycle for emerging technologies, it will take between five and ten years for blockchains to reach mainstream adoption. See Amy Forni and Rob van der Meulen, 'Gartner Identifies Three Megatrends That Will Drive Digital Business Into the Next Decade' (*Gartner*, 15 August 2017) <www.gartner.com/newsroom/id/3784363> accessed 13 April 2018.

[9] For a critical account, see David Gerard, *Attack of the 50 Foot Blockchain: Bitcoin, Blockchain, Ethereum & Smart Contracts* (CreateSpace Independent Publishing Platform 2017).

[10] Carolta Perez, *Technological Revolutions and Financial Capital: The Dynamics of Bubbles and Golden Ages* (Edward Elgar 2003).

[11] Clayton Christensen, *The Innovator's Solution: Creating and Sustaining Successful Growth* (Harvard Business School Press 2003).

"What is Bitcoin?" It's 300 pages long, was obsolete the moment it was printed and has to be corrected and updated every three months just to keep up with changes."[12] This, no doubt, is a fate my book also faces. I nonetheless remain convinced of the importance of contributing to the debate about blockchain's regulatory and governance implications at this early stage of the technology's development. Let me explain why. Immature technologies are malleable technologies. It is now – not at the stage of widespread deployment – that the parameters of how technological change affects the human condition, and its socio-economic, normative and institutional underpinnings, are defined.

Blockchains create great opportunities and serious problems. In order to grapple with related challenges we must look beyond the narratives of innovation and technology to come to terms with their significance. Even if the promises currently associated with a distributed ledger do not deliver, current innovation efforts will still result in innovation, even if not in the form currently projected. Even if blockchains do not materialize in the form currently predicted, many of the pain points that manifest in this context are of a general significance in an age of profound technological transmutation. The key themes examined in this book relate to legal automation, the regulatory potential of technology, the difficulties in regulating decentralized global networks, principles of data law[13] and technology governance (that is to say, the rules and principles surrounding software maintenance). These themes will dominate regulatory debates in the years to come, and this also outside of the blockchain context. Extraordinary amounts of capital and talent are flowing into distributed ledger development, triggering technical sophistication, new business ideas and socio-political momentum. Innovation processes are open-ended by nature, and, although precise outcomes cannot be predicted, it appears undeniable that current efforts will cause lasting change. Indeed, whereas the technology itself suffers from severe shortcomings, it inspires people to think of a decentralized future. This vision may be the core value proposition of the technology at this moment in time.

In light of the above it is maybe not surprising that the term 'blockchain' has come to simply be used as a synonym for 'technology' or 'innovation'. This pinpoints a collective perception that we're currently at a crossroads of how technological innovation affects human civilization. For lack of understanding of the precise components and consequences of this evolution, 'blockchain' has evolved to become a code word for these broader evolutions, which are not limited to DLT but, equally, pertain to developments in artificial intelligence (AI) (especially machine and deep learning), smart robotics, new forms of computing, automation and machine-to-machine communications, to name just a few. It is worth noting that it is in combination with these dynamics that blockchains' most appreciable potential lies.

[12] <www.youtube.com/watch?v=A6kJfvuNqtg&feature=youtu.be&t=83>, at 1:24.
[13] I use this expression to refer to the body of legal rules governing personal and non-personal data under EU law.

The wide interest in blockchains testifies to the need for new mental models as we transition from knowledge to information societies, in which data becomes the source of everything. Blockchains open up a new way of thinking about technology and its impact on our lives. Through the power of collective imagination, the technology serves to dream up a new world, especially in light of current problems associated with the tech industry.[14] In one way or another, the 'blockchain' is thus here to stay. The objective of my analysis consists in offering an account of related regulatory and governance challenges and laying the groundwork for future research.

The focus on regulation and governance to examine emerging technologies is warranted for a number of reasons. First, distributed ledgers, like any technology, are in and of themselves neutral but will not be used neutrally. Blockchains are capable of serving benevolent or malicious ends. Just as any other technology, they are a 'technical artefact with a particular architecture, which inevitably has both social and political motivations, as it facilitates certain actions and behaviours more than others'.[15] Blockchains can be used for good, such as in bringing banking services to the unbanked or in adding transparency to areas where it is currently sparse. Blockchains can also be used maliciously, however, and pose a threat to public order. They have already been used to facilitate tax evasion[16] and other crimes[17] and could in the future be relied on to, for example, operate automated unstoppable drone armies or assassination markets.[18] Regulation is thus one important factor that determines how a technology unfolds.

My second focus lies on questions of governance. In the blockchain context, governance is understood as the process of maintaining a technical protocol. This highlights that distributed ledgers are governed by the interplay of endogenous and exogenous regulation. I aim to distil both influences and delineate their mutual influence. My focus rests predominantly on public and permissionless projects, though not exclusively, as I engage with their private and permissioned counterparts where opportune.

I. STRUCTURE OF THE BOOK

This is the first book that examines blockchains from the perspective of European Union law. Therefore, it seeks to provide much of the groundwork needed for future

[14] Nathaniel Popper, 'Tech Thinks It Has a Fix for the Problems It Created: Blockchain' *The New York Times* (1 April 2018) <www.nytimes.com/2018/04/01/technology/blockchain-uses.html?smid=tw-nytimes&smtyp=cur> accessed 13 April 2018.

[15] Primavera de Filippi and Samer Hasan, 'Blockchain Technology as a Regulatory Technology: From Code is Law to Law is Code' (*firstmonday*, 5 December 2016) <http://firstmonday.org/ojs/index.php/fm/article/view/7113/5657> accessed 21 March 2018.

[16] Omri Marian, 'Are Cryptocurrencies Super Tax Havens?' (2013) 112 University of Michigan Law Review First Impressions 38.

[17] <https://en.wikipedia.org/wiki/Silk_Road_(marketplace)> accessed 25 May 2018.

[18] Whether the State needs to directly intervene to prevent this or whether these objectives can be achieved through self-regulation is a question we turn to in the final two chapters.

research and discussions.[19] I combine insights from EU law with regulatory theory and the 'law and innovation' and 'law and technology' schools of thought to provide impetus as to how we ought to approach an emergent and potentially disruptive technology. This tale unfolds in eight parts.

Chapter 1 introduces blockchain technology. It provides an overview of its central technical components and offers a functional perspective in highlighting its main characteristics and related implications. I will illustrate that, in its current configuration, the technology is limited and probably cannot be deployed at scale. I will also highlight the rapid technical developments that occur in this area and potential future consequences. The chapter further outlines the various layers of a blockchain ecosystem and speculates about what the predominant future use cases and implications of the technology might be.

Chapters 2 and 3 examine the technology from a regulatory perspective in focusing on the two general and overarching themes of how a complex global technology can be regulated and, conversely, how such a technology regulates those who engage with it. Chapter 2 addresses claims that, due to their decentralized and transnational peer-to-peer structure and the use of encryption, blockchains cannot be regulated. I draw parallels to early debates of Internet regulation and rebut that narrative, highlighting various centralized regulatory access points to the decentralized network that enable regulatory intervention. Chapter 3 evaluates the potential of distributed ledgers to serve as regulatory agents. In highlighting that blockchains are an aspect of the increasing automation of law, I introduce associated promises and drawbacks. This analysis further stresses that DLT forms a potent behaviour-constraining tool in the hands of those who operate it.

After this general examination of distributed ledgers and their regulatory implications, I turn to examine the data they store from the perspective of two specific areas of EU law. Chapter 4 examines the data stored on blockchains from the perspective of the European Union's General Data Protection Regulation (GDPR) whereas Chapter 5 explores the technology in relation to the provisions of supranational law governing non-personal data and current debates concerning the need for legal reform in this domain. Taking data law as my looking glass, I highlight, on the one hand, that DLT can stand in considerable tension with established legal frameworks and their underlying technical and economic assumptions (in the case of personal data). On the other hand, however, distributed ledgers could provide a technical solution in areas where law is currently falling short of achieving desired normative objectives (in this case, promoting the sharing of non-personal data between undertakings).

[19] For a general account of the relation between blockchains and law, with particular references to the US, see Primavera De Filippi and Aaron Wright, *Blockchain and the Law* (Harvard University Press 2018) (hereafter De Filippi and Wright, 'Blockchain and the Law').

From that conclusion I will move on to explore the wider policy implications of blockchain technology. In Chapter 6 I ponder the complex interaction between law, technology and innovation to formulate concrete recommendations for policy-makers faced with emerging technologies. I advance a concept of polycentric co-regulation, which constitutes an attempt to reconcile the established benefits of public regulation with the newer challenges and opportunities of the participatory and regulatory potential of technology. Chapter 7 is dedicated to the specific governance challenges presented by blockchain technology. I survey ongoing debates echoing the uncertainties as to how these technological artefacts, designed to replace trust in human beings, should be governed amidst realizations that technology doesn't eliminate the need for human consensus. The legal implications of governance decisions are also debated. My analysis closes by offering a conclusion that highlights the book's main arguments and suggests themes for further research. Considering the fast pace of development in this area, it is worth noting that this book takes into consideration developments up until the early spring of 2018.

II. BLOCKCHAINS AND OTHER FORMS OF DISTRIBUTED LEDGER TECHNOLOGY

This chapter is designed to set the scene for subsequent analysis in providing an introduction to the technology and its potential impact. My approach consists in trying to make technological concepts accessible while maintaining the necessary details and terminology needed to meaningfully engage in this space. Overall, I try to set out the technology from a functional perspective; focusing on what it does and where its most pivotal impacts might lie.

A. *Definition*

In essence, a blockchain is a shared and synchronized digital database that is maintained by an algorithm and stored on multiple *nodes* (the computers that store a local version of the distributed ledger). Blockchains can be imagined as a peer-to-peer network, with the nodes serving as the different peers.[20] Some chains operate a distinction between 'full' and 'lightweight' nodes, whereby only full nodes store an integral copy of the ledger from the *genesis block* (the first block) whereas light-weight nodes store only those parts of the ledger of relevance to them.

As its etymology reveals, a blockchain is a chain of *blocks*.[21] A block groups together multiple transactions and is then added to the existing chain of blocks.

[20] A 'peer' of course doesn't have to be a private individual but can also be a corporatione or, in the future, a machine.

[21] It is worth noting that as the technology evolves this structure might eventually cede way to other forms of data-storage.

Data is grouped into blocks that, upon reaching a certain size, are chained to the existing ledger through a hashing process. A *hash* is, essentially, a unique fingerprint that represents information as a string of characters and numbers.[22] The ledger's blocks have different key components, including the hash of all transactions contained in the block (its 'fingerprint'), a *time stamp* and a hash of the previous block (which creates the sequential chain of blocks).[23] Because blocks are continuously added but never removed a blockchain can be qualified as an *append-only data structure*. Cryptographic hash-chaining makes the log *tamper-evident*, which increases transparency and accountability.[24] Indeed, because of the hash linking one block to another, changes in one block change the hash of that block, as well as of all subsequent blocks.

Blockchain networks achieve resilience through *replication*. The ledger's data is resilient as it is simultaneously stored on many nodes, so that, even if one or several nodes fail, the data goes unaffected. In light of such replication, there is no central point of failure or attack at the hardware level.[25] Through its design, a distributed ledger moreover reduces verification costs (the verification of a transaction's attributes) and networking costs (the ability to bootstrap and operate a marketplace without the need for an intermediary).[26]

The replicated data stored in blocks is synchronized through a *consensus protocol*, which enables the distributed network to agree on the current state of the ledger in the absence of a centralized point of control. The consensus protocol governs how new blocks are added to the chain. Through this process, data is chronologically ordered in a manner that makes it difficult to alter data without altering subsequent blocks. Consensus refers to the mechanisms that coordinate data held by the various nodes, providing assurance to network participants that their versions of the ledger are consistent and accurate.

Blockchains are both a new technology for data storage and a novel variant of programmable platform that enables new applications such as smart contracts.[27] It is crucial to note that a blockchain ecosystem is *multi-layered*. First, blockchains themselves rely on the Internet and Transmission Control Protocol/Internet Protocol (TCP/IP) to operate, and can in this respect be seen as 'new application protocols that sit on top of the transport layer'.[28] Second, distributed ledgers

[22] A hash is a one-way cryptographic function, designed to be impossible to revert.
[23] Andreas Antonopoulos, *Mastering Bitcoin* (O'Reilly 2017) xxiii.
[24] Ed Felten, 'Blockchain: What is it Good For?' (*Freedom to Tinker*, 26 February 2018) <https://freedom-to-tinker.com/2018/02/26/bloc> accessed 3 April 2018.
[25] In Chapter 7 we will see that there can be a central point of attack or failure at the software governance level.
[26] Christian Catalini and Joshua Gans, 'Some Simple Economics of the Blockchain' (2016) Rotman School of Management Working Paper No. 2874598, 1 <https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2874598> accessed 3 April 2018.
[27] A smart contract essentially is self-executing software code. I examine smart contracts in further depth just below.
[28] De Filippi and Wright, 'Blockchain and the Law' (n 19) 48.

themselves provide not just an infrastructure for data management and a new infrastructure that can anchor diverse applications (the '*infrastructure layer*'). Third, a blockchain itself serves as an infrastructure on which decentralized applications (the '*application layer*') run.

Distributed ledgers provide a replicated database that is updated in a decentralized manner. While this database can be used independently, such as to record transactions in cryptoassets or register information, it can also serve as the ground level on which further edifices are constructed, which in the blockchain case are usually labelled 'decentralized applications' because they reflect the decentralized structure of the underlying network.[29] These applications can take a wide variety of forms and serve a wide variety of use cases.[30] While some applications sit directly on top of a blockchain, others use an intermediary layer in the form of a decentralized application framework that implements their own protocols for the creation and maintenance of decentralized applications.[31] A blockchain ecosystem accordingly has different vertical layers. In addition, it can have different components from a horizontal perspective, as blockchains can be interoperable, or when a single DLT relies on child chains or side chains that can serve different purposes.[32]

Blockchain ecosystems are still under construction, and, as these networks become more refined, it will be more straightforward and common to distinguish between their diverse aspects, such as the protocol and second-layer applications, but also different forms of storage and computing.[33] I now turn to consider the broader context from which blockchains in their current form emerged and take a deeper look at their technical details. Thereafter, I offer an overview of the technology's broader applications and implications.

B. *History and Evolution*

The first blockchain was created to provide the technical infrastructure of *Bitcoin* in 2009. At the time the technology itself was considered to be but a by-product of the cryptocurrency, and the term 'blockchain' doesn't even figure in Satoshi Nakamoto's famous White Paper.[34] Rather than being a completely novel technology, DLT is better understood as an inventive combination of existing

[29] This terminology reflects, on the one hand, that these are applications running on an infrastructure and that they can be managed in a decentralized fashion just as the infrastructure itself.

[30] See further below.

[31] See, by way of example: <https://daostack.io/>.

[32] Side chains allow data to be stored in another chain and then be moved back to the main chain.

[33] Note the analogies with 'the Internet'.

[34] Satoshi Nakamoto, 'Bitcoin: A Peer-to-Peer Electronic Cash System' (2009) <https://bitcoin.org/bitcoin.pdf.> accessed 20 March 2018 (hereafter Nakamoto, 'Bitcoin White Paper'). Nakamoto is the pseudonymous mastermind behind Bitcoin.

mechanisms. Indeed, nearly all its technical components originated in academic research from the 1980s and 1990s.[35]

In the aftermath of Bitcoin's creation, observers noticed the technology's capacity to serve as a decentralized record of data and digital assets that can be operated between parties that do not know or trust each other without the need for a trusted third party. This has led developers to build on the Bitcoin blockchain, to create new blockchains (such as *Ethereum*),[36] as well as other forms of distributed ledger technology that do not store data in blocks (such as hashgraphs). These networks promise to facilitate a wide range of uses in the private and public sectors.

In the private sector, DLT is currently being experimented with to enable various forms of digital money[37] and mobile banking,[38] track goods in international trade,[39] manage software licences,[40] power machine-to-machine electricity markets[41] and replace centralized sharing economy platforms,[42] among many others. More generally, blockchains promise to enable 'business governance structures that are more transparent, more flat, and more participatory'.[43] Equally, the public sector is trialling the technology. The European Union is currently exploring the option of a supranational blockchain infrastructure[44] while a UK report suggests using the technology to protect critical infrastructure against cyberattacks, for operational and budgetary transparency and traceability and to reduce tax fraud.[45] Such variegated applications are possible because blockchains are simultaneously a programmable platform that enables new applications as well as a method for data storage (essentially, an accounting system).

[35] Arvind Narayanan and Jeremy Clark, 'Bitcoin's Academic Pedigree' (2017) 60 Communications of the ACM 36.

[36] Ethereum is a so-called second generation blockchain, which not only allows to track transactions (as Bitcoin) but also provides computer programming language that allows for the construction of decentralized applications on top of the network infrastructure.

[37] Such as Bitcoin.

[38] <https://www.bitpesa.co/>.

[39] <https://www.everledger.io/>.

[40] Walter Blocher, Alexander Hoppen and Peter Hoppen, 'Softwarelizenzen auf der Blockchain' (2017) 33 Computer und Recht 337.

[41] Janusz Sikorski, Joy Haughton and Markus Kraft, 'Blockchain Technology in the Chemical Industry: Machine-to-machine Electricity Market' (2017) 195 Applied Energy 234.

[42] Steve Huckle et al., 'Internet of Things, Blockchain and Shared Economy Applications' (2016) 98 Procedia Computer Science 461.

[43] Carla Reyes, Nizan Packin and Benjamin Edwards, 'Distributed Governance' (2017) 59 William & Mary Law Review Online 1, 19.

[44] European Commission, 'Study on Opportunity and Feasibility of a EU Blockchain Infrastructure' (Call for tenders) <https://ec.europa.eu/digital-single-market/en/news/study-opportunity-and-feasibility-eu-blockchain-infrastructure> accessed 13 April 2018.

[45] Mark Walport, 'Executive Summary' in Government Office for Science, 'Distributed Ledger Technology: Beyond Block Chain. A Report by the UK Government Chief Scientific Adviser' 14 <www.gov.uk/government/uploads/system/uploads/attachment_data/file/492972/gs-16-1-distributed-ledger-technology.pdf> accessed 3 April 2018.

C. *Blockchains as an Accounting System*

Blockchain infrastructure is basically a common asset registry, an innovation in database design that either directly stores data or links to data. These shared accounting systems can be used by different entities to standardize and link data and 'enable credible accounting of digital events'.[46] Through their structure, they present the potential to coordinate information between many stakeholders. With these characteristics, blockchains help track and store evidence about transactions and participants.

While these distributed and verifiable records only ever store data, this data can be taken to represent anything we believe and agree it represents. Bitcoin is, essentially, data that is valuable because people have come to believe it is. Similarly, over time other forms of *digital assets* have emerged that are still nothing but raw data taken to represent a good, service or entitlement. Blockchain-based assets can purely have on-chain value (as in Bitcoin) or be the avatar of a real-world asset, whether a good (such as a token representing a bike), a service (such as a voucher for a haircut) or an entitlement (such as a legal right).

Often labelled as *the Internet of Value*, distributed ledgers thus promise to disrupt the online circulation of value.[47] Whereas the Internet provides a protocol for the exchange of information, blockchains provide a protocol for the exchange of value. Indeed, right now economic assets are but a different kind of information expressed in bits and bytes on the Internet. Blockchains empower value transfers without the need for a traditional intermediary. Distributed ledgers allow for value to be administered in a decentralized fashion, providing a transparent and secure record of transactions. For example, the Bitcoin blockchain provides a 'public append-only and tamper-proof log of all transactions ever issued'.[48] Given that data stored on a DLT can be personal or non-personal data from the perspective of EU law, I will examine its status under the relevant legal regimes in Chapters 4 and 5.

In providing a distributed and verifiable record of data, blockchains may come to transform record-keeping systems. While this may sound underwhelming, it can have far-reaching implications as the importance of accounting in socio-economic settings must not be ignored. To illustrate, Max Weber considered that the invention of double-entry bookkeeping founded capitalism.[49] Blockchains are an innovative system for determining 'who did what when' that can be deployed to enable

[46] Roman Matzutt et al., 'A Quantitative Analysis of the Impact of Arbitrary Blockchain Content on Bitcoin' (26 February 2018) 1 <https://fc18.ifca.ai/preproceedings/6.pdf> accessed 3 April 2018 (hereafter Matzutt, 'A Quantitative Analysis').

[47] Amy Cortese, 'Blockchain Technology Ushers in "The Internet of Value"' (*cisco*, 10 February 2016) <https://newsroom.cisco.com/feature-content?articleId=1741667> accessed 3 April 2018.

[48] Matzutt, 'A Quantitative Analysis' (n 46) 1.

[49] Max Weber, *General Economic History* (Frank Knight 1927) 276 ('the most general presupposition for the existence of this present-day capitalism is that of rational capital accounting').