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Abstract

Drawing on an empirical study of cryptocurrency white papers, this paper proposes an actor-based taxonomy of cryptocurrency blockchains. First, it describes the evolution of blockchain architecture with reference to the economic services that blockchains supply. Second, it discusses the socio-technical platform of blockchains as proposed in cryptocurrency white papers. Third, it analyses the socio-economic consequences of these technically diverse blockchain platforms, by proposing a taxonomy of their digital architectures in reference to two groups of actors that maintain blockchain infrastructure: transactioners and accountants. Defining cryptocurrency as data money, and locating cryptocurrency ownership as the possession of an exclusive right to move data privately in a public or private space, the paper describes a blockchain as a digital actor-network platform that makes it possible to define and distribute these data transfer rights.

Keywords: blockchain; cryptocurrency; Bitcoin; infrastructure; platform; data money.

Introduction

Contemporary economic relations revolve around 180 fiat currencies issued by states and marketed by banks. Since 2008, and for the first time in history,

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cryptocurrency blockchains have been forging a parallel monetary economic universe that may need neither states nor banks for minting and transferring currencies. In less than a decade, the market capitalization of cryptocurrency economic universe reached US$820 billion, exceeding 89 per cent of the world's national economies by December 2017, when Bitcoin's closing price briefly exceeded US$19,500.[1] By January 2020, there were 5,035 cryptocurrencies, traded in more than 20,317 cryptocurrency markets all over the world, making them the most varied money and most rapidly emerging market form in history.

Journalistic accounts of these currencies draw on clashing reactions: Those who are under the spell of Bitcoin *schadenfreude* have described it as a bubble that is doomed to vanish. An influential editorial has called it 'a greater fool's gold' (*The Guardian*, 2018). Bitcoin evangelicals see a revolutionary potential in it. They believe that it facilitates autonomous economic action in a beyond-political world without any state intervention (Tapscott & Tapscott, 2016). Academic literature disagrees. Research has shown that money is not a thing, but a process, produced and maintained by social relations and political institutions (Dodd, 1994; Hart, 2000; Zelizer, 1994). We also know that the bursting of the dot.com bubble did not prevent Silicon Valley from giving birth to the world's first trillion-dollar companies, such as Amazon. Therefore, many academics are not convinced that Bitcoin's volatility will bring about the end of blockchains and cryptocurrencies (Bjerg, 2016; Dallyn, 2017). Furthermore, it has been shown that these new currencies are 'multi-faceted, politically contested and sociologically rich in [their] functions and meanings. There is not one Bitcoin, but several' (Dodd, 2018, p. 36).

Scholars have also shown the very political universe of Bitcoin proliferation (DuPont, 2017; Golumbia, 2015). Almost 80 per cent of Bitcoin mining in 2017 was carried out by five mining pools only, thus implying power asymmetries (Swartz, 2017). The assumption that states and banks cannot control cryptocurrencies creates the illusion that a blockchain operates without institutional mediation undergirding social and political relations (Nelms *et al.*, 2018). Banks and states have been using and producing blockchains at a time when blockchains are presented as the historical instrument to undermine their power. This detracts from the credibility of evangelicals who argue that blockchains are anti-system, anti-capitalist and anti-state.

However, there exists one gap in the emerging literature: The scholarly literature addresses this new development in two ways, neither of which are adequate for explaining and analysing the working of blockchains and cryptocurrencies. First, micro-economic research on crypto-assets builds models that draw on problematic neoclassical assumptions concerning how actual markets work (Ciaian *et al.*, 2016; Jang & Lee, 2018). Such studies assume that the specific nature of the commodity and the socio-political nature of its universe have no significant effect on how their prices are made, whether in pork belly or in Bitcoin. As empirically demonstrated in the literature, both the nature of the object of exchange and the infrastructure of the market itself have formative effects on prices. This infrastructural dimension of markets has to be studied, not edited out (Barry, 2013; Callon, 1998; Lépinay, 2011; MacKenzie, 2006; Roitman, 2005; Slater & Tonkiss, 2001).

Yet, predominantly digital infrastructures such as blockchain are different from predominantly non-digital infrastructures such as roads, electricity networks and irrigation canals. To Larkin (2013) 'infrastructures are matter that enable the movement of other matter' (p. 329). However, computer programs and data are not matter; they are protocols or representations that operate in/on matter that consumes electric power, all made possible by labour power. Blockchains are infrastructures that enable the movement of data as representation and value. In a world where all infrastructures are being entangled with varieties of digitality, digital infrastructures, like blockchains, require from social researchers a critical and empirical attendance to the specificities of socio-technical universes they build. I do not assume an essentialist 'nature' of digitality apart from material things, but draw on the analyses of materiality of representational objects like data and algorithms as illustrated by Dourish (2017). Like constitutions, protocols constitute relationships by imagining rights, subjects, objects and trajectories of action and inaction. But unlike constitutions, one cannot disobey them, for they make action impossible if one does not follow the trajectories of movement that they define. They display syntax error, unless they are hacked. Yet for the actors that cannot be defined by the computer code, infrastructural inversions are almost always the norm (Jensen, 2017; Morita, 2017).

Second, many analysts either show what cryptocurrencies are *not*, or how these currencies are not *new*. With exceptions such as (Dodd, 2018; Maurer, 2017; Parkin, 2019; Rella, 2020; Shaw, 2016; Swartz, 2017; Zook & Blankenship, 2018) the existing social science literature rarely draws on empirical social analysis; it interprets blockchains and cryptocurrencies either by drawing on anecdotal experience, or on the theoretical premises of the very empirical developments they aim to understand. This literature has been critiqued by showing their inclination to treat their assumptions as conclusions instead of starting out with an empirical analysis of how blockchains take place in various economic contexts (Garrod, 2019; Jones, 2018). It is this gap in the literature that this paper addresses, by offering an actor-based taxonomy by empirically analysing cryptocurrency blockchain white papers.

Theoretically, the argument draws on studies of economization, as discussed by Çalışkan and Callon (2009, 2010). The study of socio-technical infrastructures plays a crucial role in making sense of economic action and agency, because they structure possible fields of action in identifiable ways (Anand, 2012; Appel, 2012; Barry, 2013; Brian, 2013; Elyachar, 2005; Foucault & Gordon, 1980; Harvey & Knox, 2015). However, one has to be careful against reviving sociological structuralism, this time in the form of *infrastructuralism*. It would be problematic to categorically propose that infrastructures are primary frameworks that give birth to secondary social behaviour or 'the action'.[2] Networks can determine or have a larger say in how actors behave, but this is a possibility, not a rule.

A distinction should be made between infrastructure and architecture. Infrastructures arrange the ways in which architectures, that are built on them, connect and bypass each other. They are meta-structures that make possible the building of architectural designs that harbour and form possible trajectories of action. However, depending on a strategic vantage point, structures may function like infrastructures. The internet is infrastructural to blockchains, and a specific blockchain can be infrastructural to the architecture of a cryptocurrency exchange. In economization relations enmeshed in digital materialities, infrastructures and structures are not static things where matter makes other matter flow. They are dynamic processes whose function changes according to the vantage point one approaches these relations. In that context, the term 'socio-technical', or better still, 'socio-digital' refers to an assemblage or *agencement* of devices, representations, and actors whose interaction produce empirically observable consequences that may, in turn, change the infrastructure itself. These socio-digital assemblages, that may take the form of a stack economization on platforms such as cryptocurrency exchanges, equip agents with devices of action to be deployed in contexts that shape and are shaped by human intentions, interests, mistakes and plans.

The empirical research draws on the white papers of the most valuable 100 cryptocurrencies as of 1 June 2018. Almost all cryptocurrencies are offered with a 'white paper'.[3] These are position papers, written by anonymous, known individuals or groups of individuals, historically making cryptocurrency or *Data Money* as the first money form that is created, in part and in varying degrees, by scientists or people who use scientific and designerly competences, and without the contribution of banks and states. These more than 2,000 white papers now make up an oeuvre longer than 50,000 pages. Most of these documents, however, introduce cryptocurrencies of only negligible economic value. As of 1 June 2018, the most valuable 10 cryptocurrencies represented 75.01 per cent and the most valuable 100 cryptocurrencies carried 90.06 per cent of all cryptocurrency value in the world.[4]

Providing researchers with an opportunity to study the evolution of blockchain architectures, white papers develop, describe and present major forms of blockchains and their respective cryptocurrencies. The first part of the paper presents the evolution of blockchains from the value-exchange-distributed ledger of Bitcoin and smart-contract-exchange platform of Ethereum, to market-making blockchains like Cybermiles and interchain platforms that aim at bridging separate blockchains themselves, such as Aion. Without developing a critical awareness of the socio-technical evolution of these digital ledgers, one cannot grasp the specificity, nature and consequences of their architecture.

Blockchains draw on imaginaries of digital metallism (Maurer *et al.*, 2013), a discursive framework that grants blockchain projects tools of intervention in actual economic universes, yet by making it difficult to understand blockchains if one uses these metallistic analogies that blockchain architects themselves use. Digital metallism has a reverse discursive thread that represents material processes as if they were *not* physical or material, which may be called *intangibilism*. References to the 'cloud' are a good example. 'Clouds' are located in warehouses that dot the global countryside, not up in the sky as if they were intangible things.

The term 'Bitcoin mining' exemplifies this elusive nature of blockchain architecture well. One does not dig out data to find Bitcoins in a digital mineshaft. Mining, an analogical concept Satoshi Nakamoto used for the first time in his Bitcoin white paper, is a form of computational accounting for whose practice the underlying protocol rewards the accountant with cryptocoins. Furthermore, cryptocoins are not coins *per se*, but digitally represented exclusive *rights* to send data privately in a public economic space.[5] Market actors exchange these specific rights and trade these digital coins for services and goods.

The second part of the paper introduces a descriptive presentation of the content of white papers, their writers, their arguments' scientific qualities, and their imaginaries. In this section, drawing on a computational text analysis with R, we see that white papers theorize the maintenance of reintermediations, markets and economies in a social context. Furthermore, these white papers, all written in English and by male authors, propose a specific social world that draws on a bifurcation between digital and non-digital things.

The third part presents an actor-based taxonomy of blockchains in terms of their control mechanisms which structure identifiable courses of action for economic agents. It is important to understand the blockchain heterogeneity so as to better grasp what kind of socio-technical or socio-digital assemblages they are, and what consequences those different types entail in relation to economic agency. Assuming the homogeneity of blockchains and not controlling for their actor-network heterogeneity may lead to erroneous theoretical generalizations or empirically partial observations. The paper shows that blockchain digital infrastructure defines two major types of actors: transactioners and accountants, and argues that blockchains can be categorized based on how their architectures define who can be active as transactioner or accountant.

Drawing on this distinction, the paper demonstrates that there are two types of blockchain architecture: public and private blockchains. Furthermore, these blockchains are diversified based on who can account for their transactions: Open Accounting Blockchains and Closed Accounting Blockchains. In discussing the consequences of these four blockchain categories, the paper shows that, without developing a nuanced understanding of the heterogeneity of blockchain architecture, it is impossible to make sense of how blockchains work, let alone what their consequences are. The paper ends by interpreting cryptocurrency as data money and locating cryptocurrency ownership as the possession of an exclusive right to transfer data privately in a public or private space, and by showing that blockchains are digital actor-network platforms that make it possible to define and distribute these data transfer rights.[6]

The evolution of blockchains

When the Bitcoin blockchain was developed by an anonymous writer by the name of Satoshi Nakamoto 10 years ago, its cryptocurrency was referred to as 'electronic cash', and the platform of its production and exchange was presented as a 'peer-to-peer network' without naming it a 'blockchain' (Brunton, 2019). The terms *block* and *chain* never came together as one word in that paper. Yet, this nine-page-long white paper was to introduce an economy whose capitalization would reach US$ 305 billion in less than a decade, surpassing the market worth of Visa, the world's largest credit card company by US$ 50 billion in December 2017.

One does not need cryptocurrency or blockchain to digitally represent money or currency, and transfer them via internet. These transfers and representations are as old as the times when financial intermediaries such as banks began using computers. In 2008, the first blockchain of the world managed to produce and transfer value without an intermediary in public. The mechanism looks complex, but it draws on a simple principle of accounting. Imagine that Alice sends US$ 1 to Bob. Alice's bank withdraws US$ 1 from her account, and Bob's bank adds US$ 1 to his. The transaction appears in the double-entry book-keeping system of the bank and is reported as part of aggregate accounting data to the state for tax purposes. Alice cannot spend the same US$ 1 again, for her account would physically lose it, and if she went to the bank to withdraw all her money, she would end up having US$ 1 less cash.

Nakamoto proposed a way to transfer value, like the system explained above, minus banks and states. Alice sends 1 Bitcoin (BTC) to Bob without going through a formal financial institution; an attending problem is how to prevent Alice from spending that 1 BTC again. This is a challenging difficulty to address, because unlike difficult-to-forge paper or metal money, it is very easy to copy and paste a *digital* representation.

Digital representations of fiat currency, or digital currencies, are still fiat and categorically different from cryptocurrencies in two ways. First, they are not *data monies* whose circulations or exchange draws on the *transfer* of exclusive *rights* to send data without an intermediary's supervision. Second, digital fiat currencies, although lacking the physical paper representations, are still minted and supplied by banks and states. Hence, what makes data money unique is its novel treatment that prevents it from being forged, copied or spent again, while at the same time ensuring that its transfer is not reversible at will. Bitcoin blockchain developed a system to address this difficulty, generally called the double-spend problem and irreversibility of transactions.

Let's say, Alice wants to send 1 BTC to Bob. This transaction proposal is encrypted by sophisticated programs to make it a *unique* digital representation that cannot be re-represented without a series of passwords. Then, this proposal to transact 1 BTC appears on an internet network, where a community of accountants see this digital proposal among hundreds of others around it. These accountants then choose, for example, 500 of them and write them down on a digital page called a 'block'. If they manage to add this new page to the Bitcoin digital ledger, the proposed transaction between Bob and Alice is *realized*. Once recorded in the digital ledger, it is almost impossible to change, alter, modify, or cancel this transaction, thanks to the protocol that runs the system.

Why would someone volunteer to be an accountant of such a system, unless she earns something from it? Nakamoto addressed this problem by giving a digital thing that may be found valuable to any accountant who managed to add one more page to the ledger. And this potentially valuable digital thing is called a Bitcoin. What makes it valuable is not 'an abstract and subjective belief', but its *material* utility in proving an actual *service* of value creation and transfer without the necessary presence of a central formal institution or intermediary.

In the beginning 'the thing' was 50 BTC, which represented some value to the accountants that Nakamoto called miners. Until March 2010, BTC did not have any significant monetary value. There was no BTC market, only scattered auctions here and there, with no market price to quote. However, with the opening of the first digital currency exchange market in 2010 – that is, Bitcoinmarket.com, a now defunct intermediary institution designed for Bitcoin exchange – the value of BTC began to pick up. Here, it is worth underlining the fact that a development with the stated aim of *disintermediation* began to be valued only after it contributed to the making of a new intermediary institution, a Bitcoin exchange market. Such an unprecedented valuation of Bitcoin was also due, most probably, to the 2008 crisis that took down with it much trust in conventional financial institutions. Ten months following the emergence of the first Bitcoin exchange market, Bitcoin was traded for US$ 1, changing the entire landscape of its accounting, because more and more accountants could earn more by contributing to Bitcoin accounting process. A currency issued and backed by no state had reached the value of a currency issued and backed by the United States.

The Bitcoin protocol controls Bitcoin creation by four mechanisms: First, the amount of Bitcoin per each mined block would be halved after every 210,000 blocks. In 2009, it was 50 Bitcoins, while in 2012 this number decreased to 25, and in 2016 became 12.5. The more miners the accounting system attracts, the faster its rewards shrink. Second, one receives an automatic reward as soon as one mines a block. Many miners compete for this; therefore, a chance event also controls the number of miners who can receive the reward. The miner who guesses a number that the protocol uses once, called the nonce, is given the right to close that block, and only after this correct guess, that miner's block is added to the ledger. Third, the value of the cryptocurrency itself is in part controlled by the protocol in a deflationary context, by fixing the number of Bitcoins to be mined at 21 million. Finally, the protocol defines a transaction fee that can be set as zero or more by the transactioner, which once exceeded US$20 million a day on 21 December 2017, when a total of 1,496 BTC were paid to miners. A person who wants that change the transaction speed is free to increase, or decrease it, all the way to zero. Thus, after the 21-millionth Bitcoin, mining will only be carried out with transaction fees.

Going back to our imaginary example, Alice, after attaching an attractive transaction fee to her proposed transaction, has her proposed transaction included in a block. As soon as the block is added to the ledger thanks to a successful miner, that 1 BTC (minus the fee) becomes Bob's property. What if Alice wants to spend again the Bitcoin she sent to Bob? She cannot, because 'spending' means transferring the right to send it to someone else, and because Bitcoin is the *right* to *send* fixed and non-replicable data to someone else privately in a public ledger; once sent and registered, that right has been transferred to Bob for good.

Double-spending and irreversibility are enhanced by making every transaction public, without giving Alice and Bob's real names. Imagine a magical notebook: you write something in it, and this note pops up on everyone's notebook and can no longer be altered as soon as the majority of owners of the notebooks accepts its validity. Even if you erase the note in your own notebook, it will remain on record in others' notebooks. The attempt to change the ledger, and thus spend the same Bitcoin again or send it to someone else, is so costly that Bitcoin blockchain users avoid it.

Following Bitcoin blockchain, various other blockchains were designed, either independently constituted or constructed as a derivative of the Bitcoin algorithm. Yet, with the emergence of the Ethereum blockchain, it became possible to send digital assets only if certain conditions were met, thus embedding a new value in the computation itself. Buterin published the Ethereum blockchain white paper, giving birth to the second-generation blockchains.

First-generation blockchains facilitated sending data, whereas second-generation blockchains made it possible to send data if certain conditions were met. In other words, Ethereum allows embedding contracts into digital value and transferring a short computer program, thus changing the nature of accounting from checking for value to checking for a working contract, or a program. Let's say, Alice decides to send Bob 1 BTC, but only if Carol sends Bob 2 BTC. This is a conditional context: The transfer of value between Alice and Bob only happens if a certain condition is met on the other end, which is the successful transaction between Carol and Bob.

The outcome was groundbreaking in the sense that the advanced computer language of the Ethereum blockchain rendered it possible to imagine value as contract, and with minor and relatively easy alterations; others began to use Ethereum as a framework to imagine new cryptocurrencies without building new blockchains. Without changing the main logic of imagining value as a right to send data, Ethereum gave birth to the big bang in the cryptocurrency universe.

These second-generation blockchains continued to develop their infrastructural skills, so much so that the Truthcoin blockchain managed to include out-of-chain conditions to be accounted for by smart contracts. Let's say, Alice sends 1 BTC to Bob only if the weather temperature in New York City is 35 Celsius or above. Obviously, the weather is not a blockchain event; it is what coders call an 'off-chain event'. However, the data generated by meteorological sources can be coded into smart contracts to create off-chain world events to trigger the realization of 'in-chain contracts', or making 'oracles', as coders would put it. This new development facilitated the transfer of almost any financial off-chain instrument into blockchains, such as stop-loss-orders on derivative contracts.

The opening of such a wide spectrum of options in blockchains led to imagining more complex transactional relations and infrastructure-making, giving birth to the third-generation blockchains: blockchain architects have developed systems that create an 'interchain' network, such as Aion, by putting mutually exclusive blockchains with dissimilar computing protocols into contact and transaction with each other (see Table 1).

As such an evolution took place, corporations and states also started to develop their own blockchains, for there is nothing fundamentally 'public' about blockchain technology. Depending on one's intentions, one can create specific keys to lock or unlock relations in a blockchain, as this paper demonstrates in the third section below. However, paying attention to the evolution of blockchain platforms into complex and structurally rich infrastructure, contributes to a more nuanced analysis of these infrastructures and the particular ways in which they effect economic agency. To address this, one needs to study the specificity of these architectures, by looking at the white papers that construct them in the first place.

Cryptocurrency white papers at a glance

A white paper is a curious thing, stuck between science and investment. Emerging at the beginning of the twentieth century in Great Britain, white papers originally presented a government's position on a matter of controversy. Its cover was white, hence the name. Almost one century after their emergence a new type of white paper emerged, this time digitally. Like an architectural plan of a building, white papers plan the making of a blockchain architecture.

With the publication of Nakamoto's Bitcoin White Paper on the internet, it became customary to write one for proposing a new cryptocurrency or blockchain. These white papers aim to fulfil three functions. (1) *Persuasion*: A blockchain used by no one is a chain with no valuable cryptocurrency. All groups or individuals who develop a blockchain architecture should convince as many agents as possible about the usefulness of its services. (2) *Proving*: Even though people may find it useful in their economic lives, the blockchain architecture may not work. Thus, the white paper has to describe in detail, frequently by mathematical modelling, the proof of its working. (3) *Education*: White

Table 1 Evolution of blockchain infrastructure

Evolutionary type	Example	Function
Value Exchange Blockchain	Bitcoin	Value Transfer
Program Exchange Blockchain	Ethereum	Program Transfer
Interchain	Cybermiles	Interchain Operability

papers teach the ways of using their models, programming technique and framework of exchange. As a result, white papers not only understand and describe a world of interaction, but also design and produce the very world that they are depicting, thus forging new forms of performativity in late modern relations of economization.

White papers usually open with a historical discussion of blockchains, and without exception, with a reference to Nakamoto. Then, they move on to describe the shortcomings of the state of the art, define a gap in practice, and present a service that they can supply with their specific blockchain or cryptocurrency, followed by describing how the underlying protocol work. The majority ends with a list – at times supplemented by photographs and biographies – of the authors, teams or advisors, in part showing how they have been recognized as entrepreneurs, business administrators or academics. Much like a scientific paper, almost all end with a conclusion and bibliography.

The average length of a white paper is 25.74 pages, with an average of 8,060 words. The shortest paper is a single page long, whereas the longest runs 62 pages, excluding appendices.[7] The writers of 56 per cent of these papers choose to remain anonymous (such as with no writer) or pseudonymous (such as Satoshi Nakamoto), and these papers present cryptocurrencies that carry more than 70 per cent of all cryptocurrency value in the world. It is a telling irony that these white paper's authors claim to address questions of trust, but keep their identity secret.

Of all white papers, 44 per cent display the names of actual people, all with working email addresses, LinkedIn entries and Twitter handles. On average, a white paper is authored by 2.59 writers. None of the non-anonymous writers of white papers are women.[8] Of these papers, 59 per cent start with an abstract, and on average they cite 14.60 publications in their bibliographies. Of these references, 24.31 per cent are academic publications. Wikipedia is the most commonly cited source in their bibliographies, appearing at least once in 26 per cent of white papers. Nakamoto is the most cited writer, referred to at least once in 40 per cent.

Fourteen per cent display the publication place, either by mentioning a company address or the place itself. Twenty-one per cent make their publication year visible. It is possible to learn the publication date of the rest with a simple search engine, but authors chose not to make the date visible at first sight. Of these white papers, 88 per cent came out between 2015 and 2018, following the publication of the Ethereum white paper. This supports the validity of this paper's observation that the emergence of the Ethereum blockchain marked a big bang for cryptocurrencies.

A computational text analysis of the white papers shows that the most regularly used words fall into three frequency categories: The first incorporates words used more than 2,500 times: 'transaction', 'node', 'blockchain', 'user', 'network', 'token' and 'data', making this set the centre of intellectual attention in white papers that aim at proposing a new money form materialized in the right to transfer data among users, accounted by nodes, and on a blockchain network. The second set brings together words that appear between 1,250 and 2,500 times, making visible the urgency of the papers' writers to make visible 'the new', 'novel', and/or 'original' service and its main building blocks (literally) that these blockchains propose. The third group is composed of words that appear between 500 and 1,250 times in white papers, focusing mostly on the socio-digital aspects of these platforms that operate as markets as transaction infrastructures working on a decentralized and orderly manner.

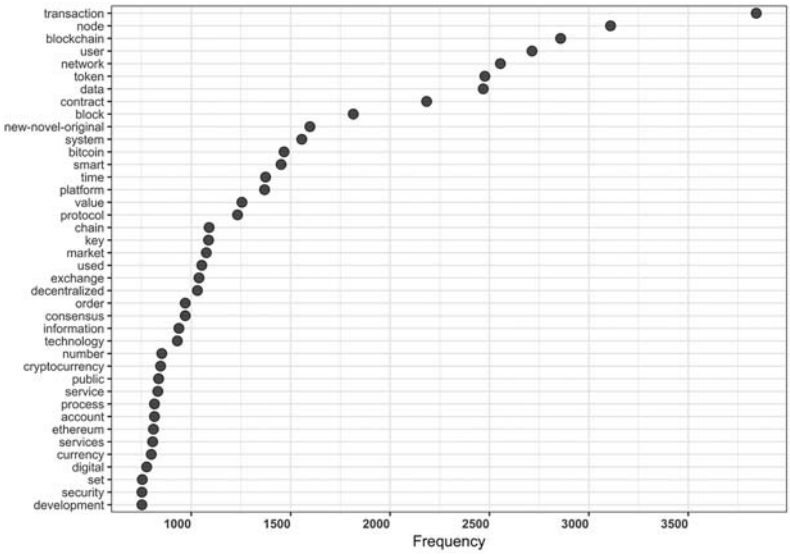
Analysing the simple frequencies is of limited help in understanding the nature of the social scientific attention on which these white papers draw, for it should not be a surprise to see the terms 'transaction', 'node', and 'blockchain' to appear frequently in white papers. Such a challenge can be addressed by supporting the analysis with a social scientific filter. Constructed on a calculation of the supervised frequency distribution, this new analysis can draw on checking the appearance of social scientific concepts that appear in a dictionary of social science. Calhoun's (2002) is the most cooperative dictionary with 1,800 entries supported by a comprehensive bibliography. The rationale of my choice of this dictionary as a filter does not only draw on its popularity and social scientific care, but the transdisciplinary focus it deploys in social sciences that allow for a robust socio-technical attendance.[9]

In terms of social science concepts, white papers use 'finance' more than 700 times, 'economy' more than 400 times and 'social' more than 350 times. Culture (30 times) and politics (29 times) do not appear often in white papers.

Such a filter illustrates a different picture of these white papers that use 'value' most frequently, followed by 'market', 'exchange', 'technology' and 'currency', alluding that white papers deal with a *market* phenomenon that is surrounded by the development of a *technology* for a *currency exchange ecosystem*. Furthermore, these five most frequently used social scientific terms as plotted in Table 3 are the only ones that also appear in Table 2. 'Money', 'rights' and 'credit' also appear recurrently, usually in making visible the function of cryptocurrency as medium of exchange, store of value and unit of account. Infrastructure appears as among the most frequent used space-related social scientific category, referring to the digital geography that 'nodes', 'actors', 'persons', 'consumers' and 'individuals' relate to each other.

Absences say much regarding priorities one can observe in the corpus of white papers. For a development that is presented by its evangelicals as 'revolutionary', white papers do not frequently refer to any kind of revolution: The term appears in only 1.3 per cent of the papers. Furthermore, freedom (35 times), equality (9 times) and liberty (one time) appear very rarely. In terms of economic actors, white papers refer to 'the individual' as economic agent more frequently than any other. Class is used frequently, but to mean a cluster of variables or factors; 'social class' is used not even once. One paper refers twice to gender in its disclaimer of liability section, and another refers to it once, to mean 'male'. 'Trust' is used very often, always referring to the absence of the need for a third party or intermediary to

Table 2 Frequency of words used in blockchain white papers



validate or make possible transactions, whereas 'attack' refers to anonymous or known economic agents' possible acts that aim at rewriting, erasing or damaging any data (and thus 'trust') in the ledger.

Table 3 Frequency of social scientific concepts in blockchain white papers

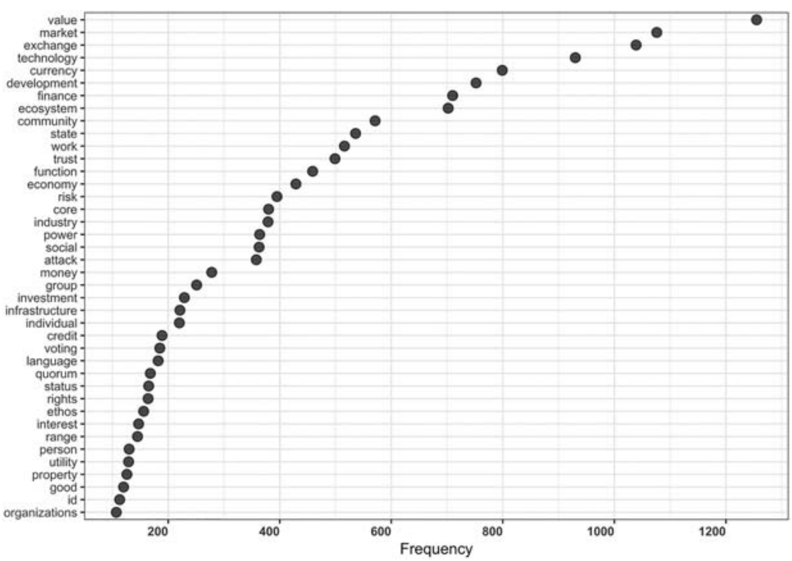


Table 4 The imagination of two worlds in white papers

	Old world	New world
Age	Industrial Age	Information Age
Infrastructure	Material	Digital
Representation of Value	Gold (Metal)	Cryptocurrency (Data)
Symbol	Machine	Computer

White papers imagine a world divided into two. They define the place where blockchains operate as a 'digital' or 'virtual world', sometimes referred to as 'crypto-world' and 'new world'. The other is called 'the real world' (in 47 papers) and physical world (in 4), referring to anything that is located outside of the blockchain. The same bifurcation is at times constructed as 'off-chain' and 'on-chain worlds'.[10]

White papers see 'their own world' as an architecture, infrastructure, or platform, very frequently using them interchangeably and to mean more or less the same thing: a socio-technical arrangement that makes possible fields of action. A quarter of white papers locate a fundamental time change during the time of their publication, juxtaposing the *ancien* as either 'traditional', 'old', or 'industrial', *vis a vis* the contemporary as 'Information Age'. Three white papers mention gold as the currency of the Industrial Age and Bitcoin as the gold of this age (see Table 4).

One should not expect scientific diligence and social theoretical discipline from these white papers, for they do not claim to be scientific in the first place, but draw on scientific research and argumentation to propose an economic service. Their aim is successful performativity, as they are forging a technical world with the intention of building a social interaction. The next section describes the various types of the socio-technical infrastructure constructed in these white papers and used on the ground today.

A taxonomy of blockchains

It is a myth to think that blockchains are *free* to use *public* ledgers that create *disintermediation* via distributed bookkeeping carried out by *anyone*. Blockchains are not necessarily public digital ledgers. There are many private blockchains or even hybrid blockchains that bring together the possibility of private domain accounting in a public setting.[11] Blockchains are not necessarily free, either. A transaction fee accompanies almost all Bitcoin transfers, even when the person who proposes the transaction does *not* attach a transaction fee to her proposal: If she is performing a transaction on a cryptocurrency exchange, the exchange usually adds a fee to its pool of proposed transactions to ensure that its 'customers' get their transactions approved faster.

Blockchains do not create disintermediation in economic relations, as they may or may not need conventional intermediary institutions, such as states or banks; however, they do create new intermediations (Zook & Blankenship, 2018). Blockchains do not disintermediate, but reintermediate. This is true even for the Bitcoin blockchain, which is presented as the ultimate force of disintermediation (Tapscott & Tapscott, 2016). In 2018, 87.2 per cent of all Bitcoin transactions took place in tens of thousands of cryptocurrency markets, none written on the Bitcoin blockchain unless the buyer chose to 'withdraw' her Bitcoins from the exchange. One immediate consequence of this process of reintermediation is the near complete disappearance of anonymity, for a great majority of exchanges require their clients to register with formal identification and credit cards, thus introducing the cryptocurrency ownership to the visibility of conventional accounting systems and networks that banks and states use.

Thus, cryptocurrencies are one of the driving forces of creating new intermediaries in economization relations, not a force erasing them. Finally, their accounting or mining can be open to everyone; yet, in reality, much like in conventional accounting practice, only specialized accounting systems and experts can operate mining operations for Bitcoin, after mobilizing important financial investments. There is no free bookkeeping, even in the cryptocurrency universe. Thus, it would be erroneous to treat blockchain architectures as monolithic entities that structure economic relations in one way only. One needs to be attentive to their types.

Since the emergence of the third-generation blockchains that allow building in-chain markets and interchains, it became possible to move any conventional economic sector to blockchains. Hence, it would not be practical to categorize blockchains with reference to their services or products, since this would be an exercise in categorizing all economies in their entirety, only this time based on blockchains. Such attempts in popular representations of blockchains have given birth to tens of different 'types' of blockchain that confuse rather than help us understand them. There are also technical classifications of blockchains according to their various consensus mechanisms, such as proof of work, stake, velocity, asset, activity, access, capacity, devotion, importance, elapsed time, alienation, spending, reserve etc. One can propose categories based on the nature of digital block-making. While very useful and legitimate for understanding the purely technical operation of chains, these taxonomies are less effective in controlling for how economic agencies are imagined, mobilized and equipped in/by blockchains.

This paper proposes a categorization that accounts for mutually exclusive configurations of actor-network interactions in terms of transaction and accounting practices in crypto-infrastructures. White papers propose two groups of actors in all blockchains: *Transactioners* are those who use the digital ledgers for realizing their transactions – such as Alice and Bob, who transact the exchange of 1 BTC. *Accountants* are those who account for these transactions by mining. These two are mutually dependent groups of actors. Without accountants, no transaction is registered in the ledger. Without transactions, accountants cannot account for anything. Transactioners receive accounting services from the accountants via the blockchain, and accountants receive cryptocurrencies as fees for their mining of the data and letting blockchains to use their computer hardware. A transactioner and an accountant can be the same person, but from the perspective of their economic activity, they perform different roles.

Blockchains vary according to the extent to which transactioners and accountants are excluded from or included in the blockchain infrastructure, regardless of the nature of the transactions (such as value transactions or smart contract transaction) or the nature of accounting (such as proof of stake or proof of work). There are two forms of transactioner participation in blockchains: (1) Private blockchains, such as that of Ripple, can block who may participate in a certain blockchain. (2) Public blockchains, such as those of Bitcoin or Ethereum, are required by their protocols to include any actor to transact. There can also be hybrid blockchains that provide their users with rooms for private or consortium activity in their infrastructures. Third-generation blockchains are generally equipped with these hybrid characteristics.

Blockchains can also block those who want to participate as accountant. Closed Accounting Blockchains select those who can be active in its accounting system. Open Accounting Blockchains permit any actor with the necessary technical devices to serve as an accountant for its operations – that is, Bitcoin mining is open to anyone who has the skills and devices to join. This does not mean that in an Open Accounting Blockchain such as Bitcoin anyone can be an accountant, an option that Nakamoto thought he wrote into the code. Now, it is practically impossible to be a Bitcoin miner with a personal computer. One has to invest in many and very expensive processors called ASICs. However, this is not an infrastructural impediment in design, but an economic cost that many actors cannot carry (see Table 5).

Each of these blockchain types draws on mutually exclusive infrastructural qualities and implies varying socio-technical configurations of actor-network relations. Open Accounting Public Blockchains cannot prevent any actor from joining their transactional or accounting practices. These human actors use material and digital devices to interact with the blockchain. Let's say, Alice wants to send 1 BTC to Bob; therefore, she is a transactioner who cannot be prevented from using the Bitcoin blockchain, because it is a public blockchain. Alice turns on her computing device, starts an application, usually called a digital wallet, writes down the amount she wants to send to Bob and then, with a click, the wallet sends a transaction request to the

Table 5 An actor-based taxonomy of blockchains

	Public	Private
Open Accounting	Anyone can transact Anyone can account	Chosen transactioners Anyone can account
Closed Accounting	Anyone can transact Chosen accountants	Chosen transactioners Chosen accountants

02646711598afe981a6019a6299d9803a4dc04f328f22041bedff886bbc2962e

Figure 1 A hash of a binary representation

blockchain network. Alice's wallet is represented by an encrypted password made up of 64 digits, and each digit is composed of hexadecimal characters. These passwords are very difficult to guess and in reality, consist of hashes of an even longer binary representation as can be seen in Figure 1.

One has to remember that all these accounting practices are performed by computers with enormous hash power referring to a computer's capacity and speed in solving mathematical puzzles during a mining operation. These computers are owned by companies, and these companies hire workers to plug in those computers, turn on the air-conditioning units to cool their processors, clean around them, and fix and maintain them for smooth operation. Thus, in reality we can argue that the Bitcoin's Open Accounting Public Blockchain brings together human transactioners and corporate computers in order to build a value exchange architecture.

Open Accounting Public Blockchains, by bringing together transactioners and accountants in an open and public digital space, thus function like states, because they issue currencies; like banks, because they approve and account for transactions; like marketplaces, because it is possible to buy and sell tokens on their infrastructures. Yet, they have to play with time in order to achieve contribution to their operations without permission. Because they do not have a central authority to approve transactions and write them down, they are slow and have to slow down in order to factor chance events into their accounting system.

The problem of slow pace is addressed by Closed Accounting Public Blockchains, such as Cybermiles or Facebook's proposed Libra. These blockchains permit anyone to operate in their system as transactioners but decide who may serve as an accountant for these transactions. These are blockchains about which one has to be careful, because they want their data monies to be used by all, but prefer their accounting system to be secretive and exclusionary. Closed Accounting Blockchains do not allow chance and computing power determine who can close a block, thus preventing the creation of a distributed and decentralized mining or accounting system. Yet, they gain speed in their operations. Their accounting systems can work faster than Open Accounting Blockchains, and they need less electricity and thus hash power to be operational.

Open Accounting Private Blockchains subcontract the mining of their transactions at the protocol level to anyone who would like to pursue mining. For example, a union can construct a private blockchain if its members would like to subcontract the accounting practice of their possible inter-union member transactions to a distributed system. In this Blockchain, only the union's members can pursue transactions, but they have to wait until their transactions are accounted for by anonymous and public accountants.

Closed Accounting Private Blockchain, on the other hand, decide who may be a transactioner and an accountant in their system. These Blockchains are built by corporate entities who use blockchain technology to decrease their book-keeping and transaction costs. All private and public banks are either operating or developing a Private Closed Accounting Blockchain. There are hybrid Open or Closed Accounting Blockchains which are a type of *public* blockchain that can have a *private* space in their interaction architecture. They can choose to operate on an Open Accounting mining system, or they can determine *a priori* who may account for their transactions, thus choose to draw on a Closed Accounting system.

Open Accounting Public blockchains are *not* public in terms of the 'public ownership' of their means and devices of production and maintenance. An Open Accounting Public Blockchain, such as Ethereum and Bitcoin, can be developed and proposed to the public by a corporation, an individual, a political party, or even a nation-state. There is no point of *possessing* a blockchain, for they cannot be 'owned' like a piece of land or a webpage. In reality, blockchains are *networks* of claims that distribute ownership *rights* among the *actors* that use them; in other words, they are actor-network platforms incorporating agency into digital frameworks. These private or public networks create the possibility to attach *non-digital* value to the *digital* representations of owning the right to move data.

Approaching blockchains as actor-network digital platforms that render possible the valuation and transfer of the rights to move data privately provides social researchers with the theoretical capacity to describe and analyse the rich universe of blockchains without imagining them as rigid devices or monolithic infrastructures that do things just because of their mere existence. In this way, it becomes possible to observe under which conditions and how they produce disintermediation and reintermediations, whether and how they can compete with and replace the functions of banks and state, in how many ways they empower and limit individual and collective action, and finally whether they hold any revolutionary or reformatory potential at all.

Conclusion

Empirically studying the evolution of blockchain infrastructure and the white papers of the most valuable 100 cryptocurrencies, this paper has proposed a three-tiered evolution of four types of blockchain architecture, all bringing together the socio-technical infrastructure of this novel digital ledger technology. The paper has shown that the categorical transformations that the blockchain infrastructure has undergone require social researchers to attend to its dynamic renovation in studying the social and economic consequences of blockchain technology. Value exchange blockchains, like Bitcoin, are simple, slow, yet effective platforms that make it possible to imagine and transfer value in novel ways. Contract Exchange Blockchains provide their users with devices to exchange simple computer programs that can operate as contracts, thus making it possible to build new value or contract exchange platforms within one blockchain.

Third-generation blockchains allow for the building of in-chain markets with off-chain data flowing in them. This possibility permits blockchain architectures to operate as markets themselves, not only registering individual transactions, but also bringing together dynamic encounters of supply and demand, as long as the underlying commodity can be represented digitally. Furthermore, these new-generation blockchains render it also possible to construct relational bridges between blockchains that operate on diverse protocols, opening a way to build inter-chains. Drawing on this analysis, we can conclude the following: First, it is impossible to pass universal and categorical judgments on how 'the blockchain technology' works, since there is no single type of architecture that can be located and evaluated. Second, blockchains' dynamic evolution poses a challenge for social researchers due to their potential to revise and reform many institutional formations of contemporary economization relations.

Taking on such a challenge requires developing critical attention to the types of blockchain architectures that stand on general blockchain infrastructure. Proposing an actor-based taxonomy, this paper has demonstrated that blockchains are maintained by two major types of actor: transactioners and accountants. Their agency, however, is structured in reference to the specific architecture of the particular blockchain. Open Accounting Blockchains allow every accountant to perform mining at will, as long as the miner has the necessary devices, such as ASICs. Closed Accounting Blockchains can choose which actor can perform accounting, and to what degree. This option introduces a more centralized blockchain operation, by increasing the speed of transaction registration in the chain.

Approaching blockchains from the vantage point of transactioners, the paper has observed two types of architecture: (1) Public blockchains are open to anyone for securely transferring private data, the movement of which represents a kind of value. One does not have to be registered, accepted, recognized or need permission to become a transactioner in such a socio-technical architecture. (2) Private blockchains require permission or acceptance to become a transactioner in their architecture. These permits can be given to a consortium or an individual – in either case, this renders the blockchain a private one.

This paper has defined blockchains as actor-network platforms that facilitate the imagining and transfer of economic value, by digitally representing it as a right to move data securely. In practice, blockchain infrastructure constitutes a *network* of claims that provides actors with devices and competences to transfer ownership *rights* among each other. Yet, no one can *own* this platform of rights, like a piece of land or a webpage, for once 'owned', the blockchain cannot operate as an infrastructure, even in private blockchains. Attaching *non-digital* value to the *digital* representations of owning the right to move data, various types of blockchain architecture are supported and surrounded by formalized digital exchanges that also render it possible to exchange value off-chain and then have it registered on-chain.

This paper aims to stimulate future research concerning the socio-technical universe and implication of blockchain infrastructure. It sheds light onto what kind of an actor-based taxonomy of blockchain architectures informs economic agency that began to exchange data monies, or rights to send fixed and non-replicable data to someone else in a public ledger. These data monies are categorically different from digitally represented fiat currencies or other digital payment systems in the sense that they do not need the authority of a bank, state or corporation in accounting, minting or controlling currencies. Drawing on the materiality of financializing the right to send data, we saw that data money's materiality is historically and categorically different from paper or metal money, or their digital representations.

Such an analysis, however, is limited in the sense that it doesn't say much about the practical working of the thousands of cryptocurrency exchange markets created in part thanks to the seemingly disintermediating blockchains. We still do not know in what ways these markets relate to and configure blockchain architectures, and how they work and interact with each other. We still know very little about the social world of digital economic markets, their prices, power asymmetries and valuation processes. Furthermore, social research is far from identifying the potentially novel forms of performativity taking place in blockchain and other digital infrastructures.

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1 This paper draws on www.coinmarketcap.com closing price data, cross-checked with CBOT and CME data. GDP data source is World Bank (2020).

2 I would like to thank Janet Roitman for drawing my attention to such a possibility.

3 Digibyte, Dogecoin, GAS, Huobi Token and Monacoin have no formal white papers in this paper's top 100 list, yet their blockchains are included in the analysis. The raw data of all of these white papers and the R code can be found here: https://github.com/sibirbil/DataMoney https://doi.org/10.5281/zenodo.4126559.

4 These cryptocurrencies are Aelf, Aeternity, Aion, Allsports, Ardor, Ark, Augur, Bancor, Basic Attention Token, Binance Coin, Bitcoin Cash, Bitcoin Diamond, Bitcoin Gold, Bitcoin Private, Bitcoin, Bitshares, Bytecoin, Bytom, Cardano, Centrality, Cortex, Cryptonex, Cybermiles, Dash, Decred, Dentacoin, Digibyte, DigixDAO, Dogecoin, Dragonchain, Elastos, Electroneum, Enigma, EOS, Ethereum Classic, Ethereum, Ethos, Funfair, Fusion, GAS, Golem, Gxchain, Huobi Token, Hypercash, ICON, Internet of Services, Kin, Komodo, Kucoin Shares, Kybernetwork, Lisk, Litecoin, Loom Network, Loopring, MaidSafeCoin, Maker, Mıota, Mithril, Mixin, MOAC, Monacoin, Monero, Nano, Nebulas, Nem, NEO, Nexusi, Nuls, OmiseGo, Ontology, 0x, PIVX, Polymath, Populous, Qash, Qtum, Rchain, Reddcoin, SiaCoin, Skycoin, Status, Steem, Stellar, Stratis, Substratum, Syscoin, Tether, Theta Token, Tron, Vechain, Verge, Veritaseum, Waltonchain, Wanchain, Waves, Waykichain, XRP and Zcash, Zcoin, Zilliqa.

5 I define public as a sphere whose usage and entrance cannot be limited to a select group of individuals. A private sphere, can be used by many individuals and groups, such as a private club, but cannot qualify as public for it has a formal boundary that controls entry.

6 Computer scientists such as Don Patterson also see cryptocurrency as a possession of an exclusive right to transfer data. For an excellent discussion of data money transactions from a computer science perspective see (Patterson, 2014).

7 A few of these publications use the computer screen as page unit. In order to compare their length and page statistics, three white papers were formatted to fit into a US legal-size page.

8 The author identified the authors' gender from their first names, LinkedIn data and photographs, yet the paper makes no assumption regarding the assumed gender positions these writers might have taken.

9 Core social scientific categories are stemmed to represent white papers' foci. For example, finance and financial were plotted together.

10 Ontology white paper locates its blockchain as a bridge between 'the real world' and 'distributed data systems'.

11 The technical literature concerning cryptocurrencies rightfully locates private blockchains as permissioned blockchains that locate authority nodes for the accounting process (Narayanan & Clark, 2017).

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