Calum Bowden

FORKING IN TIME: BLOCKCHAINS AND A POLITICAL ECONOMY OF ABSOLUTE SUCCESSION

APRJA Volume 7, Issue 1, 2018
ISSN 2245-7755

> *Time is the most important thing in human life, for what is pleasure after the departure of time? And the most consolatory, since pain, when pain has passed, is nothing. Time is the wheel-rut in which we roll on toward eternity, conducting us to the incomprehensible. (Alexander von Humboldt quoted in McClelland)*
>
> *It is possible that Time, the essential element, matrix, and measure of all known animal art, does not enter into vegetable art at all. The plants may use the meter of eternity. We do not know. (Le Guin 624)*

In December 2017, a bitcoin (BTC) pushed $20k, ether (ETH) soared over $1000 and ripple (XRP) jumped from $0.22 to $3.32. These are cryptocurrencies, digital money built on a secure database called a blockchain. The story currently told about blockchains is tale of get-rich-quick fueled by a FOMO – fear of missing out – instilled by real-time media. Blockchains did not always create the latest financial bubble, and cryptocurrencies are just one use of the technology. First described in the 2008 paper, "Bitcoin: A Peer-to-Peer Electronic Cash System" authored under the pseudonym Satoshi Nakamoto, the technology removes the need for banks and payment systems and promises to disrupt traditional economic relationships and financial institutions by enabling secure transactions without the need for a trusted third party (8). As a full copy of the data is stored by every computer participating in the network, blockchain evangelists believe the technology will transfer power from institutions to individuals. Where the Web follows a centralised model storing data on a single computer, called a server, blockchains store data on all participating computers in a distributed, peer-to-peer, network. Network consensus and cryptographic proof allow people to transact with low risk of foul play as a single coin or asset cannot be used twice.

Blockchains are capable of impartially enforcing the rules and protocols they are programmed with, but humans are still needed to implement them. Vili Lehdonvirta suggests that in discussions of blockchain governance, the enforcing and the making of rules are often conflated. On the Bitcoin and Ethereum networks, currently the two largest blockchains, most rules are made by close-knit communities of developers who interact in tech hubs, conferences, and through Web platforms like Twitter, Medium, Slack, Github, and Meetup. The rules decided on by core developers must be upheld by an increasingly limited pool of 'miners' who vote with their computational power to solve puzzles that keep the networks secure.[1]

This essay focuses on the way blockchains construct time and the implications that has on governance, paying particular attention to the original Bitcoin network. Blockchains enforce succession through consensus, and for this reason, the philosopher Nick Land argues that "The Blockchain solves the problem of spacetime". I use Land's argument as a starting point for understanding the crucial role time plays in the governance of blockchain networks. I ask if the technology can, in fact, be understood to solve the problem of absolute succession, to investigate ways in which forking, both a byproduct of distributed consensus and the mechanism through which blockchains are upgraded, breaks the power concentrating around Land's definite article Blockchain.

Blocks and chains

> *The Times 03/Jan/2009 Chancellor on brink of second bailout for banks. (Bitcoin Wiki)*

The Bitcoin network launched in January 2009 encoded with a message critiquing government support of the banking system. The prototype blockchain network proposes a cryptographically secure database structure to create a medium of exchange and store of value not tied to a nation state. All nodes in the network are required to store a full copy of the data and agree on a time-stamped record. In the Web's centralised model, when a server is compromised or goes offline, the data stored on it can no longer be accessed. The blockchain is said to distribute risk and provide greater network strength as the data cannot be compromised by losing any node in the network (Nakamoto). Data about new transactions, or changes to the existing database, need to be broadcast to the whole network so each node can update its record and reach agreement on the correct order of transactions. Blockchains do this through what is called a 'consensus mechanism', and there are many different and debated models. Hash-based proof-of-work is the consensus mechanism proposed by Nakamoto and Bitcoin, and is currently used by the Ethereum network amongst others. In proof-of-work, computers called miners compete to solve puzzles that keep the network secure.

The formation of a new block begins with a miner taking a unidirectional cryptographic hash of new transactions. Hashing takes the data and compresses it into a long hexadecimal number that represents the original data in much less information, allowing it to be broadcast to the other nodes. Each miner collects new transactions into blocks and competes to solve a computational puzzle. The network sets the difficulty of the puzzle based on the amount of computational power available, specifying how many of the first digits of the hash must be a '0'. Like the rolling of many 16-sided dice to find a specific number of 0s in a row, it is highly unlikely that a mining node will find this sequence of 0s when hashing a set of transactions into a hexadecimal number. To satisfy the difficulty, the miner adds random bits of data, called a 'nonce', to the end of the file that contains all of the transactions. Each new nonce is a new chance that the data will encode into a hex number with the sequence of 0s specified. When a mining node finds a nonce that satisfies the difficulty, it broadcasts the block to the network, which as of writing would be around block number 500010. All the other nodes can then perform a hash on the same set of transactions with the same nonce to verify that the resulting hash satisfies the difficulty. New blocks are accepted if the transactions contained within it are valid and not already contained in a block, and this is confirmed when a node begins to work on the next block in the chain, such as number 500011. Each block is signed with data representing the previous block and with a timestamp in the standard of Unix time, which counts the seconds since 1 January 1970, making it more difficult to falsify the time at which the block existed. Bitcoin limits new blocks to ten-minute intervals, creating a regular rhythm to Bitcoin time.

"The blockchain solves the problem of spacetime"

In a video lecture dated 3 October 2015, Land asks if we are dealing with blockchains or the Blockchain, a universal and singular blockchain network ("Nick Land 'The Blockchain

Solves the Problem of Spacetime.'"). October 2015 was before the speculative rise of the blockchain and the liquid cryptocurrency investment market. Ethereum launched that year in July, and a bitcoin cost $244 (CoinDesk). Assuming the definite article, and in stating that the Blockchain "solves the problem of spacetime", Land constructs a problem around Einstein's theory of relativity for its rejection of absolute and successive time. In Land's estimation, the Blockchain makes it impossible to be post-Kantian, basing his claim on a synthesis of Kant's definition of space as geometry and time as arithmetic dominated by succession.

For Kant, space and time are opposed elements of perception, and not things that exist independently. Space is not an intrinsic property of things but rather the subjective conditions required for perception of outer appearances, an empirical reality required for perception of the external world (Kant 64). Conversely, time is not something which exists by itself, or as a determination of outer appearances, but rather as the form of inner sense (Kant 69). Land opposes the impossibility of post-Kantianism with spacetime. For Einstein, space and time are physical realities. He situates the problem of synchronicity in space, framing it as the problem of knowing that two watches in two different places are displaying the same time (Einstein 3). In spacetime, physical reality is a synthesis of space, time, and matter (Mahalanobis, in Einstein XXII). While Kant understands space and time as components of the mind and how it experiences the world, Einstein makes space and time a physical reality. In enforcing absolute succession through consensus across a distributed network of computers, the Blockchain presents time as separate from space, which Land argues scrambles the notion of 'pre' and 'post' and the "actual set of successions". While Land heralds the Blockchain for providing "artificial absolute time for the first time ever in human history", in placing the Blockchain both post-spacetime but not post-Kantian, technological and theoretical development become neither linear nor successive. Time gets slippery.

Time is money

The definite article Blockchain, as put forward by Land, proposes a theory of time that is against not only Einstein, but many other modernist and postmodernist thinkers: Hannah Arendt, Claude Levi-Strauss, Gilles Deleuze, and Karen Barad (to name only a few). Looking at a single blockchain, like Bitcoin, the network maintains consensus on a single record of events. If nodes receive different versions of the next block, the longest chain is always taken to be correct, meaning it was created first and indexes the most computational power (Nakamoto 5). Due to the time it takes for information to spread across the network, there might be multiple chains with different versions of the next block at any given moment. This is called a fork and is a byproduct of distributed consensus. As more blocks are added to the competing chains, eventually the one that is the longest and indexes the greatest proof of work will be taken to be correct. Nodes working on the other chain will discard it, creating what is called an 'orphaned block' (Blockchain.info). As the longest chain is always taken to be correct, falsifying the blockchain would require redoing every previous proof of work, making it impractical and costly. When miners create a valid block, they are rewarded with bitcoins. In the blockchain universe, a coin is a nonreversible chain of digital signatures (Nakamoto 2). Each bitcoin is backed by its own transaction history, ensuring it can only be transferred by its owner. Time, or more

precisely the arithmetic succession of blocks, becomes money, and it is an exponentially increasing supply of electrical energy, most often carbon-based, that keeps the clock ticking (Vries).

In *Capital Volume 1*, Marx delineates the mechanisms through which capitalism transforms time into money. Commodities only have value, he says, because abstract human labour is materialized in them (Marx 311). The quantity of the labour is measured by its duration, which Marx calls labour time. Measured in hours or days, labour time becomes value itself. The value of the textile factory worker, for example, is the amount of time they spend operating a loom, exchanging each hour of labour for a government backed currency like Pound Sterling or the Dollar. During the industrial revolution these currencies were representative, meaning backed by a commodity like gold or silver. Time is turned into value and is exchanged for a token with no intrinsic value, but for a symbolic guarantee that the money can be exchanged for a commodity. The United States ended the gold standard in 1971, turning the dollar into a full fiat currency, meaning its value is controlled by the U.S. Federal Reserve through policies that control the supply of money and set interest rates (Lowrey). Today, most currencies no longer guarantee a commodity and their value is reliant on nation states.

Cryptocurrencies fold together the measure of the value-forming substance and the medium of exchange. For Marx, time is the measure of labour, the value-forming substance, and is exchanged for a currency. For Bitcoin, and other networks that use proof of work, the value-forming substance is the electrical energy that powers arithmetic succession. In the 19th century, observations of energy dissipation and heat transfer came to defend the irreversibility of time. The Second Law of Thermodynamics states that a system becomes statistically more disordered as it moves through time. This was taken to prove linear and successive progress, which Marx defends though his historical materialism and theories on the development of society. Bitcoin builds on Nick Szabo's notion of 'bitgold'. Computationally intensive puzzles, that consume increasing amounts of electrical energy, are used to create digital assets that are scarce, unforgeable and have value independent of third party due to the cost of their creation, similar to a precious metal. Cryptocurrencies, backed by a transaction history recorded in a secure blockchain-based database, are a medium of exchange that derive value by measuring the value-forming substance – most often electrical energy – through the linear succession of blocks.

In folding together the measure of a value-forming substance and the medium of exchange, blockchains further abstract the human labour from the creation of value. Blockchains are heralded for their ability to enable a machine to machine economy, capable of transacting without the need for human oversight (Hannaert). With proof of work, Bitcoin demonstrated cryptocurrencies as a means of building infrastructure. People who join and maintain the network as miners are paid rewards in bitcoin for solving the computational puzzles that keep the network secure. Called crypto-economics, this is the design of how the network drives people to do certain things. In "Fragment on Machines", Marx prefigures the current blockchain paradigm of dehumanisation through economic incentives:

> *In machinery, knowledge appears as alien, external to him [the worker]; and living labour [as] subsumed under self-activating objectified labour. The worker appears as superfluous to the*

> *extent that his action is not determined by [capital's] requirements. (Marx, "Fragment on Machines" 53)*

Cryptocurrencies design capital to determine specific actions. A blockchain is an automated rule enforcement machine, and the most common rules are around the creation of new blocks. Once set into motion, the possibility of a new block requires that transactions have occurred, and that computers are connected to the network and to a power source. Humans are needed to set blockchains into motion and to keep computers connected to the network.

Bitcoin proposed the Blockchain as a system that folds the measure of a value-forming substance into a medium of exchange, that designs human behaviour by manipulating the movement and location of money. That money is not defined politically but by the conditions that create it and its own transaction history, and is digitally stored within a linear and successive chain of blocks. Bitcoin is only the prototype blockchain network and brings together the distributed ledger technology with a cryptocurrency. While cryptocurrencies may derive value from irreversible succession, blockchains cannot be said to create absolute succession and solve the problem of spacetime as each chain is defined by locally variable characteristics that must be established as, and remain, valuable.

The politics of synchronization

In his treatise on Poincaré and Einstein's endeavours to coordinate time, Peter Galison shows how the synchronization of clocks was at the modern junction of knowledge and power, cutting across physics, engineering, philosophy, colonialism, and commerce. Pragmatic questions, such as how to synchronize two clocks in different places, ultimately led era defining theoretical arguments on the nature of time as relative to be built into seemingly inconspicuous technology like clocks. Theory had become a machine (Galison 74). While blockchains, as automated rule enforcement systems, seem opposed to an anthropocentric worldview, the linear time defined by the immutable succession of blocks is fundamentally based on the way humans perceive time. Spacetime, as a single four-dimensional fabric, opposes the correlation between thinking and being. In spacetime, human perception of the physical world, or their experience of duration, does not figure.

Not only is the notion of time as successive and linear constructed by the Blockchain, but it also seems to enframe conceptualisation of it. Fred Ehrsam, founder of the cryptocurrency exchange Coinbase, likens the development of the distributed databases to evolution, suggesting only a "Cambrian explosion" of economic and governance designs can provide solid foundations of blockchain-based life (Ehrsam, *Blockchain Governance*). Evolution assumes time as something linear and successive, where the past moves towards the future. In the myth of social and technological progress, things get better. The storm of progress propels the angel of history into a future they cannot see.

In "Notebook V" of the *Grundrisse*, Marx suggests capital paradoxically pushes beyond spatial barriers without always surpassing it. Rather, Marx argues, capitalism generates its own resistances and contradictions to the universalization of exchange. Ernst Bloch termed this the contradiction of the nonsynchronous, arguing that under capitalism people are seen to be living at the same time, while not existing in the

same Now. Examining the rise of National Socialism among rural peasants in 1930s Germany, Bloch suggests that contradictions between the uneven universal time of capitalism and the "good old days" creates anger and resentment that can be easily be exploited by those vying for political power. If the definite article Blockchain creates artificial absolute time, then multiple blockchains, with different rules that determine the creation of new blocks, suggest a new form of nonsynchronicity. The Polkadot network, called a heterogeneous multi-chain, wants to allow these independent blockchains and their records of events to exchange information and transact. Interfaces emerge to govern the conditions of exchange between Nows out of sync.

The sharing of fundamentals is another sense of synchronization. This describes the syncing of parts of a given social context, the effects of shared infospheres or filter bubbles accessed through mobile devices loaded with social media. This form of synchronization forms the context in which collective decisions are made, impacting the mechanisms of governance. Charting the transition from a democracy of opinion, Paul Virilio argues that the current regime is comprised of the synchronization of emotions (31). This, he suggests, leads to reactionary political responses and an emphasis on the short term and immediate. A symptom of emotional democracy is FOMO, and can help to explain the rise of the cryptocurrency economic bubble. Experiencing the meteoric rise of cryptocurrency prices together, people have begun flocking to the virtual money machines for fear of missing the next great rally and chance to get rich quick.

Forking in time

Forking is the main mechanism through which blockchain time splinters and allows the irreversible sequence of blocks to be broken. It is a byproduct of distributed consensus, leaving chains and their alternative sequences of events 'orphaned', or no longer part of the main chain. Public blockchains can adopt new rules through forks which are hard, meaning not compatible with the previous software, or soft, meaning backwards compatible such that new blocks can be accepted by nodes running the old software. In a hard fork, a developer or miner clones the data intentionally, replicating the chain of blocks to create a new network with different rules. On 1 August 2017, there was a hard fork of Bitcoin, creating a new chain called Bitcoin Cash. A subset of participants in the Bitcoin network wanted to prevent a soft fork that would change how transaction signatures were stored (Bukov). Hard forks are often a last resort means of overcoming the inability of the community to reach consensus on potential software upgrades, and here the disagreement was over how to best speed up transaction times. What is unique about forking is that since it creates a copy of the existing database, users and coin holders who might not have the technical knowledge or social status to affect a fork, are also implicated. Any person holding bitcoin at the time of the split received an identical amount of bitcoin cash.

Hard forks cause not only the database to split, but also its polis, the community of miners, developers, and users who must choose which software to support. Newly forked blockchains can only remain secure and valuable if there is a diverse pool of miners who continue to keep their databases in sync. Bitcoin Cash was a high profile fork of the largest cryptocurrency in the midst of

a raging financial bubble, and the decision to continue supporting either network was a financial decision. As of June 2018, Bitcoin Cash is the fourth largest cryptocurrency with a market capitalization of $15 billion and a price of $887 per coin (Coin Market Cap). For context, this puts Bitcoin Cash at around the same valuation as the Gross Domestic Product of Jamaica or Malta (International Monetary Fund). But most hard forks do not create the astronomical financial value of Bitcoin Cash. The website Coin Market Cap indexes 1531 cryptocurrencies. Hundreds of coins have a value less than one cent and market capitalizations under $1000. For 0.01000 BTC (about 50 Euros), Forkgen will create a custom hard fork of the Bitcoin network. These blockchain networks with medium to low market value oppose Land's notion of the definite article and suggest a world outside of blockchains at the scale of nation states.

Founder and developer Trent McConaghy calls for tokenizing the enterprise and suggests hard forks as a means of fueling the distribution of network value back to the community that produces it. Forking closed or proprietary databases is not possible, putting most of the Web off limits. The business model of Web platforms like Google, Facebook, Uber, and Amazon is based on the unidirectional capture of the value users produce in exchange for access to the services provided. As cryptographically secure rule enforcement machines, blockchains lower the variable cost of operating a secure database, in turn lowering the cost of making changes to that database. McConaghy cites the Coase Theorem, which states that organizations grow disproportionately large when transaction costs within an organization are lower than between organizations. Since blockchains make the cost of transacting within and between organizations effectively the same, McConaghy argues that by allowing for forking, public blockchains enable more fluid, self-organized communities: "The community can decide if it has the courage to embrace change […] if some subgroup doesn't agree, it can splinter off (yes, fork) to do its own thing. […] Communities can self-organize around the original community or the new one, based on their beliefs." Whether or not blockchains do, in fact, do this is not the point. Rather, what is interesting is the fundamental role forking plays for McConaghy and its absence from Land's argument altogether. While both see the value of blockchains collectively produced and captured through distributed consensus, only McConaghy's blockchain, with its emphasis on community-driven forking, attempts to reverse the chain of value production from the network to its polis.

Bitcoin emerged from small group of libertarian cypherpunks working to create a liberation technology capable of distributing power away from traditional financial and political institutions through cryptographic security: "Technology represents one of the most promising avenues available for re-capturing our freedoms from those who have stolen them" (Hammill). But as Bitcoin grew into a global network, it drew in stakeholders with different values, including the banks and governments it originally sought to undermine. The Blockchain is also bolstered by those waging an assault against liberal democracy. Neo-Reactionaries, of which Nick Land is a key theoretician, advocate an 'accelerationism' that pushes capitalism to its most destructive and dehumanising limits with the help of cryptocurrencies seemingly purified of politics ("The Dark Enlightenment."). Land's transhumanist position, suggests the philosopher Yuk Hui, drives for a meltdown of society through the absorption of all cultural relativity into an intelligent cybernetic machine. This helps to contextualise Land's desire for the definite article Blockchain

and his problematization of spacetime. The impossibility of post-Kantianism is also the impossibility of cultural relativity and the impossibility of a decentered Western canon of knowledge. Hui suggests, in the face of this rising neofascist movement, the pluralisation of time not only becomes a radical practice, but a means of building the world to come. Hui calls "to fragment the world according to difference instead of universalizing through the same; to induce the same through difference, instead of deducing difference from the same".

As a secure database that folds the measure of a value forming substance into a depoliticized medium of exchange, the Blockchain seems like it might be capable of absorbing all cultural relativity into an intelligent cybernetic machine. That is until it is forked. Forking might not fragment the world, but it does fragment each network and alter the way it produces value. As a provisional conclusion, I advocate forking as a means of breaking the power concentrating around the definite article Blockchain, to reconstruct the framework through which the value of the technology is established. Like other socio-technical systems, blockchains are unable to ensure self-governance through technology alone. Time provides a lens for glimpsing the political economy of blockchains and forks help to reveal their entanglement with a *polis*, a citizenry of developers, miners, and coin holders. Blockchains hide the sites from which new rules emerge, relocating governance processes to the design of market incentives, the design of the conditions under which new blocks are created, and the moments around the hard and soft forks that alter the software. These hidden governance processes impact the production and accumulation of value, and are ultimately responsible for directing its flow.

Notes

[1] Currently 70% of miners are based in China, and 70% use hardware made by one manufacturer (*The Economist*). But as China begins to ban cryptocurrency exchanges, miners are leaving the country, making blockchain's entanglement with the 'off-chain' world apparent.

Works cited

Bloch, Ernst. "Nonsynchronism and the Obligation to Its Dialectics." *New German Critique*, Translated by Mark Ritter, no. 11, 1977. Print.

Bukov, Anton. "Bitcoin Cash SegWit Hack." *Medium, Augmenting Humanity*, 5 Dec. 2017. Web. medium.com/bitclave/bitcoin-cash-segwit-hack-e82c7029f841.

Coindesk. "Bitcoin Price Index – Real-Time Bitcoin Price Charts." *CoinDesk*. Web. www.coindesk.com/price/.

"Cryptocurrency Market Capitalizations." *CoinMarketCap*. Web. coinmarketcap.com/all/views/all/.

Ehrsam, Fred. "Accelerating Evolution Through Forking." *Medium*, 12 Sept. 2017. Web. medium.com/@FEhrsam/accelerating-evolution-through-forking-6b0bba85a2ba.

——. "Blockchain Governance: Programming Our Future." *Medium*, 27 Nov. 2017. Web. medium.com/@FEhrsam/blockchain-governance-programming-our-future-c3bfe30f2d74.

Einstein, Albert, et al. *The Principle of Relativity: Original Papers*. University of Ottowa, 1920. Print.

"Fork It Till You Make It." *Forkgen: Automated Fork Coin Generator*. Web. forkgen.tech/.

Galison, Peter. *Einstein's Clocks, Poincaré's Maps: Empires of Time*. New York: W.W. Norton & Co., 2007. Print.

"Genesis Block." Edited by Bitcoin Wiki, *Bitcoin Wiki*, 30 Nov. 2017, 03:09. Web. en.bitcoin.it/wiki/Genesis_block.

Hammill, Chuck. "Long but Good: Hammill on Encryption." Edited by Russell Whitaker, *Cypherpunks-Mailing-List*, 21 Sept. 1992,. Web. raw.githubusercontent.com/Famicoman/cypherpunks-mailing-list-archives/8b5351749866ae8ffe947b93ad7f42c9cce3490/cryptome.org/cyp-1992.txt.

Hannaert, Raphael. "IOTA: The Catalyst for a Powerful Machine-to-Machine Economy." *Medium*, Bitcoin Center Korea, 2 Oct. 2017. Web. medium.com/bitcoin-center-korea/iota-the-catalyst-for-a-powerful-machine-to-machine-economy-aaecea7b1255.

Haraway, Donna J. *Staying with the Trouble: Making Kin in the Chthulucene*. Durham: Duke University Press, 2016. epub.

Hui, Yuk. "On the Unhappy Consciousness of Neoreactionaries." *e-Flux* journal, vol. 81, Apr. 2017. Web. www.e-flux.com/journal/81/125815/on-the-unhappy-consciousness-of-neoreactionaries/.

Kant, Immanuel, et al. *Critique of Pure Reason*. London: Penguin, 2007. Print.

Land, Nick. "The Dark Enlightenment." *The Dark Enlightenment*, 25 Dec. 2012. Web. www.thedarkenlightenment.com/the-dark-enlightenment-by-nick-land/.

——. "Nick Land 'The Blockchain Solves the Problem of Spacetime.'" *YouTube*, The New Centre for Research & Practice, 6 Oct. 2016. Web. www.youtube.com/watch?v=2PMGuNZreWA.

Le Guin, Ursula K. *The Unreal and the Real: the Selected Short Stories of Ursula K. Le Guin*. New York: Saga Press, 2016. Print.

Lehdonvirta, Vili. "The Blockchain Paradox: Why Distributed Ledger Technologies May Do Little to Transform the Economy." Oxford Internet Institute, 21 Nov. 2016. Web. www.oii.ox.ac.uk/blog/the-blockchain-paradox-why-distributed-ledger-technologies-may-do-little-to-transform-the-economy/.

Lowrey, Annie. "Ron Paul vs. the Federal Reserve: Does He Really Want to End the Fed?" *Slate Magazine*, 9 Feb. 2011. Web. www.slate.com/articles/business/moneybox/2011/02/end_the_fed_actually_maybe_not.html.

Marx, Karl, and Ben Fowkes. *Capital: a Critique of Political Economy*. London: Penguin in Association with New Left Review, 1990. Print.

Marx, Karl. "Fragment on Machines." *#Accelerate#*, edited by Robin Mackay and Armen Avanessian. Falmouth: Urbanomic, 2014, pp. 50–63. epub.

——. "Notebook V." *Grundrisse: Foundations of the Critique of Political Economy (Rough Draft)* Translated with a Foreword by Martin Nicolaus. London: Penguin Books in Association with the New Left Review, 1977. Print.

McClelland, Mike. “What Use to Be Caracas.” *Global Dystopias*, edited by Junot Díaz, Boston Review, 2017. Print.

McConaghy, Trent. “Tokenize the Enterprise.” *The BigchainDB Blog*, 6 June 2017. Web. blog.bigchaindb.com/tokenize-the-enterprise-23d51bafb536.

Nakamoto, Satoshi. “Bitcoin: A Peer-to-Peer Electronic Cash System.” 2008. Web. https://bitcoin.org/bitcoin.pdf.

“Once a Leader in Virtual Currencies, China Turns against Them.” *The Economist*, 30 Sept. 2017. Web. www.economist.com/news/finance-and-economics/21729795-after-bans-exchanges-and-initial-coin-offerings-bitcoin-miners-fear-they-are.

“Orphaned Blocks.” *Blockchain.info*. Web. blockchain.info/orphaned-blocks.

“Polkadot.” Polkadot. Web. *polkadot*.network/.

Rose, Nikolas S. *Powers of Freedom: Reframing Political Thought*. Cambridge: Cambridge University Press, 2010. Print.

Szabo, Nick. “Bit Gold.” *Unenumerated*, 27 Dec. 2008. Web. unenumerated.blogspot.de/2005/12/bit-gold.html.

Virilio, Paul, and Bertrand Richard. *The Administration of Fear*. Los Angeles: Semiotext(e), 2012. Print.

Vries, Alex De. “Bitcoin’s Growing Energy Problem.” *Joule*, vol. 2, no. 5 (2018): 801–805. doi:10.1016/j.joule.2018.04.016. Print.

“World Economic Outlook Database, April 2018.” *International Monetary Fund*, Apr. 2018. Web. www.imf.org/external/pubs/ft/weo/2018/01/weodata/download.aspx.