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TOWARD A PHILOSOPHY OF BLOCKCHAIN: A SYMPOSIUM

INTRODUCTION

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Abstract: This article introduces the symposium "Toward a Philosophy of Blockchain," which provides a philosophical contemplation of blockchain technology, the digital ledger software underlying cryptocurrencies such as bitcoin, for the secure transfer of money, assets, and information via the Internet without needing a third-party intermediary. The symposium offers philosophical scholarship on a new topic, *blockchain technology*, from a variety of perspectives. The philosophical themes discussed include mathematical models of reality, signification, and the sociopolitical institutions that structure human life and interaction. The symposium also investigates the metaphilosophical theme of how to create a *philosophy of anything*, specifically a new topic such as blockchain technology. Repeated themes are identified, in all areas of philosophical inquiry (ontology, epistemology, and axiology), and conceptual resources are elaborated to contribute to a philosophical understanding of blockchain technology. Thus, philosophy as a metaphilosophical approach is shown to be able to provide an understanding of the conceptual, theoretical, and foundational dimensions of novelty and emergence in the world, with a particular focus on blockchain technology.

Keywords: blockchain, cryptocurrency, smart asset, smart contract, smart networks, ontology, epistemology, axiology, economic theory, algorithmic trust.

1. Introduction and Background

What Is a Blockchain?

Blockchain technology (a.k.a. distributed ledger technology) enables the secure transfer of money, assets, and information via the Internet without the need for a third-party intermediary, such as banks or other financial institutions (Swan 2015, ix). Transactions are validated, executed, and recorded chronologically in an append-only and tamper-resistant database, where they remain always available on the Internet around the clock for on-demand lookup and verification. Blockchain technology is what underpins such applications as the bitcoin cryptocurrency. Bitcoin was the first and perhaps most obvious application of blockchain technology—a decentralized payment system allowing for the real-time transfer of digital currency, at any time and to anyone in the world. Just as SMTP (simple mail transfer protocol) constitutes the underlying software protocol by which Internet users can send an e-mail to each other in a seamless and interoperable way, regardless of their e-mail provider, so the bitcoin protocol allows people to seamlessly transfer money between one another, regardless of their bank. With bitcoin, money can be transferred from one continent to another, at very low cost and in a matter of seconds, instead of waiting days or weeks and paying high commissions, as is the case with current international money transfers and remittance solutions.

But money transfer is just one application enabled by blockchain technology. The same technology also provides the means to record and transmit digital goods over the Internet, while ensuring that these goods cannot be copied or multiplied (thereby addressing the double-spending problem that has been an issue with digital currencies). Indeed, once they have been digitized as "smart assets," the recording, search, purchase, sale, tracking, and logging of resources can be coordinated with a much higher degree of automation, speed, trackability, and assurance. A blockchain can be used, for instance, as a digital registry to record, transfer, and verify asset ownership (home, auto, stocks, bonds, mortgages, and insurance) as well as to preserve the integrity and authenticity of sensitive documents or records (such as passports, visas, driver's licenses, birth and death certificates, voter registration, contracts, wills, patents, and medical records).

Eventually, as governments, corporations, and startups work toward the implementation of real-time payments, and also digital registration systems for the transfer and verification of digital assets and legal documents, a variety of legal, financial, and governmental services could be reengineered and readjusted for the Internet era.

Why the Philosophy of Blockchain?

The Internet is an important and transformative element that has arisen in the contemporary era. Already in 2014, in *Philosophical Engineering: Toward a Philosophy of the Web*, Halpin and Monnin invited the discussion of the philosophical aspects of an emerging technology, the *Internet* (Halpin and Monnin 2014). This is what inspired the framing of the present symposium, which considers philosophical themes in regard to another emerging technology, the *blockchain*. The advent of blockchain technology brings about a new perspective or era in network computing, as indicated in figure 1. What we have witnessed thus

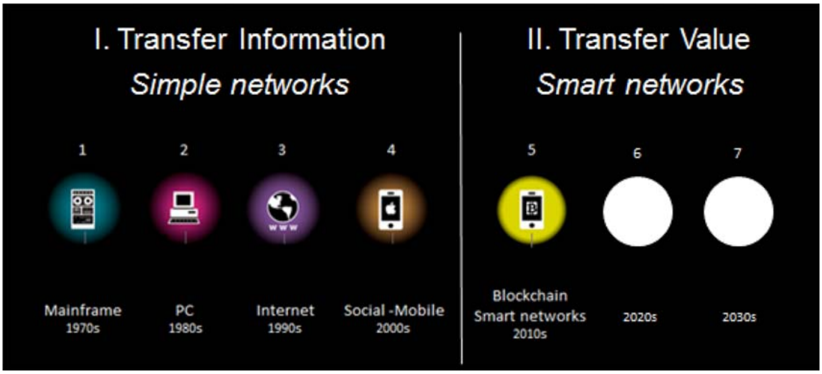

FIGURE 1. Two fundamental eras of network computing (expanded from Sigal 2011) [color figure can be viewed at wileyonlinelibrary.com]

far might be the first phase of the Internet, characterized by the transfer of information via simple networks. Today, a second phase of network computing is emerging—one that enables the secure, end-to-end, and computationally validated transfer of value (whether it is represented by money, assets, or contractual arrangements) via smart networks.

The idea behind smart networks is that value transfer is performed by the network itself. Intelligence is built directly into the network's operations through a sophisticated protocol that automatically identifies, validates, confirms, and routes transactions within the network. In the case of most existing blockchain-based networks, what makes the peer-to-peer transfer of value possible is the proof-of-work protocol (sometimes referred to as *mining*): that is, the economic competition between agents who contribute their computing resources to securing and maintaining the network. As a result of this process, a new form of "algorithmic trust" is created, one that significantly distinguishes itself from the more traditional typology of trust that was initially only between human agents.

One implication of transferring value with blockchain-based smart networks instead of relying on human-based institutions is that the traditional intermediaries responsible for verifying and validating transactions may become obsolete. As a result, the institutional structure of society could shift to one that is computationally based and thus has a diminished need for human-operated brick-and-mortar institutions. Blockchain technology applies to advanced and emerging economies alike. In the context of advanced economies, institutions could be reengineered, leading to a future where a substantial portion of human interactions, in particular value transfer and contractual engagements, are automated for quicker, easier, cheaper, and lower-risk execution. In the context of emerging economies, blockchain technology offers new opportunities for the two billion "unbanked" people in the world (PricewaterhouseCoopers 2016), and could serve as an important leapfrog technology in both monetary applications and digital asset registries. Land titling and property transfer systems have been stressed as having a crucial role in economic development (de Soto 2003). If widely adopted, blockchain-based networks could become a tracking register for the world's activity, a kind of societal memory (a concept explored in Greg Bear's *Eon* [1985]). Given the potential impact of blockchain technology in restructuring the traditional operation of economic, financial, legal, and governance systems, we can see great benefit in articulating a *philosophy of blockchain* as a conceptual resource for understanding these progressions in our modern world.

What Would Constitute a Philosophy of Blockchain?

The Internet prompted us to rethink such topics as the self, the relationship between the physical world and the virtual world, the individual and society, and the concepts of materiality, embodiment, temporality, spatiality, and possibility. Blockchains too warrant this degree of philosophical inquiry. They invite a full range of consideration in the classical areas of philosophy: ontology, epistemology, and axiology. Broadly speaking, ontology treats questions of existence. What is blockchain technology? How is it being characterized, created, and implemented? How does it operate in the world? What are its definitions, classifications, teleology, possibilities, constraints, and limitations? Accordingly, from a practical point of view, an ontological philosophy of blockchain would provide a concise definition of what the technology is, including its purpose, function, and dimensions. The second area, epistemology, deals with knowledge. We can ask what new kinds of things blockchain technology is helping us to know or understand. This can be with regard to both new knowledge and new ways of knowing. We can ask about the corresponding standards of proof, or truth, that supports this new knowledge. Is there new knowledge that is required to create and engage with blockchain technology? The third area, axiology, especially ethics and aesthetics, concerns how blockchain technology is valorized, taken up, and regarded by individuals and society. What aspects are being valued, overvalued, undervalued, and overlooked, and by whom? What is being omitted and why? What behavioral norms are being established? Who is adopting blockchain technology and why? What constitutes an aesthetics of blockchain in the sense of what aspects are seen and valued as being beautiful, elegant, or aesthetically pleasing?

What Is the purpose of a Philosophy of Blockchain?

The task of philosophy is to help in naming, articulating, and describing different concepts and conceptual levels in their generative progression and meaning. Hence, the purpose of a philosophy of blockchain is to articulate conceptual resources for understanding what blockchain is and what it could be, its potential impact, advantages, and drawbacks, and the new opportunities it provides, both individually and societally. "Philosophy" here is used to refer to the theoretical underpinnings, the foundational definitions, as well as the general abstractions of blockchain technology, basically everything that might constitute the conceptual grounding of the notion of blockchain.

Such conceptual resources are necessary because blockchain technology brings together and integrates many fields, such as mathematical cryptography, distributed network technologies and versioning (for example, Git, Tor), financial accounting (ledgers, account balance instantiation and transfer), identity specification, economics and governance concepts, and user-based information security. Another reason these conceptual resources are needed is that blockchain is a complicated idea that is difficult to grasp immediately. Conceptual metaphors ("this is like that") can help us approach and comprehend new ideas (Lakoff and Johnson 2003). As people first heard of blockchain technology as the software that underpins cryptocurrencies like bitcoin, the first conceptual metaphor was that "blockchain is like PayPal," an Internet-based way of transferring money from one person to another. Because of bitcoin, blockchain seems to fit particularly well within the conceptual category of digital money and online payment systems. The next conceptual metaphor draws upon network computing with statements like "blockchain is like Napster for money": a decentralized peer-to-peer network for transferring money on the Internet in a decentralized manner. In fact, in the extent that the bitcoin blockchain operates without human intermediaries, it challenges the monolithic and traditional understanding of the fundamental concept of money. How can we have money without a bank? Who confirms these transactions? Who maintains the centralized ledger recording all these transactions? Thus, the conceptual metaphor that "blockchain is like Napster for money" helps us see the blockchain as a peer-to-peer network without a central intermediary. Blockchain is like PayPal, but it also incorporates a few features that make it significantly different from the traditional PayPal model, in that it is an inherently decentralized system, operating on top of a peer-to-peer network, and without any central party in charge of coordinating the network.

These initial conceptualizations are based on a concrete and widely deployed use case (for example, the cryptocurrency bitcoin), but there is much more to that. Another conceptual metaphor currently in operation is that blockchain is a financial technology (fintech) capable of reengineering the financial services sector and enabling better and faster reconciliation between the accounts of different banks, securities brokers, traders, and clearing firms. This helps to provide the foundation for more generalized conceptualizations of blockchain technology that connote the greater capacities afforded by the technology, even if those have not yet been fully realized. Yet another conceptual metaphor is that, at its core, blockchain technology is a next-generation network protocol that allows for the recording, transfer, and verification of physical or digital assets, both in the immediate term (spot market) and in future time frames (futures market).

More generally, everything discussed so far falls under the conceptual metaphor of blockchain technology as a "better horse" (a better version of something we already know), as opposed to a "new car" (a disruptive innovation that gives rise to something completely new). The latter applies to a whole category of applications that are as yet unplumbed—such as million-person genome databanks, global energy delivery and storage markets, and real-time voting systems (Swan 2015). For example, regarding the concept of money, the better horse notion of a blockchain is "digital cash" (something we already know), whereas the new car notion of a blockchain is "programmable money"—something that provides the ability to configure all of the parameters of a currency: who can use it, how, where, and for what, and what will happen in future time frames, such as expiration, redistribution, price indexing, and demurrage (the carrying costs associated with holding money). As opposed to digital cash, which simply represents money in a digital format, the ability to program the design and operations of money is a new capability that was not previously available. The digital realm also allows us to specify and compose our world (present or future) in new and exciting ways. Temporality is a particularly interesting property that becomes more configurable in the context of blockchain-based systems. The "blocktime" (the time over which a certain number of blocks will have confirmed) is a notion of time that is specific to a blockchain. Accordingly, there could be arbitrage opportunities between human clocktime cycles (for example, monthly rent is due) and blocktime cycles (for example, earning money in bitcoin or having a peer-to-peer bitcoin-based loan). Understanding blocktime as an alternative time paradigm could allow the contingency risk of future events to be reduced, for example, setting the temporality regime as a standard feature in smart contracts via a drop-down menu option (Swan 2016).

Symposium Thesis

The present symposium explores the metaphilosophical issue of whether an open call to thinkers to consider the philosophical implications of a new occurrence in the world—blockchain technology, in our case—can lead to the emergence of a new field of philosophy for that particular thing. The selected papers included here have proven our initial hypothesis to be true. The call has given rise to a wide range of approaches in the contemplation of blockchain technology, and to the generation of conceptual resources that contribute to a wider understanding of blockchain technology as a new element of phenomenological reality and philosophical concern.

2. Summary of Contributions

This section provides a summary and analysis of the papers making up the symposium and of the broader philosophical themes they raise.

Summaries

The following are detailed summaries of the argument, method, conclusion, and implications of the findings in the seven ensuing papers.

(1) In "On the Philosophy of Bitcoin/Blockchain Technology: Is It a Chaotic, Complex System?" Renato P. dos Santos maintains that, while the bitcoin blockchain's proof-of-work consensus method is complicated, it is not complex. Building upon Crutchfield's Statistical Complexity,[1] dos Santos points to two principal methods for measuring the complexity of a system: algorithmic complexity and statistical complexity. The first method analyses the complexity of a particular data set by the length of the program necessary to reproduce such data. This method, however, is not generalizable to other data sets produced by the system or to the system as a whole. Accordingly, algorithmic complexity lacks the ability to distinguish between signal and noise. The second method, statistical complexity, relies on statistics as a means for measuring noise, and constitutes therefore a more general method of measuring complexity (Badii and Politi 1999, 9).[2] And so *statistical complexity* can be defined as measuring the amount of information in a system that describes the system's dynamics and that can be used to predict the future states of that system (Shalizi 2006, 59). Statistical complexity is measured along the parameters of randomness (entropy) and order (complexity).

Applying Crutchfield's Statistical Complexity to measure the predictive information in the bitcoin blockchain consensus system (the process of cryptographically winning the opportunity to validate a new

[1] Also known as Crutchfield-Young Statistical Complexity (from 1989) and Grassberger-Crutchfield-Young Statistical Complexity (from 1986) (Shalizi 2006, 59).

[2] Other proposed methods for measuring complexity have not been sufficiently demonstrated—for example, power laws and thermodynamic depth (Shalizi 2006, 61, 65).

block of transactions), dos Santos finds a low degree of predictive information in the system, and he concludes that the system has entropy (randomness) but does not qualify as being complex. While the bitcoin blockchain consensus method has high entropy (per the randomness of the successful nonce guessing by any particular mining machine), on this formal measure it is not complex. The complexity-related characteristics of the bitcoin blockchain consensus method are more in line with those of a fair coin flip (Crutchfield's Statistical Complexity = 0), which has high randomness but also high order (low complexity); one will win the coin toss, just as one mining machine will win the nonce guess. On the other hand, the bitcoin blockchain consensus method's complexity-related characteristics are not in line with those of a double pendulum—with Crutchfield's Statistical Complexity $\gg$ 0 (much greater than 0)—which has a simple construction and less randomness but high disorder (high complexity), as it is unknown where the two pendula will be in any moment. The potential implication of this analysis is that blockchain systems—as noncomplex systems—would be unlikely to enter chaotic regimes, such as market flash crash situations.

(2) In "Blockchain Identities: Notational Technologies for Control and Management of Abstracted Entities," Quinn DuPont supports an understanding of digital technologies—such as blockchains—as "notional technologies" in the model of Nelson Goodman's "notational system," citing the blockchain-based digital artwork (photos and digital designs) asset management platform Monegraph as an example. Notational technologies are technologies that name and operationalize identities within a context. For Goodman, many situations count as notational schema (for example, the alphabet and natural language, where terms are indistinct, replicative, and confusing) but not more precisely as notational systems (in which terms are unambiguous and semantically disjoint and differentiated). Goodman's fine-grained model is helpful for specifying the distinct identities that arise in the context of a blockchain-based system. The notations in a blockchain are digital symbols that represent specific identities (such as a token, hash, or address). Identity management is a crucial element of digital systems, and the benefit of considering blockchains as Goodman-type notational systems gives access to the kind of granularity that might be necessary in specifying the detailed layers of identities in blockchain systems.

(3) In "Blockchain, the Greater Good, and Human and Civil Rights," Kobina Hughes argues that blockchain developers are in a unique position to address human rights concerns and reduce the digital divide. He suggests that, in addition to "blockchain lite" applications that generally address and improve commerce and governance, developers may also elect to focus on "blockchain heavy" applications

that overtly target human rights protection in such areas as corruption and electoral fraud. For example, blockchain-based economic aid tracking applications could help to staunch capital flight, a serious global problem that at minimum impairs the ability of governance bodies to comply with the core U.N. human rights doctrine of the "responsibility to protect." Likewise, blockchain-based birth and death registries could be an immediate means of improving the documentation and tracking of individuals, particularly as related to human trafficking, refugee situations, and electoral fraud. The example of space exploration as a supranational "benefit of all" technology is drawn upon to create an inspirational vision for blockchain's capacity to create public goods. The implication is that blockchain technology provides a more deliberate lever for addressing human rights issues than may have been available previously.

(4) In "Blockchain Technology as an Institution of Property," Georgy Ishmaev underlines the novelty of blockchain technology in the social context by considering a blockchain as a self-sufficient institution of "property." He suggests that blockchains have the necessary and sufficient conditions to compose the institution of property without reliance on traditional legal means. Invoking Penner's essentialist theory of property (which emphasizes exclusion and separability) and Hegel's recognitive system of property rights (which highlights universal access), Ishmaev shows how blockchains both eliminate the need for a third-party authority to enforce exclusion rights (a criterion raised by Penner) and provide a transparent system that facilitates the identification of existing property rights and increases people's ability to know and understand how the system works (a criterion imposed by Hegel). For Hegel, the existence of a complete model of property signals a far greater ontological existence than the one provided by the current regulatory framework of property rights. Today, a society-wide system that recognizes property would have to exist in order for any particular object to be recognized as property. In the context of a blockchain-based system, a set of cryptographically secured tokens can be used to indicate that there is a global system of cryptographically controlled assets. According to Hegel's model, the very existence of a cryptographically activated asset also suggests the existence of a system for its registration, ownership, and transfer. And, indeed, these criteria are satisfied by the specific blockchain's protocol that provides universally accepted mechanisms for the registration and transfer of these tokens within the blockchain property system. The implications of these findings are that traditional property relations in society (that is, the means by which public property is currently administered) could eventually be replaced or supplemented by blockchain models and perhaps even be implemented in new domains, such as the ownership of private data (in virtual contexts).

(5) In “On the Continuity and Origin of Identity in Distributed Ledgers: Learning from Russell’s Paradox,” José Parra Moyano suggests that in some cases the setup and administration of smart assets (physical world assets controlled by blockchains) might give rise to a logical dilemma such as a Russell’s Barber’s Paradox—illustrated by the query, “If the barber is the one who shaves all those, and only those, who do not shave themselves, then does the barber shave himself?” Parra Moyano introduces the notion of a “validating instance” as an entity that is required to bind an on-chain entity (such as a digital token or address) to an off-chain asset (such as a physical world asset). In some situations, he argues, the mechanism might stall, because a validating instance cannot inscribe itself on a blockchain without another off-chain entity entering into play in order to vouch for it—thus replicating the structure of a Russell’s Barber’s Paradox. After second thoughts, however, the problem does not seem to be a logical inconsistency as much as a loosely coupled control mechanism. If a validating instance is required to create a bridge between a blockchain-based asset and its representation in the physical world, then the key aspect is not whether or not an entity can inscribe itself in a blockchain but rather how the control coupling works between the on-chain and off-chain entities. One implication is that tighter coupling may be required between on-chain and off-chain assets if the smart assets concept is to be widely adopted as a virtual marshaling and control mechanism for assets in the physical world. Another implication is that logical analysis methods, such as known paradoxes, might be helpful as a critical tool with which to evaluate the security and other features of blockchain operations. A third implication is that computational systems might serve as a venue for novel mathematical discovery.

(6) In “Can Cyber-Physical Systems Reliably Collaborate Within a Blockchain?” Ben van Lier argues that, in an increasingly networked world comprising both virtual and physical systems, in which humans collaborate with machines, trust-producing mechanisms like blockchains will become crucial. Indeed, for van Lier blockchains are exemplary of the current state of the world as one composed of emergent cyber-physical systems (systems interconnecting virtual and physical components), with newly arising elements and properties merging and agglomerating into the existing world system to generate new wholes. The relevant and distinguishing properties of blockchains are fault-tolerant communication, voting, consensus, distributed ledgers, and transaction execution. This supports the idea that blockchains are an example of a technological phenomenon that is made up of different interconnected and autonomous systems that, when combined, create a new whole or entity in the world, both conceptually and operationally. According to van Lier, the future could be one world composed of many different networked “systems of systems,” with multiple interconnected systems (virtual and physical) undertaking autonomous

activities and making independent decisions. In a world made up of increasingly complex cyber-physical systems, complexity science could be an appropriate method for understanding and analysis of this new world. The implication of this analysis is a greater understanding of the nuances of how humans and machines may coexist cooperatively in a trust-based manner in the future.

(7) In "Computing Ledgers and the Political Ontology of the Blockchain," Pablo R. Velasco considers the political structure of monetary systems in the traditional sense and in the blockchain model, and he finds that blockchains trigger a shift in authority from institutions to computational systems. With blockchains, authority is displaced from the institutional actors in the system to the instrumental control of trust by the software. In order to understand the difference between fiat banking-system politics and distributed ledger politics, Velasco engages in a comparative analysis of the political ontology of money as it is traditionally produced by central banks and of money as it is produced in the context of a blockchain-based system. Both the traditional monetary system and a blockchain-based system are inherently political, in the sense that such qualities as control, trust, and authority are intrinsic to these two systems. Yet, while in fiat monetary systems, control, trust, and authority are vested in the institutional actors involved in the system, in blockchain-based systems, these qualities are properties of the software protocol. With a blockchain, the state disappears from the monetary realm: governmental authority is displaced not only from the money transmission process but also from the production process itself. This has at least two implications. One is that qualitative elements become established as part of the production process. The other is that as reality becomes increasingly composed of computer-made elements (such as blockchains, video games, and virtual reality), the production of qualitative goods (intangible social goods such as authority and trust) traditionally generated by human-operated institutions is being transferred to computational systems.

Philosophical Themes of Contributions

This section highlights, groups, discusses, and thematizes the philosophical aspects of the contributed papers. In Table 1, there is a list of the papers and their philosophical themes.

Thematic Discussion

The papers in this symposium consider themes within three main categories of philosophical concern: ontology, epistemology, and axiology. The specific problematics addressed can be summarized as fitting models to

TABLE 1. List of papers and philosophical themes

	Paper title	Philosophical themes
1	dos Santos: "On the Philosophy of Bitcoin/Blockchain Technology: Is It a Chaotic, Complex System?"	Complexity, statistics, correspondence, meaning
2	DuPont: "Blockchain Identities: Notational Technologies for Control and Management of Abstracted Entities"	Signification, correspondence, syntactic and semantic meaning, performance
3	Hughes: "Blockchain, the Greater Good, and Human and Civil Rights"	Valorization, inclusion, ethics, moral responsibility, human rights policy, responsible technology development
4	Ishmaev: "Blockchain Technology as an Institution of Property"	Politics, institutions, property, social agreement
5	Parra Moyano: "On the Continuity and Origin of Identity in Distributed Ledgers: Learning from Russell's Paradox"	Logic, paradox, identity, individuation, sortal, reference
6	van Lier: "Can Cyber-Physical Systems Reliably Collaborate Within a Blockchain?"	Complexity, human-technology collaboration
7	Velasco: "Computing Ledgers and the Political Ontology of the Blockchain"	Political philosophy, authority, trust, control

the description of reality (ontology, what is reality [papers 1, 5]), signification (epistemology, what can we know [2, 6]), and sociopolitical institutions (axiology, ethics, and right conduct in the world (3, 4, 7]).

The first theme, ontology, is fitting quantitative models to reality. Modernity is characterized by the application of scientific and mathematical models in an attempt to understand the world and new occurrences in reality. Two papers appeal to complexity science (1, 6), and one invokes Russell's Barber's Paradox (5) in an attempt to comprehend blockchain as a new occurrence in the world, and they characterize its parameters. While the consensus algorithm of a blockchain may be complicated but not statistically complex on a formal definition (1), understanding a blockchain as an example of a heightened networked web of complex interactions between humans and machines may be a valid heuristic (6). Mathematical and logical formulations such as conjectures and paradoxes may also be helpful in identifying the structure of a new computational technology such as a blockchain (5).

The second theme, epistemology, is fitting models of knowing to reality. One paper explores signification and investigates the signifier-signified problematic (2). Another explores what we can know of network societies and human-machine collaboration (6). Other papers examine the correspondence between the physical and the virtual world

(2, 5, 6, 7). Some of the key elements in the process of knowing include naming, the performing of actions, and the ability to confirm and refer to what is known. Epistemological issues are heightened in the blockchain context due to the coupling between the physical and virtual domain, where the tightness of linkage in these relationships is unconfirmed, both when they are initially established and persistently over time. One challenge in establishing correspondence between these two domains is due to the different natures of these two worlds: the virtual world is quantitative (digital ones and zeros), and the physical world is qualitative (messy, variable, irrational). Ultimately, we are still in the early days of the experimental process to identify the computational equivalents of human-based qualities, such as trust and truth.

In the context of signification, the idea of using Goodman's notational system as a fine-grained method for specifying blockchain identities suggests a broader analysis of signification. For example, Saussure's dyadic semiotic sign (the signifier and the signified) and Peirce's sign (with explicit extension to the physical world) might be helpful in further delineating the correspondence of blockchain entities as they move between the physical domain and the virtual. Performance is likewise important, including what counts as the performance of an action in the blockchain context, and what might grant identity or over-personify it. For humans, performativity is connected to the expression of identity. While this is not directly applicable to blockchains, one might consider performativity metaphorically. Both John Austin's speech acts (mere utterance has performative action) and Judith Butler's notion of performance (identity is real only to the extent that it is performed) can be transposed easily into the blockchain context in that transactions do not exist in a fully realized way until they are broadcast (that is, performed)—and if transactions are not broadcast to the network, they are simply deemed not to exist. Nuances in performativity theories could be helpful in further specifying the range of existence of blockchain entities; in the case of transactions, from wallet submission to validation, confirmation, broadcast, and propagation. Indeed, while a peer node merely publishing transactions on the network might not necessarily have a higher claim to identity than any other database, a smart contract that can update its own code might have more ground to do so.

Finally, when it comes to messages being received and acknowledged, blockchain networks have a sense of peer-to-peer reciprocity that is articulated in the "hear say yes" affirmation relation Derrida sees in Joyce (Derrida 1991, 256). Blockchain peer nodes engage in a "hear say yes" affirmation as the means by which state changes are confirmed and propagated through the system, since each party cosigns and assents to the new state of the network. Accordingly, decentralization is not merely architectural (in the setup of the peer-to-peer mesh network) but also operational, in the sense that each participating node is responsible for evaluating and confirming the new blocks that will become part of the new state of the world, rather than just accepting the update from a hierarchically superior main node.

The third theme, axiology, is fitting models to sociopolitical institutions. Axiologically, some of the main topics regarding what is valorized or ignored in the world are ethical and moral issues, and aesthetics. First looking at what we valorize as being moral or ethical, we are concerned with right conduct as we enact our lives individually and collectively. In this area, one paper looks at property as a political institution (4), another at the political structures of money production (7), and a third at human rights issues in the context of political corruption (3). Second, concerning what we valorize as aesthetic (what is elegant, efficient, beautiful, or sublime), one paper discusses the blockchain-based protection of digital artworks (2), with the assumption that digital artworks are valuable in society. A broader consideration of the aesthetics of blockchain might encompass on one hand an evaluation of the computational elegance or efficiency of the cryptographic equations or software, for example using techniques like Occam's razor (the simplest solution is the most efficient and elegant). On the other hand, the aesthetics of blockchain might range to the analysis of artworks made with blockchain code or the political messaging of blockchains, such as Cryptoart's fine art combined with bitcoin storage or cryptographic art, such as the ASCII Bernanke recorded in the bitcoin blockchain (Pastebin 2011).

From a high-level abstraction, the framing of all these papers is epistemological, in the sense that the general problem is a grasp at understanding blockchain technology as a new occurrence in the world. Within the general epistemological problem of an understanding of blockchains, there is a host of other issues: what blockchains are ontologically, what we can know of ourselves and our world through blockchains, and how we can make the world a better place (or not) axiologically with blockchains. To answer these questions, we must explore a variety of known ontological, epistemological, and axiological approaches to bring us toward a more profound articulation and understanding of blockchains, as has been demonstrated here with mathematical and scientific models, signification models (naming, performativity, and confirmation), and world sociohistorical political and aesthetic models.

3. Results and Conclusion

Implications of a Philosophy of Blockchain

The papers, both individually and in thematic synthesis, support the thesis of this symposium that conceptual resources may be obtained through an open call for the philosophical investigation of a topic, in this case blockchains. Overall, from the papers it emerges that, on one hand, blockchains seem to have some elements of models, concepts, and objects that we already know but, on the other hand, also have other elements that are unlike the things we know. This establishes blockchains as having an ontological status of novelty or emergence in providing something new compared to what we have previously understood as reality. The argument in favor of blockchains perceived as a novel occurrence in the world is configured in two ways in the papers. First, there is the idea of novel emergence in a unitary sense: blockchain technology is itself a new kind of thing. Second is the point that blockchains are a novel emergence in a generative and systemic sense: blockchain technology is not a stand-alone and discrete kind of thing but one that is intertwined with many other aspects of what we are doing and thinking about ourselves and reality, in both physical and virtual domains. In addition, blockchains connote the possibility of "moreness" for our existence in the world and our ability to shape and create reality. This line of philosophical reasoning suggests that a blockchain is not just a new widget but rather a new *kind* of widget. Taken to the extreme, blockchain technology might constitute a new and foundational mode of configuring reality. At minimum, blockchains could lead to a new era of network computing, in which the secure value transfer of money, assets, and contractual arrangements can occur in an automated and trustworthy manner via computational systems. It is as difficult now to foresee the full impact of blockchain technology as it was (and maybe still is) to estimate the full effect of the Internet.

While conceptual resources for a better understanding of blockchain technology have been obtained in this analysis, particularly in the sense of higher-order generalizations that explain the phenomenon, limitations must also be acknowledged. It would be pyrrhic to have the expectation of a singular and fully formed philosophy of blockchain as a result of this exercise. In terms of the development of the field of philosophical inquiry, the philosophy of blockchain is a topic that is more conceptual than, for example, the formal scientific progression of ideas through the phases of conjecture, theory, hypothesis, and law. Although perhaps more than conjecture, the philosophy of blockchain does not yet qualify as a theory. This is because typically a theory is theoretically well supported, explanatorily powerful, and phenomenologically robust, with consistency and testability. On one hand, future efforts could work toward establishing a "theory of blockchain" in the philosophical domain, building on the ontological and epistemological claims made here. On the other hand, blockchain philosophy may never be formalized as a scientific theory, and there could be arguments against evaluating it this way. The key point is that some novel conceptual resources have been obtained in this exercise.

In conclusion, the primary result of this symposium is that conceptual resources have been generated for the problem at hand of achieving a better understanding of blockchain technology from a philosophical perspective. This constitutes a successful start toward building a comprehensive philosophy of blockchain to the extent that repeated themes have been identified, in all areas of philosophical inquiry (ontology, epistemology, and axiology), and ideas have been elaborated to contribute to a philosophical understanding of blockchain technology. The secondary result of this symposium is metaphilosophical. This is the validation of philosophy as a means for understanding a new domain, and as an investigative tool for the analysis of an emerging technology. Philosophy as a metaphilosophical approach is demonstrated as one that can provide an understanding of the conceptual, theoretical, and foundational dimensions of novelty and emergence in the world, particularly in this case of the emergence of blockchain technology. The immediate benefit of substantiating philosophy as an approach for blockchain studies is that it helps to frame the field of blockchain philosophy. The positivist ontological and epistemological claims made in this analysis could lead to more specific inquiry in areas ranging from the foundational to the applied. New areas of investigation might be inaugurated—for example, critical blockchain studies, the economic theory implications of blockchains, and an examination of temporality, risk, and futurity in decentralized financial systems.

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