Blockchain Governance—A New Way of Organizing Collaborations?

Article *in* Organization Science · March 2020

Fabrice Lumineau
Purdue University

BLOCKCHAIN GOVERNANCE—A NEW WAY OF ORGANIZING COLLABORATIONS?

Fabrice Lumineau
Purdue University
Krannert School of Management
403 W. State St.
West Lafayette, IN 47907-2056, USA
Email: lumineau@purdue.edu

Wenqian Wang
Purdue University
Krannert School of Management
403 W. State St.
West Lafayette, IN 47907-2056, USA
Email: wang4106@purdue.edu

Oliver Schilke
The University of Arizona
Eller College of Management
405GG McClelland Hall, 1130 E. Helen St.
Tucson, AZ 85721, USA
Email: oschilke@arizona.edu

ABSTRACT
The recent emergence of blockchains may be considered a critical turning point in organizing collaborations. We outline the historical background and the fundamental features of blockchains and present an analysis with a focus on their role as governance mechanisms. Specifically, we argue that blockchains offer a way to enforce agreements and achieve cooperation and coordination that is distinct from both traditional contractual and relational governance as well as from other IT solutions. We also examine the scope of blockchains as efficient governance mechanisms and highlight the tacitness of the transaction as a key boundary condition. We then discuss how blockchain governance interacts with traditional governance mechanisms in both substitutive and complementary ways. We pay particular attention to blockchains' social implications as well as their inherent challenges and limitations. Our analysis culminates in a research agenda that explores how blockchains may change the way to organize collaborations, including issues of *what* different types of blockchains may emerge, *who* is involved and impacted by blockchain governance, *why* actors may want blockchains, *when* and *where* blockchains can be more (vs. less) effective, and *how* blockchains influence a number of important organizational outcomes.

Keywords: blockchains, digitalization, collaboration, relational governance, contractual governance, transaction costs, technological innovation, research agenda

Forthcoming in Organization Science

Acknowledgments: Guidance from associate editor Ann Majchrzak and three anonymous referees is gratefully acknowledged. We also thank Zhi Cao, Christian Catalini, Jake Dreier, Hanna Halaburda, Ying-Ying Hsieh, Arne Keller, Hart Posen, David Nguyen, JP Vergne, and seminar participants at the University of New South Wales and Macquarie University for their insights and comments on earlier versions of this paper. All errors remain our own.

Introduction

Blockchains are hailed as a global revolution (Olenski 2018, Poppo 2018) that "could someday underlie everything from how we vote to who we connect with online to what we buy" (Wall Street Journal 2018, p. B4). A blockchain is a cryptography-based decentralized system consisting of an ongoing list of digital records that are shared within a peer-to-peer network (i.e., a chain of blocks of digital records).[1] Many experts regard blockchains as one of the most disruptive technological innovations of recent times that may fundamentally change how collaborations are organized (e.g., Davidson et al. 2018, Dutra et al. 2018, Friedlmaier et al. 2018).

This article makes three key contributions. First, we direct attention to an important new phenomenon—blockchains—and elaborate on its potentially wide-ranging consequences for organizations. Organization scholars may run the risk of underappreciating the vast social implications of this important empirical phenomenon and mistaking it for a mere technological feature for fintech companies. However, although blockchains are deeply engrained in network technologies and first became prominent in the financial service sector, they must be brought to the forefront of the agenda of organization science because of their potential to disrupt the way collaborations are organized across a wide range of social and organizational settings (Constantinides et al. 2018). Indeed, blockchains have gained significant traction in structuring transactions in sectors as diverse as entertainment, retail, charity, automotive, and healthcare (Cole et al. 2019, Marr 2018). Therefore, we intend to portray blockchains as a new form of infrastructure governing a great variety of transactions, thereby substantially broadening the scholarly discussion of this phenomenon in organizational research.

Second, focusing specifically on blockchains' role as governance mechanisms, both within and across organizations, we raise the novel question of how they will affect traditional forms of governance—most notably, contractual and relational governance (Hoetker and Mellewigt 2009, Poppo and Zenger 2002). In principle, blockchains could replace or support these traditional governance mechanisms, and we will start to outline a contingent account of whether and when the substitutive or complementary effect will likely dominate.

Third, we broaden our discussion beyond governance issues and offer an overview of some of the most pressing questions related to blockchains that organization scholars are well equipped to address. By revealing a wealth of exciting research possibilities, we contribute to defining a research agenda that can help organization scholars identify key gaps and resolve existing tensions in the discussion of blockchains. In this way, our article seeks to spur new scholarship at the intersection of information technology (IT) and organizational design (Tilson et al. 2010, Yoo et al. 2006, Zammuto et al. 2007) in order to shed new light on how blockchains may create important opportunities for innovative forms of organizing.

In the following, we start by outlining the historical background and fundamental technical features of blockchains, which have important social implications for the governance of collaborations. We argue that blockchains can be viewed as a type of governance mechanism that is distinct from traditional contractual and relational governance. Then, we discuss how blockchains' technical features translate into significant social implications that blockchains may bring about, specifically analyzing the interplay between blockchain governance and traditional governance mechanisms. After pointing to several important limitations associated with the use of blockchains, we conclude with an agenda of future research opportunities regarding how blockchains could change the way collaborations are structured, elucidating why blockchains deserve further attention from organization science scholars.

History and Fundamental Features of Blockchains

History and Relevance of Blockchain Technology

The notion of a cryptographically secured append-only chain of blocks was originally advanced by Haber and Stornetta (1991). However, it was not until the introduction of Bitcoin in October 2008 that the idea of a decentralized digital system gained significant traction (Nakamoto 2008). The initial motivation for designing blockchains was to challenge traditional financial models, which rely heavily on intermediary institutions such as banks. In traditional models, these intermediaries are important components in solving the classic double-spending problem—that is, the possibility that one unit of digital cash can be spent twice by the same party. Such intermediaries keep ledgers for every account and trace and verify every claimed transaction. While these traditional models can be efficient and convenient, the need to rely on intermediaries poses considerable risks; everyone involved can be adversely affected by the third-party authority tampering with the record or by the record being hacked by others.

In 2008, Nakamoto claimed to have designed a system supporting a new type of cryptocurrency, the Bitcoin, to solve the double-spending problem without recourse to a centralized authority—that is, in a completely decentralized way. In the Bitcoin blockchain, the ledgers are not kept exclusively by any single node but are distributed to everyone who has access to the Internet. Via certain consensus algorithms, everyone shares and keeps an identical list of transaction records. These records are stored in blocks that are linked linearly using cryptographic hash functions (i.e., one-way mathematical functions that map data of any size to data of a fixed size, Schueffel et al. 2019) and that can thus be traced back to the genesis block (i.e., the first block back to which every other block can be traced, Yuan and Wang 2018). Some servers (computers) in the blockchain, called miners, are incentivized by token rewards to verify every claimed transaction and propagate valid ones to the rest of the system. Thus, no one is able to spend a single Bitcoin twice or spend more than one has. Such validating processes are deliberately made costly by a consensus mechanism called proof-of-work. Therefore, practically speaking, no single node has the required computational power to fake transaction records. Thus, in the Bitcoin blockchain, all recorded information is believed to be immutable and trustworthy. People can trust the information they receive without the need for interpersonal trust in either a third party or other participants. Figure 1 visually summarizes the general principles of the blockchain technology.

---Insert Figure 1 about here---

Although initially closely tied to cryptocurrencies—such as Bitcoin, Ethereum, Ripple's XRP, and Litecoin—blockchains have great potential to fundamentally change the way individuals and organizations collaborate in a variety of settings. In recent years, with the development and improvement of Nakamoto's (2008) original idea, blockchains have become a new way of solving problems related to recording, tracking, verifying, and aggregating various types of information (Felin and Lakhani 2018). Blockchains have now progressed far beyond cryptocurrencies to provide an infrastructure for organizing transactions in many fields and applications (Catalini 2017, Friedlmaier et al. 2018), such as payment processing in the finance and insurance industry, tracking songs in the music industry, and tracing bills of lading in the transportation industry. Established enterprises, start-ups, and venture capitalists are investing significant resources in developing a variety of blockchain-powered applications. According to a recent report (CBInsights 2020), the total number of funding dollars invested in blockchain start-ups exceeded $3.0 billion in 2019. Firms use blockchains to organize both intra- and interorganizational collaborations (Kim and Laskowski 2017) on both digital and physical assets (Loten 2018). We next present two vignettes to provide illustrative evidence of how blockchains may change the way transactions are governed.

The IBM, AIG and Standard Chartered insurance blockchain. Recently, IBM, AIG and Standard Chartered Bank initiated a collaboration aimed at devising a multinational insurance policy based on a blockchain (IBM 2018a). In this collaboration, blockchain technology enables a shared, real-time view of policy data and documentation to all parties involved. The blockchain permits the recording and tracking of events in each country related to the insurance policy and the automatic execution of payments if prespecified conditions are met. Compared to other modes of information exchange, the blockchain enables all permissioned parties to have a unified view of the data, while no single party is able to make changes without the consensus of the other members. As a result of this high level of transparency, the potential for fraud and errors can be reduced, as well as the need for frequent e-mails requesting policy and payment data and updates on the status of policies, all of which is anticipated to significantly reduce transaction costs and delays in settlements. The blockchain also obviates the need for insurance brokers, who have traditionally taken a significant cut for assuming the task of coordination.

The GSA federal procurement blockchain. The General Services Administration (GSA), a federal agency providing procurement services for U.S. government offices, is one of the largest buyers globally. The volume of GSA procurement contracts with commercial vendors amounts to approximately $55 billion a year (U.S. General Service Administration 2018). As a government agency, the GSA has the obligation to ensure both efficiency as well as fairness and openness in federal procurement. In this pursuit, the GSA initiated a collaboration with United Solutions, a technology company providing digital transformation services, to develop a new procurement blockchain (Nayak and Nguyen 2018). This blockchain keeps records of historical procurement data, including time, deliverables, pricing, and assessments. Because such information is immutable (no single party can change it without the consensus of all the nodes in the network), the blockchain is expected to boost confidence in the fairness of the procurement process. The immutable information stored in the blockchain increases transparency and can serve as evidence in the case of an investigation. Moreover, to reduce human errors and realize transaction cost savings, the blockchain features routinized codes that are triggered by certain stimuli and allow for automating key processes such as financial reviews (Friedman 2018). With more efficient real-time information sharing and automation, the blockchain promises to significantly shorten procurement cycles, in hopes of reducing the contract awarding time from 100 to less than 10 days (Nayak and Nguyen 2018). In the future, fully automated transactions will be supported through smart contracts plugged into the GSA blockchain.

These two examples illustrate the potential of blockchains to solve major issues in making collaborations both more reliable and faster. IBM, AIG and Standard Chartered as well as the GSA are far from alone: a recent survey among Fortune 500 executives indicated that 94 percent plan to launch blockchain-based initiatives in the immediate future (Souza 2018). The vast array of potential applications originates from the specific technical features of blockchains. Both Nakamoto's initial design and the latest developments in IT give blockchains "the potential to create new foundations for our economic and social systems" (Iansiti and Lakhani 2017, p. 120). We suggest that two of the most salient characteristics of blockchains that enable novel ways of organizing transactions are *decentralized consensus* and *machine-based automation*.

Fundamental Features of Blockchains

Decentralized consensus. When information is shared across a network, a consensus must be maintained of the true state of the information among the collaborating parties. Reaching consensus in a *centralized* network with a fully trusted authority relies on the central party (for example, a bank or a logistics provider) distributing the information and on other parties accepting such information as the agreed truth. However, achieving consensus on the single truth in a *decentralized* network requires careful design of the consensus algorithms. Blockchains are a solution to this problem, as in a blockchain, consensus is reached in such a way that no single party owns the whole decision right. Unlike traditional centralized systems for organizing transactions, in which information is controlled by a single party, in a blockchain, more than one party verifies, accepts, or rejects transactions. Control is thus shared among several independent entities, who can make updates to the blockchain and interact directly without the need to rely on central coordination (Constantinides et al. 2018). Decentralized consensus is thus one of the major merits of blockchains, as it can significantly reduce the degree to which people have to rely on a centralized party as the sole information holder and decision maker. In contrast to traditional centralized systems, blockchains enable the complete copy of identical information to be held by anyone who has access to and wants to keep it. The level of decentralization varies across different blockchains depending on several factors, such as the adopted consensus algorithm (e.g., proof-of-work, proof-of-stake, or Byzantine fault tolerance) and the number of peers in the network (Werbach 2018).

One potential major benefit of decentralized consensus is data integrity. In traditional centralized databases, outsiders can locate the position of data and steal or modify it. However, as blockchains use decentralized consensus algorithms to ensure that the information is replicated throughout the system, it is difficult for a single actor to bypass the consensus algorithm and gain control over (and tamper with) the data. Thus, the risk of data tampering by the intermediary is alleviated and the absence of a single central database removes the target of hacks. These hash-based chains with encryption are considered almost impossible to hack; the data are kept immutable and transparent across the network and thus safeguarded against tampering (Friedlmaier et al. 2018).

Machine-based automation. A second important feature of blockchains is that they are run automatically in machine-driven systems. Traditionally, parties have primarily relied on human actors to execute collaborations. In contrast, blockchains put machines at the center of the collaborations, while human actors remain on the edge (Hsieh and Vergne 2018). This feature gives blockchains the ability to bypass human actors' unpredictability and inability to process massive amounts of information (Simon 1957) and to exploit the benefits and strengths of machines, such as reliability as well as faster and cheaper computation.

While automation is a feature shared by other forms of IT solutions (Zammuto et al. 2007, Zuboff 1988), in blockchains, the machine-based automation characteristic is greatly amplified by the implementation of smart contracts. Smart contracts are programs written in the blockchain that automatically verify and approve valid transactions that satisfy prescribed protocols. Although the notion of smart contracts appeared before the invention of blockchains, it did not gain prominence until blockchain technology made it possible to keep agreements immutable and to implement arrangements across networks for virtually any kind of asset or arrangement (Werbach 2018).

In sum, our examination of their features reveals that blockchains promise to be a viable solution to many long-standing collaboration issues. The two main technical features of blockchains—decentralized consensus and machine-based automation—enable an original combination of appealing functionalities, such as information immutability and reliability, transparency and traceability of records, and autonomous enforcement of agreements. In this way, blockchains should be viewed as innovative blends of existing technologies, including cryptography and distributed databases (Narayanan and Clark 2017). As such, blockchains are to be considered an "architectural innovation" (Henderson and Clark 1990), which rests on the recombination of existing components in previously unforeseen ways (Hsieh et al. 2018).

In the following section, we advance the argument that blockchains represent a distinct type of governance mechanism. We first provide a brief overview of prior research on governance and then discuss how blockchains differ from contractual and relational governance as well as from alternative IT solutions. We proceed to elaborate how blockchains can shape the dimensions of cooperation and coordination among the parties to a transaction and specify the scope of blockchains as an efficient governance mechanism.

Blockchain Governance

Governance to Organize Transactions

"A transaction occurs when a good or service is transferred across a technologically separable interface" (Williamson 1985, p. 1). Organizing a transaction—among entities within organizations or across independent organizations—presents a number of key challenges (Salvato et al. 2017, Voss 2003). The limitations of human nature—opportunism and bounded rationality—comprise the fundamental source of hazards in a transaction (Simon 1957, Williamson 1985). Consequently, parties make certain governance choices to mitigate exchange hazards (such as those associated with asset specificity, difficult performance measurement, or uncertainty) and to promote the combination of their resources in their social interactions (Poppo and Zenger 2002, Williamson 1996). Combining the views from economic and management scholars, we conceptualize a governance mechanism as the institutional arrangement through which an agreement is enforced (Reuer et al. 2010, Williamson, 1985). In particular, the extant literature argues that parties to a transaction make governance choices to achieve both *cooperation* and *coordination* (Gulati et al. 2012, Malhotra and Lumineau 2011).

Cooperation is defined as the "joint pursuit of agreed-on goal(s) in a manner corresponding to a shared understanding about contributions and payoffs" (Gulati et al. 2012, p. 533). The realization of cooperation involves aligning interests between transacting parties so they are willing to devote efforts to the joint goal (Salvato et al. 2017). However, due to the potential opportunistic nature of human actors, the transacting partners have incentives not to behave as agreed upon but to follow their own interests with guile. Such uncooperative behaviors can take various forms (Luo 2006), including blatantly breaching formally documented agreements or violating implicit expectations such as oral promises or latent norms. Moreover, mirroring the adverse selection and moral hazard problems in the agency literature (Eisenhardt 1989, Mishkin 1995), these behaviors may occur both *ex ante* (i.e., before the formation of the agreement) and *ex post* (i.e., after the formation of the agreement) (Williamson 1985). To mitigate these cooperation issues and ensure that obligations are upheld, one of the key functions of governance mechanisms is to provide enforcement prescriptions that limit uncooperative behaviors (Heide 1994, Ménard 2000, Ryall and Sampson 2009, Srinivasan and Brush 2006).

Coordination refers to the “deliberate and orderly alignment or adjustment of partners’ actions to achieve jointly determined goals” (Gulati et al. 2012, p. 537). Whereas cooperation relates to aligning interests, coordination is about aligning expectations between transacting parties. Okhuysen and Bechky (2009) identify accountability, predictability, and common understanding as three integrating conditions of coordination. According to these authors, accountability refers to “who is responsible for specific elements of the task” (p. 483), predictability refers to whether the parties can “anticipate subsequent task related activity by knowing what the elements of the task are and when they happen” (p. 486), and common understanding refers to “a shared perspective on the whole task and how individuals’ work fits within the whole” (p. 488). To seek solutions to these coordination challenges, partners turn to governance mechanisms that help them organize their interactions and manage interdependencies (Gulati et al. 2005).

Although the degree and nature of cooperation and coordination issues can vary greatly across transactions, both need to be considered. To this end, organization scholars have paid extensive attention to how distinct governance mechanisms can support the dimensions of cooperation and coordination. In doing so, they have particularly focused on (a) contractual and (b) relational governance mechanisms.

Contractual and Relational Governance

One important approach to aligning interests between transacting parties and organizing their intents into a binding agreement is that of contracts (Macneil 1978, Reuer and Ariño 2007, see Schepker et al. 2014 for a review). Contracts can be defined as legally enforceable agreements giving rise to obligations that are enforced or recognized by law (Poole 2016). By specifying rights and obligations (Zhou and Poppo 2010) and providing clear payoff structures and legal sanctions (Parkhe 1993), contracts can effectively protect the investment of the transacting parties from the opportunistic inclination of their partners (Li et al. 2010, Macneil 1978, Schilke and Cook 2015, Williamson 1985). In addition to supporting cooperation, contracts can also serve as a mechanism for facilitating coordination (Reuer and Ariño 2007). As knowledge repositories (Mayer and Argyres 2004), contracts contain agreed-upon information regarding the division of labor, including a breakdown of the work and the roles and responsibilities of each party. Contracts can also facilitate communication between the parties and help to build a collaborative environment (Faems et al. 2008, Schilke and Lumineau 2018). When contracts are used to mitigate misunderstandings between the collaborating parties, honest mistakes are effectively reduced (Hoetker and Mellewigt 2009, Mayer and Argyres 2004), and accountability, predictability, and common understanding are enhanced.

In addition to contracts, parties can also employ relational mechanisms to govern their transactions. This approach relies on the social relationships between the parties or their shared norms, which include the expectations of how the partners will behave during the relationship (Dyer and Singh 1998, Nee et al. 2018). Unlike contractual governance, which relies on enforcement by a court or other certificated third party (Williamson 1985), relational mechanisms are self-enforced by the collaborating parties (Li et al. 2010). With relational governance, cooperation is sustained by the value of future relationships (Baker et al. 2002, de Figueiredo and Silverman 2017). Typical relational governance mechanisms include trust and relational norms (Macneil 1980). Trust refers to a psychological state in which entities are confident that another entity will reliably act in their best interest (Lewicki et al. 1998), while relational norms refer to shared expectations about the behaviors of each partner (Heide and John 1992, Zhang et al. 2003). Studies have shown that trust and socially embedded relationships can effectively reduce concerns about opportunism (Das and Teng 1998, Ring and Van de Ven 1992), facilitate coordination by smoothing the sharing of information and knowledge (McEvily et al. 2003), and create a harmonious atmosphere for the relationship (Faems et al. 2008).

Debate in the organizational literature is ongoing and lively regarding the interplay between contractual and relational governance mechanisms (see Cao and Lumineau 2015, Poppo and Cheng 2018 for recent reviews). Some scholars argue that these mechanisms work as substitutes (e.g., Dyer and Singh 1998, Li et al. 2010, Lui and Ngo 2004), while others hold that they complement each other (e.g., Poppo and Zenger 2002, Zhou and Poppo 2010). These studies not only enhance our understanding of how different mechanisms work together in organizing relationships but also offer implications to the transacting parties for designing effective governance mechanisms.

However, the role of blockchains as an emerging governance mechanism has yet to be incorporated in this scholarly discussion. As illustrated in the first section, actors in the insurance industry have started to rely on blockchains to exchange relevant information and execute transactions, and the GSA uses a procurement blockchain to organize transactions with its vendors. A multitude of firms—ranging from start-ups to large multinational corporations—in numerous industries are increasingly investing resources to develop and implement blockchain-based procedures. Intriguing about this trend is that blockchains help transacting parties achieve cooperation and coordination in a way that is *not* analogous to either contractual or relational governance.

Among the various ways in which the three governance mechanisms differ, we argue that a fundamental difference relates to their *modes of enforcement*. Enforcement is commonly defined as "the process of ensuring compliance with laws, regulations, rules, standards, or social norms" (Wikipedia 2020). Importantly, the specific manner in which enforcement is realized varies across governance mechanisms (Heide 1994, Ménard 2000, Srinivasan and Brush 2006). The following section elaborates contractual, relational, and blockchain governance and discusses how they differ in terms of the way enforcement is achieved.

How Blockchain Governance Differs from Contractual and Relational Governance

Contractual governance relates to a legally binding promise defining the rights and obligations of the parties (Masten 1993, Poppo and Zenger 2002). A contract is legally enforceable whenever it is consistent with the requirements of the law. In case a breach of contract occurs, the law ensures the injured party can pursue legal remedies such as compensation or cancellation. The basic purpose of a contract is to prevent changes in the actions of the parties to an agreement or to at least provide compensation for such deviations by enabling recourse to a third party (Furmston and Tolhurst 2016). When using contracts to govern collaborations, the parties are dependent on the enforceability of the legal system (Achrol and Gundlach 1999, Zhou and Poppo 2010). Once a party's behavior deviates from the contract, the other party may go to a court or an arbitrator to settle the dispute (Williamson 1985). Thus, the effectiveness of using contracts to govern collaborations depends heavily on the quality of the country's legal system (Oxley 1999, Zhou and Xu 2012).

Relational governance is based on the patterns of behavior to which parties are expected to conform (Dyer and Singh 1998). Relational governance emphasizes flexible arrangements and extensive information exchange to establish a shared value system and sense of solidarity between partners (Heide and John 1992, Ring and Van de Ven 1992). Both previous collaboration experiences and the continuous interactive process between the parties are valued. Therefore, using relational governance assumes that the identities of the collaborating parties matter. Its key regulatory principles are the norms shared among the collaborating parties. Relational governance relies on self-enforcing agreements—agreements enforced only by the parties themselves (Halac 2012). Relational governance ultimately rests on enforcement through the "shadow of the future" (Gibbons and Henderson 2012, Poppo et al. 2008a) or the threat of terminating the collaboration and thus foregoing future benefits stemming from it (Gil and Zanarone 2017). As such, relational governance differs from governance provided by contracts that depend on external parties to enforce or interfere with the agreement. In the case of relational governance, the agreement is in effect as long as the parties believe it is mutually beneficial and a breach has not occurred (Telser 1980).

By contrast, *blockchain governance* represents a self-contained and autonomous system of formal rules. Instead of relying on enforcement through the law (as in contractual governance) or through the value of future relationships (as in relational governance), blockchain governance relies on a set of protocols and code-based rules. These rules are developed through formal programming languages, such as Ethereum's Solidity. The rules embedded in blockchains are automatically enforced by the underlying blockchain-based network. As observed by De Filippi and Wright (2018, p. 5), blockchains "create order without law and implement what can be thought of as private regulatory frameworks."

Indeed, *in contrast to contractual governance*, blockchain governance supports collaborations without recourse to law. As a result, using blockchains to organize transactions does not directly rely on the enforceability of the external legal system (Werbach 2018). Instead, enforcement in blockchains is achieved through pre-scripted codes and algorithms, such as smart contracts. As emphasized by Catalini and Boslego (2019), contrary to the name's implications, smart contracts are simply self-executing computer codes and are thus not a contract in the traditional sense. Transacting parties using blockchains are forced to behave as required by the collective agreement, as any deviating behaviors will not be verified or acknowledged by either the algorithm or the other nodes in the system. The underlying logic here is not to set up terms as preparation to seek legal recourse for any subsequent misbehaviors but rather to regulate the participants' behaviors from the beginning.

In addition, *in contrast to relational governance*, direct connections between collaborating parties are not required in a blockchain. In most public blockchains, the collaborators do not even know who they are collaborating with (similar to other centralized systems such as SWIFT or trading platforms). Blockchains thus share some similarities with the notion of atomistic market exchanges (Williamson 1996), in which the identity of the parties does not matter. This feature implies that the transacting parties need not establish expectations of the partner's behaviors or build confidence regarding the partner's integrity by judging from their past experience or their ongoing interaction. Nonetheless, parties collaborating through blockchains can still have confidence that transactions are faithfully and immutably recorded and that all participants are behaving in accordance with the rules of the system. Therefore, the identity of collaborating parties in blockchains does not matter to the same extent as it does in relational governance. Key differences among the three governance mechanisms are summarized in Table 1.

---Insert Table 1 about here---

How Blockchain Governance Differs from Other IT Solutions

Studying IT in the context of governance is all but new (for instance, see Drnevich and Croson 2013). Especially as the global and corporate information infrastructure has become increasingly digitalized (Tilson et al. 2010)—with an increasingly prevalent use of the Internet, Electronic Data Interchange (EDI) networks, and electronic markets (Hanseth and Lyytinen 2010)—IT has been highly prominent in the scholarly debate around organizational arrangements and has evolved to become "one of the threads from which the fabric of organization is now woven" (Zammuto et al. 2007, p. 750).

In particular, IT can spawn organizational forms that are more flexible and less hierarchical (Zammuto et al. 2007) and can fundamentally structure collaborations (Griffith et al. 2003); thus, it has important social implications for organizing transactions (Lyytinen and Damsgaard 2011, Wirtz et al. 2010). Integrating information systems research with new institutional economics, scholars argue that IT can significantly reduce social frictions and transaction costs (e.g., Clemons et al. 1993, Drnevich and Croson 2013).

Based on the benefits of IT in reducing transaction costs, scholars have shown great interest in studying how IT informs make-or-buy decisions. Early discussions suggest that IT will lead to a general shift from hierarchies towards more market-coordinated transactions (Malone et al. 1987). Going a step further, scholars argue that IT has implications beyond the market-hierarchy dichotomy in that it can trigger a "moving to the middle" trend (Clemons et al. 1993, p. 13); that is, while IT facilitates greater levels of outsourcing, firms tend to narrow the number of outside collaborators and to form a long-term and close relationship with them (Bakos and Brynjolfsson 1993).

Notwithstanding the broad discussion of the wide-ranging implications of IT for organizations, there is a key difference between blockchains and prior IT solutions—such as enterprise resource planning, transaction systems, customer relationship management, database management system, graphical user interface, or material requirements planning—in terms of the ability of these IT solutions to serve as a governance mechanism in their own right, and this difference again pertains to enforcement as a key function of governance (Heide 1994, Ménard 2000, Ryall and Sampson 2009, Srinivasan and Brush 2006). In traditional IT systems, "the rules just 'frame' users' way of thinking of operating the IT artifact rather than the IT use being seen as part of an explicit regulatory process that materializes the meaning of the underlying rules" (De Vaujany et al. 2018, p. 756). Consequently, traditional IT solutions merely "invite" social practices to follow the rule, but the actor can force the system around it (De Vaujany et al. 2018). In contrast, blockchains depart from such IT solutions due to blockchains' capability of autonomous enforcement. In blockchains, social interactions are governed by pre-deterministic rules, and, "once the wheels of a smart contract are put into motion, the terms embodied in the code will be executed" (De Filippi and Wright 2018, p. 74).

To illustrate, let us compare blockchains to EDI, which has for a long time been usefully employed to facilitate interorganizational collaboration in supply chains (Drnevich and Croson 2013, Lyytinen 2001). EDI enables "standardized interorganizational communication between independent computerized information systems and associated technological components" (Damsgaard and Lyytinen 1998, p. 276). Although this technology can be highly effective in exchanging information (e.g., procurement orders and shipment notices) and standardizing interactions (Clemons et al. 1993), EDI mainly serves as a support tool rather than a governance mechanism *per se*, because it lacks the ability to enforce agreements. For this purpose, EDI needs to be augmented by contractual and/or relational governance, which provides enforcement prescriptions. Blockchains go beyond EDI in that they make it possible for agreements to be autonomously enforced according to the rules defined in smart contracts (Beck et al. 2018) without (necessarily) resorting to contractual or relational governance mechanisms (De Filippi and Wright 2018). Blockchains implement a private enforcement framework that does not necessarily require the law or expectations of future interaction. This capability of autonomous enforcement makes blockchains unique and sets them apart from other IT solutions. These other solutions do not enforce but merely assume a supportive role to other governance mechanisms—including blockchain governance. For example, scholars view the combination of EDI and blockchains as promising to achieve higher security and to result in fewer errors along the supply chain (Fiaidhi et al. 2018). Further, as will be discussed later, the development of Internet-of-Things devices and sensors may support the verifiability of transactions, thus improving the effectiveness of blockchain governance.

The discussion above resonates with scholarship on sociomateriality, which emphasizes that social practices and technical materials are inseparable (e.g., Barrett et al. 2016, Gaskin et al. 2014, Orlikowski and Scott 2008). What were formerly "purely social" mechanisms (contractual and relational governance) are now backed up by advanced IT solutions, such that the social and the technical are increasingly intertwined in shaping organizational activities. The same logic applies to the technical and social aspects of blockchains, in that the technical features (specifically decentralized consensus and machined-based automation) endow blockchains with wide-ranging social functionalities, potentially transforming the traditional patterns of social interaction. This working in concert of the technical and the social is unique and distinct from other IT solutions. In blockchain governance, technical features are the clear starting point and the central mechanisms through which social patterns are shaped. In contrast, other IT solutions merely supporting traditional forms of governance tend to be "tagged on" after the fact. While they can be effective in supporting and amplifying both relational and contractual forms of governance, such technical solutions are not at their front and center.

Blockchains as Governance Mechanisms

These considerations suggest that blockchains constitute a governance mechanism that is distinct from both contractual and relational governance mechanisms, whereas other forms of IT lack the ability to fully accomplish enforcement. Historically speaking, relational mechanisms of enforcing collaborative agreements could date back to as early as tribal societies (if not even earlier) when humans were co-located face-to-face, while contractual mechanisms appeared with the emergence of binding enforceability through centralized authority. While the subsequent development of information technology has largely augmented the power of the two traditional mechanisms, the recent development of blockchains emerges as a new solution that surpasses the traditional logic of relying on relational bounds between the actors or the binding force of the court. Blockchains may therefore be thought of as the first governance form that truly leverages digital technology's computational- and data-based capabilities in ways that reach far beyond "analog" or traditional forms of social governance. As we elaborate next, the interdependence between the technical and social dimensions of blockchains can explain particular kinds of exchange patterns.

Blockchains facilitating cooperation. By employing machines to automatically execute transactions, blockchains help to mitigate cooperation failure at its source—potential opportunism in human nature (Williamson 1985). As a technology-centered system, blockchains can decrease the leeway for opportunistic behaviors by leading the actors to perform as agreed upon (Lumineau and Oliveira 2020). For example, in proof-of-work-based cryptocurrency blockchains, miners verify every claimed transaction and reject those that are not valid, such as transactions in which someone claims to send more money than he or she has. Other kinds of blockchains also have consensus mechanisms to ensure that invalid activities are rejected. In addition, prescripted smart contracts embedded in blockchains can enable automated transactions when certain conditions are triggered by information feeds. Indeed, the automated execution of transactions combined with the merits of decentralization in blockchains enables immutable records and prevents against unilateral human change. As such, in a system that is run automatically by objective machines, human actors barely have space to violate the documented agreements.

Moreover, since the shared data are highly reliable, records are not only virtually impossible to tamper with (as no one can deliberately distort the established information) but also easily traceable. Therefore, *ex post* opportunistic behaviors are more easily detectable. For instance, one benefit of the GSA procurement blockchain is that it ensures fairness in the governance procurement processes, as it maintains immutable transaction information that is transparent to all the vendors who have permission. As such, it enables mutual monitoring among the vendors to detect potential fraud or gaming.

Despite a better detection of *ex post* opportunistic behaviors, some *ex ante* problems are more intractable, as information asymmetry between parties is inherent and difficult to identify and address. Although blockchains are good at recording information, they cannot perfectly ensure that every source of information is authentic (Catalini 2017). Such limitations may pose a significant impediment to a wider application of blockchains, especially when the digital ledgers are to be connected to physical properties (Arruñada 2018). These issues are referred to as the "first mile/last mile" problem, which exists because human actors are oftentimes involved at the interface between the digital and the physical world (Catalini and Boslego 2019). Nevertheless, we suggest that their decentralized consensus property and data integrity benefit allow blockchains to mitigate *ex ante* adverse selection risks from a different angle—that is, by building a credible reputation system and redefining the payoff structures of deviating behaviors.

To illustrate, in the online purchasing industry, customers often receive low-level products that are claimed by the supplier to be of high quality. Customers may rely on online reviews to gain knowledge about the reputation of a given supplier (Resnick et al. 2000). However, because the reviews are usually hosted by a third party and the reviewing process is not transparent to the public, customers have good reasons to question the integrity of the reviews. With this in mind, suppliers need not view the review system as a credible threat that prevents them from engaging in deviating behaviors. However, with blockchain technology, all transactions and reviews can be faithfully recorded, and tampering or distortion are disallowed, which makes the reviews highly credible. Hence, the costs of deviating behaviors by the suppliers will be increased significantly, as such behaviors will result in credible bad reviews that may significantly harm their reputation and subsequent performance. In turn, both *ex ante* and *ex post* opportunism can be mitigated by using blockchains.

Blockchains facilitating coordination. While their unique approach of enforcing agreements provides an important mechanism for supporting cooperation between transacting parties, blockchains also offer promising opportunities for facilitating coordination. For instance, Walmart has launched a food supply blockchain to improve the traceability of its products (Allison 2018). Using this blockchain to organize transactions with its suppliers not only prevents opportunism from deceitful suppliers (i.e., integrity issues) but also helps to identify quickly and pass certain information to those who simply did something wrong and want to remedy the mistake (i.e., competence issues). Similarly, the blockchain initiated by Construtivo, a Brazilian software company, offers a solution to burdensome information sharing, especially during the design and construction phases of infrastructure projects, by storing crucial project data on a blockchain and making this information available to contractors and engineering companies (Greenspan 2017). With the blockchain, collaborating parties have trustworthy and consistent knowledge about the status and progress of their joint project.

While a considerable portion of coordination features are inherited from other IT, others are unique to blockchains. Importantly, because the data shared through blockchains are independently verified, blockchains enable parties who do not fully trust each other to create consensus about a set of shared facts (Brown 2016). In blockchains, information must be validated by multiple independent entities, which can dramatically increase data integrity and reliability. In essence, blockchains collapse the two processes of data exchange and the reconciliation of records into one. For example, in the shipping industry, entities normally coordinate with each other by using EDI, e-mails, and phone calls, which can create inefficiencies and errors in locating a particular container when data are stored in separate systems (IBM 2018b). As a solution, the TradeLens blockchain led by Maersk and IBM enables nearly real-time data sharing and realizes data reconciliation across the network in a decentralized way (Aitken 2018).

In addition to supporting *procedural* coordination (i.e., day-to-day communication and exchange of information), blockchains can also facilitate *structural* coordination between transacting parties (i.e., the distribution of rights and responsibilities in a relationship, such as the division of labor, roles, and task descriptions). Specifically, the structural coordination of blockchain governance is implemented through machine consensus (Hsieh and Vergne 2018). Machine consensus refers to the process by which participants in a blockchain reach agreements based on the codes and algorithms that define the rules and protocols of the system. In such a system, the parties can choose to join or leave at will, but once they have joined the blockchain, it is implied that they acknowledge and accept the predefined rules. Given their formalized nature, blockchains work as written and traceable knowledge repositories that contain information about how the whole system functions. Collaborating parties in the blockchain can obtain a sense of the plans and rules that can enable the parties to identify how the protocol defines responsibilities for tasks (i.e., accountability) and makes sure the tasks are performed in a preplanned manner (i.e., predictability) (Okhuysen and Bechky 2009). Building on such knowledge, everyone who is authorized to access the system can reach a common understanding of how their work fits with the collective goal.

The extreme case of the blockchain-based organization DAO (decentralized autonomous organization) illustrates how blockchains facilitate structural coordination via machine consensus (Catalini and Boslego, 2019, Hsieh et al. 2018, Murray et al. 2020). A DAO has no centralized manager giving administrative orders or assigning tasks to the organization’s employees. Without centralized administrators, routine activities are coordinated and performed based on the structural specification of the actors’ roles encoded in algorithms. Software rules execute organizational routines. For example, the distributed venture capital fund called The DAO (or Đ) was instantiated on the Ethereum blockchain and had neither people in a formal manager role nor a physical address. Investors voted on project proposals by using tokens, and eventual payouts to investors were determined and executed based on their votes and the subsequent performance of the projects as measured by the prescribed smart contracts (Murray et al. 2020). This example showcases how algorithms can replace human actors in coordinating organizational activities by virtually assigning roles to different actors. Accountability, predictability, and common understanding are all pursued through machine consensus instead of through interactions between human actors. The governance of DAOs shows that, even in the absence of a central party giving instructions and distributing information, blockchains can realize coordination among autonomous actors in a decentralized way.

Scope of Blockchains as Efficient Governance Mechanisms

Just like other governance mechanisms, blockchains are unable to govern all types of transactions equally well. Next, we discuss the types of transactions for which blockchains appear most relevant, along with the types of transaction costs most likely to be affected by blockchains. The choice of governance mechanism is fundamentally shaped by the nature of the transaction (Masten et al. 1991, Williamson 1996). To delineate the scope of blockchain governance, we build on the notion of tacitness as a key attribute of the transaction (e.g., Bell et al. 2009, Heiman and Nickerson 2002, Nooteboom 1992) to provide a contingent examination of efficient blockchain governance as a function of the transaction's level of codifiability and verifiability.

The proper execution of a transaction rests on fundamental information about its cornerstones, including responsibilities, procedures, and objectives. Whereas such attributes are rather explicit for certain transactions, they can be highly tacit for others. At the broadest level, tacitness can be defined as the difficulty of communicating information (Polanyi 1958). In the context of economic transactions, tacitness can be broken down into two fundamental problems: the codifiability and the verifiability of the transaction. High tacitness implies that it is difficult to codify key transaction attributes (Hennart 1988, Kogut and Zander 1992). For instance, certain transactions may confront their parties with complications in appropriately specifying the good to be transferred or encoding the detailed usage rights associated with it (Levi et al. 2003). In short, when the tacitness associated with a transaction is higher, its codifiability is lower. In addition, highly tacit transactions are fraught with behavioral uncertainty (Reed and DeFillippi 1990, Simonin 1999), making it very difficult for a third party to measure productivity and assess the quality of the transacting parties' performance (Macho-Stadler et al. 1996, Nooteboom 1992). Whereas verification is relatively straightforward when the transaction attributes are clearly understood, a highly tacit transaction is typically much more difficult to verify (Heiman and Nickerson 2002).

The nature of the transaction, including its tacitness, has direct implications for the transaction costs associated with its governance. Various types of transaction costs can incur (Masten et al. 1991); we organize our discussion around the established distinction between *ex ante* and *ex post* transaction costs (Dyer 1997, Williamson 1985).

Ex ante transaction costs. When setting up a transaction, distinguishing partners who will behave opportunistically from those who will not is a critical step in initiating an exchange between parties, but it also creates nontrivial searching costs (Williamson and Ouchi 1981). Specifically, we refer to the transaction costs of gathering information to identify and evaluate potential trading partners. Blockchains can help to lower these costs. Given the mechanical execution inherent to smart contracts, the willingness of a party to enter into a smart contract can be interpreted as "a precommitment not to behave opportunistically in the future" (Yermack 2017, p. 26). This self-selection of transacting partners may signal both their intention to respect the agreement and their ability to do so. By deterring opportunistic partners, blockchains may therefore be particularly useful to reduce the transaction costs traditionally associated with the process of searching for and selecting among several potential candidates.

Ex ante transaction costs also include designing costs, which are the costs associated with negotiating and writing an agreement. With regard to governance design, a main challenge for the efficient use of blockchains relates to the codifiability of the transaction. Codifiability refers to the ability to precisely characterize in electronic format the specified product/service, delivery, and settlement requirements in a manner that is understandable to relevant parties (Kleindorfer and Wu 2003, Levi et al 2003). The notion of codifiability has long been applied to differentiate tacit vs. explicit knowledge within organizations (e.g., Balconi 2002, Zander and Kogut 1995), and it has more recently been extended to the interorganizational setting to depict the characteristics of transactions (e.g., Levi et al. 2003, Parmigiani and Rivera-Santos 2011). We suggest that the level of codifiability of the transaction has a significant influence on the setup costs associated with blockchain governance and on its efficiency as a governance mechanism. As a type of formal governance mechanism, blockchain governance relies on codifying transaction requirements into computer code. If the object of exchange is hard to codify in nature, the increase in setup costs implies that blockchain governance becomes less efficient. For example, the complexity of a product description, which is defined as "the amount of information needed to specify the attributes of a product in enough detail to allow potential buyers […] to make a selection" (Malone et al. 1987, p. 486), is a relevant dimension of codifiability—with rising complexity, codification becomes costlier and blockchain governance less efficient.

Ex post transaction costs. A first set of *ex post* costs comprises monitoring costs, which denote the costs associated with monitoring the agreement to ensure that each party fulfills the predetermined set of obligations. As discussed above, blockchains facilitate real-time, transparent, and verified information sharing among transacting parties. Such data integrity and reliability can support an improved detection of opportunism while mitigating monitoring costs (Roeck et al. 2019). A second set of *ex post* transaction costs is that of enforcement costs, which are the costs associated with *ex post* bargaining with and sanctioning a partner who does not perform according to the agreement. The high transparency of secured data in blockchains greatly simplifies dispute resolution. In fact, IBM (2017) reports that the implementation of blockchain technology has significantly reduced the average time to settle disputes across suppliers and partners.

However, the relevance of blockchains as an efficient governance mechanism that reduces *ex post* transaction costs is constrained by the level of verifiability of the transaction. Verifiability denotes the extent to which the quality provided by the transacting parties can be observed and verified *ex post* (Dulleck et al. 2011), with verifiability being highest among search goods and lowest among credence goods (Nelson 1970, Darby and Karni 1973). In the context of contractual governance, a lack of verifiability is known to produce difficulty in enforcing contractual agreements, which can create significant appropriability hazards (Oxley 1997). The verifiability issue is even more critical for the automatic enforcement inherent to blockchain governance, which strongly relies on high levels of verifiability of the transactions. If the information for the transaction is hard to verify, then human actor intervention and *ex post* negotiation will be necessary. Such interventions not only produce coordination costs but also open the door for opportunistic behaviors (Poppo et al. 2008b). For example, the "oracle problem" in blockchains refers to the possibility that flawed or incorrect information provided by the transacting parties inappropriately triggers the execution of a smart contract (Murray et al 2020). Such a scenario implies a potentially high level of residual risk when the transaction is low in verifiability, reducing the efficiency of blockchain governance.

In sum, we suggest that blockchain governance may reduce searching, monitoring, and enforcement costs but tends to imply relatively higher designing costs.[2] Table 2 outlines the level of relevance of blockchains specifically as a function of the type of transaction (tacit vs. explicit). We especially note the importance of codifiability and verifiability as two transactional characteristics that have an important impact on the efficiency of blockchain governance. When the transaction is subject to information asymmetry and disturbances that occur frequently and are hard to predict—either endogenous in terms of the evolution of the transaction (e.g., R&D) or exogenous (e.g., technological changes)—codifiability and verifiability are likely to be affected. Specifically, because both *ex ante* and *ex post* transaction costs will increase when the level of codifiability and verifiability is low, we suggest that blockchain governance will be most efficient when the requirements of the transaction are codifiable and the performance and deliverables of the transacting parties are verifiable.

---Insert Table 2 about here---

Discussion and Implications

By elaborating how blockchains differ from traditional contractual and relational mechanisms in governing transactions, we have suggested extending the traditional dichotomy between contractual versus relational governance by also considering blockchain governance. In this section, we begin to discuss the interplay between blockchain governance and traditional contractual and relational mechanisms. We then advance a broader research agenda of future research opportunities for organization science scholars regarding the use of blockchains for governing collaborations.

On the Interplay between Blockchain Governance and Traditional Governance

As parties often opt to simultaneously use different governance mechanisms to organize their transactions (Poppo and Zenger 2002, Ryall and Sampson 2009), understanding the interplay among these mechanisms has both theoretical and practical relevance. Since the seminal article by Poppo and Zenger (2002), governance scholars have paid much attention to whether contractual and relational mechanisms substitute for or complement each other (see Cao and Lumineau 2015, Poppo and Cheng 2018 for recent reviews). Following Siggelkow's (2002) definitions, a substitutive effect means that the marginal benefits of one mechanism *decrease* with increasing levels of the other, while a complementary effect means that the marginal benefits of one mechanism *increase* with increasing levels of the other.

Whether two types of governance work in a substitutive or complementary relationship depends on the tension between two sets of forces. First, governance mechanisms can be mutually *replacing* (i.e., one type of governance can perform equivalent functions to the other) versus *compensating* (i.e., one type of governance mechanism has unique strengths that compensate for the weaknesses of the other). Second, mechanisms can be *dampening* (i.e., one type of governance hampers the basis or strengths of the other) versus *enabling* (i.e., one type of governance creates the conditions to facilitate the other) (Huber et al. 2013). We argue that blockchains have the potential to significantly alter the way contractual and relational mechanisms can be used, but that their impact depends on the type of transaction (explicit vs. tacit).

In the context of *explicit* transactions, such as sourcing standardized construction materials, we suggest that blockchain governance will have a *replacing* impact on traditional governance mechanisms. Its effect can be equivalent to that of both contractual and relational governance. When governing transactions that are codifiable and verifiable, blockchains enable a high level of technology-based enforceability and reliability, thus replacing some of the core functionalities of contracts and outperforming relational governance on the enforceability and reliability dimensions.

Furthermore, in explicit transactions, most of the coordination requirements pertain to organizing tasks that involve relatively few unexpected events, tend to be rather static and routinized, and thus can be relatively easily codified. As discussed in the previous section, blockchains will be even more relevant when transactions are highly codifiable and verifiable. Therefore, the need to use contractual governance for codification can be replaced by relying on the formalized nature of blockchain governance. At the same time, as information can be more easily and effectively transferred across actors when it is codified

(Prencipe and Tell 2001), blockchains can replace the coordination function of relational governance, which relies on the norms of information exchange, flexibility, and solidarity for coordination (Mesquita and Brush 2008).

These replacing effects can be further strengthened by the fact that, in explicit transactions, the cost of using blockchain governance can be lower than traditional governance alternatives. On the one hand, blockchain governance can be autonomously enforced, making it cheaper than contractual governance, whose legal enforcement comes at a relatively high cost. On the other hand, blockchain governance is likely to be less expensive and easier to implement than relational governance, as the development of trust and relational norms is usually costly and time consuming (Larson 1992). Specifically, in explicit transactions, the parties can make specific plans before the transaction occurs and do not need high levels of flexibility; thus, the setup costs of blockchains are manageable.

Therefore, for explicit transactions, blockchains can fulfill almost all of the governance functions of contractual and relational mechanisms but in a potentially faster and cheaper way. For example, blockchains help transacting parties bypass the need for a trusted third party in traditional exchange systems. Such a difference allows the allocation of more revenue to the parties themselves since no centralized party charges for rents in the middle. Given the feasibility and efficiency of using blockchains to govern explicit transactions, the extra costs of employing contractual and relational governance mechanisms are unnecessary. In the presence of blockchains, the marginal benefits of introducing the other two mechanisms are significantly lowered. Therefore, for explicit transactions, we expect blockchains to have a substitutive effect for both contractual and relational governance mechanisms.

When parties engage in *tacit* transactions, such as collaborating on joint R&D activities or building a power plant, they will likely have to adapt to unforeseeable and unpredictable contingencies (Baumard 1999). Tacitness creates significant uncertainty (Reed and DeFillippi 1990, Simonin 1999), and although planning is still an important part of tacit transactions, perfect *ex ante* planning is virtually impossible, so maintaining flexibility is pivotal.

In this kind of transaction, while blockchains may still have certain advantages, using blockchains alone to govern the exchange may not be an optimal choice for the following two reasons. First and most importantly, machines, at least in their current stage of evolution, are simply following orders given by humans. While humans cannot specify all the contingencies in advance due to their cognitive limitations (Simon 1957), machines do not have the required contextual knowledge and subtle understanding to adjust to changing scenarios (Werbach 2018). In addition, blockchain designers must use machine-readable language to depict the complexity and multiplicity of events in reality, which again limits the scope of blockchains to those activities that can be relatively easily and precisely specified. Second, blockchains have limited effectiveness in coordinating tasks that involve many exceptional, dynamic, and unpredictable cases, which are common in tacit transactions. Therefore, because of the codification and verification challenges, the benefit of using blockchains will be considerably lower in tacit than in explicit transactions, and the interplay between blockchain and traditional governance requires further analysis.

Specifically, we suggest that, in tacit transactions, the *replacing* effect of blockchain governance on contractual governance continues to exist, although to a smaller extent than in explicit transactions. Blockchains may still reduce the need for detailed formal contracts if the parties organize part of the collaboration using blockchains, which implies a substitutive effect between blockchains and contracts. For example, for the major tasks (such as the R&D part of an innovation project), the transacting parties may still rely on traditional governance mechanisms. While payment is usually labor intensive, opaque, and costly (Felin and Lakhani 2018), the parties can employ the blockchain technique and enjoy its benefits, such as convenience, privacy, safety, and verifiability. Transacting parties can also use blockchains to record and trace the production process and the quality of the materials in the supply chain (Hsieh and Vergne 2018); hence, the stressful effort of including monitoring terms in the contract (Ghoshal and Moran 1996, Lumineau 2017) can be reduced to some extent. In addition, given the advantages of blockchains in promoting faster information sharing and trustworthy information recording, part of the coordination function of contracts can be substituted by blockchains. In the case of the Construtivo blockchain mentioned above, since the parties have access to both the agreed-upon requirements that have been faithfully recorded and real-time knowledge about the state of the project that is written into the blockchain, it appears less critical to include in the legal contract some of the traditional coordination clauses used in the construction industry (such as drawings, technical specifications, and communications clauses; Chen et al. 2018, Oliveira and Lumineau 2017). If key information underlying a transaction can be formally recorded, the logic of replacing suggests a substitutive relationship between contractual and blockchain governance.

As for relational governance, we expect a salient *enabling* effect of blockchains on the development of subsequent relational mechanisms. For example, the transacting parties can use blockchains to build a reputation system, which provides a credible signal that builds confidence for each party that their partner will likely behave in an honest and trustworthy way, even if circumstances change and adaptations are needed. Thus, a strong sense of goodwill can be generated as a basis for further communication and information exchange, which is beneficial for the development of trust and relational norms (Hoetker and Mellewigt 2009). This situation implies a complementary effect of blockchain governance on relational governance.

Although blockchains are initially designed to eliminate the need to rely on personal trust, they turn out to be an effective approach to nurturing future trust and relational norms between the parties. Recently, scholars have begun to debate whether blockchains eliminate, create, or redefine trust (Baur and Van Quaquebeke 2017, Botsman 2017, Werbach, 2018). We speak to this debate by advancing boundary conditions for the influence of blockchains on trust. The paradoxical relationship between blockchain and relational governance again shows the importance of a contingent analysis in determining the functions of governance mechanisms (Cao and Lumineau 2015).

Overall, our discussion highlights the need to consider contingencies affecting the relevance of blockchains as an efficient governance mechanism by itself and in combination with contractual and relational governance. We invite organization scholars to extend this line of contingent inquiry and, along with a variety of other dimensions, further analyze the types of collaborative activities that blockchains can reliably govern. The broader digitalization trend in virtually all industries will likely expand the scope of transactions that blockchains can efficiently govern and may thus dynamically alter the patterns of interplay between blockchains and traditional contractual and relational mechanisms.

A Word of Caution

While blockchains clearly show great potential, it is important to remain cautious about the current "hype," as blockchains are far from being a panacea. Several important limitations need to be considered associated with the use of blockchains. Notably, while blockchains are good at keeping data secure, they remain prone to attacks, such as when, in 2016, users exploited a loophole in the blockchain's code to sideline one-third of The DAO's funds to a subsidiary account (Siegel 2016). Since the codes are written by boundedly rational humans, potential gaps in the fundamental blockchain structure are always a possibility. In addition to these issues of competence, another weak link in the use of blockchains relates to the possibility that those writing the software embed malicious code that remains invisible to outside observers (Werbach 2018). The inflexibility of blockchain structures makes such issues even more problematic.

Further, as suggested by Catalini (2017), blockchains' information immutability is useful only when the original information entered is accurate. However, when the transferred and recorded information is not native to the blockchain, the first mile/last mile problem arises (Halaburda 2018). This problem refers to the need to include verifiers to evaluate information that is external to the blockchain and to provide the results to the nodes on the blockchain (Xu et al. 2017), opening new possibilities for opportunism.[3]

Finally, blockchains can serve as a platform for potentially illegal operations and criminal activities. Similar to many other technologies, blockchains can be employed for both good and nefarious purposes and can induce an arms race between law enforcers and criminals (e.g., Dai et al. 2017, Xu 2016). Transactions between terrorists and criminals' money laundering activities are likely more difficult to detect and monitor when blockchains are employed by these parties. The further diffusion of quantum computing and artificial intelligence could be both a boon and a bane for the development of blockchains, as these emerging technologies can support both better cryptography and easier hacking.

Blockchains are still in an early stage of development, and the trade-offs between the benefits and drawbacks of blockchains will continue to open debates and be the focal consideration of organizations deciding whether to employ the technology.

A Research Agenda for Organization Scholars

Our analysis has emphasized that blockchains have the potential to change the way actors collaborate. For organization scholars to extend this line of inquiry, this section proposes a research agenda for future research opportunities regarding the use of blockchain governance. We organize our agenda around the "5W and 1H" approach (Dubin 1978, Whetten 1989)—the questions of what, who, why, when, where, and how. As a set, these elements constitute the essential building blocks of a comprehensive phenomenological theory (Whetten 1989).

What. The first step in further improving knowledge of how blockchains can change the way we collaborate is to develop a deeper understanding of the nature of blockchains themselves. Moving beyond the fundamental features of blockchains discussed in this article, different types of blockchains vary significantly (e.g., public, private, and consortium blockchains), making it necessary to identify critical dimensions along which blockchain governance may differ. For instance, one possible approach to addressing this issue is to consider their degree of hierarchy. Whereas certain blockchains rely mostly on the pricing mechanism, which makes them more market-like, others create certain levels of power discrepancy among transacting parties, which makes them more hierarchical (e.g., the GSA procurement blockchain). Having established relevant dimensions, future research could, in a subsequent step, identify the specific antecedents driving the choice of certain types of blockchains over others.

To delve deeper into different forms of blockchains, a related question is, "What are the specific control or coordination mechanisms of blockchain governance that support collaboration?" The extant literature has documented specific mechanisms of contractual and relational governance. Contracts help to achieve cooperation and coordination by specifying rights and obligations, penalties, conflict resolution rules, task divisions and roles, and contingency adaptations (Lumineau and Malhotra 2011, Schepker et al. 2014), whereas relational governance builds on the norms of information exchange, solidarity, and flexibility (Mesquita and Brush 2008, Poppo and Zenger 2002). In turn, it is important to know how we can specifically describe the mechanisms underlying the computer codes that build a blockchain. We see exciting empirical opportunities to analyze how these computer codes reflect or induce relevant social behaviors. Specifically, we see significant value in developing constructs and empirical measures to depict the design features reflecting the cooperation and coordination functionalities of blockchain governance.

Who. The use of blockchain governance has a potentially important impact on who is collaborating with whom. Notably, blockchains support collaboration among strangers lacking social connections, significantly broadening the pool of potential collaborators. For instance, since blockchains can help standardize cooperation and coordination, they can potentially further accelerate crowd-focused collaborations, where organizations work with independent contributors to tackle innovation challenges and leverage extra-organizational resources and talent (Giustiniano et al. 2019). Hyperloop Transportation Technologies, Inc. is just one example of a crowd-based organization (Majchrzak et al. 2018) that is developing a blockchain-based ecosystem (Marchesoni 2019).

Scholars can explore how changes in the pool of collaborators affect current business models. The IBM, AIG and Standard Chartered collaboration discussed above represents a good example of how blockchains can transform an industry and its traditional protagonists—e.g., cutting out insurance brokers—by relying on online crypto platforms that do not require intermediaries. Further studies can also elucidate how blockchains may disrupt certain industries or generate entirely new markets, such as blockchain consulting and auditing-related businesses.

Another important question to be considered is, “What kinds of actors can be the most effective in using blockchains to govern collaborations?” Just as firms differ in their contractual-design capabilities (Argyres and Mayer 2007) and trust-building capabilities (Barney and Hansen 1994, Schilke and Cook 2015), a resource-based perspective suggests that the capability to employ blockchain governance mechanisms may also differ across firms. Beyond human factors (e.g., expertise of the employees), such heterogeneity could be a function of both organizational (e.g., firm structure) and technical aspects (e.g., access to and investment in certain hardware).

Scholars may also move beyond the focal collaborators and discuss, “Who will be broadly impacted?” Similar to the effects of other IT innovations (Clemons et al. 1993, Malone et al. 1987), the parties most directly influenced may be the intermediaries. In particular, the adoption of blockchains is likely to significantly disrupt those intermediaries who generate revenue from their positions of market power.

However, this possibility does not imply that intermediaries will be obliterated entirely, and the real implications of blockchains on intermediaries might be more complicated. For example, Catalini and Gans (2020) suggest that, although intermediaries may not be needed in most blockchain-powered digital transactions, they could still work complementarily on tasks such as digital forms of verification for off-line assets. Other relevant stakeholders affected by blockchains may include regulators, lawyers, and lobbyists. These influenced parties are actively seeking actions in response to the changes brought about by blockchains. For example, some banks (e.g., the Bank of England) have already started to experiment with using blockchains to issue their own digital currencies (Haig 2018). Governments have begun to consider the potential problems that might arise with blockchains and the necessary regulations.

Why. A deep and systematic discussion of the motivations for using blockchains involves considering their implications in the economic, social, and sometimes political realms. Although we have thus far primarily discussed their potential economic benefits for firms, blockchains are also appealing to a broad range of other actors with a diversity of objectives.

For many citizens, blockchains offer a way to address a crisis of confidence in traditional institutions and avoid a reliance on centralized authorities, especially given that individuals often desire greater access to and transparency of information that has been controlled mostly by large entities (e.g., large platform owners, central banks, and governments). For instance, citizens may want blockchains to help make election processes more trustworthy by lessening voting fraud concerns. Similarly, given that information on blockchains is not fully controlled by any single party, blockchains may be useful in the building of open information networks that are free of government censorship. For nongovernmental organizations, blockchains may help to provide emergency relief for humanitarian crises. The United Nation's World Food Programme directed crypto-based vouchers to approximately 10,000 Syrian refugees using the Ethereum blockchain (del Castillo 2017). Start-ups may use blockchains to issue their own tokenized currencies to attract funding from a wide source of investors, a process known as an initial coin offering, which can allow entrepreneurs to raise funding more easily and more quickly than traditional financing approaches can. Of course, actors are driven by more than efficiency considerations to adopt blockchains. As such, more research is warranted to study the early adoption and diffusion patterns of blockchains, since the diffusion of any complex technology is influenced by multiple dimensions, such as scientific, public and economic ones (Yoo et al. 2005).

When. A rather straightforward but nevertheless important question to be answered is, "When is it more suitable for entities to adopt blockchains?" Analysis should be more detailed of the efficient domains of blockchains, both individually and in combination with traditional governance mechanisms. Distinguishing between tacit and explicit transactions is only one way to characterize transactions. Other approaches (e.g., digital vs. physical assets or bilateral vs. multilateral ties) can be used to classify and examine the suitability of blockchains. A criterion to define "more suitable" should be established before such an analysis. An integral analysis of the benefits and the costs of using blockchains and a simple consideration of the difficulty of implementing the technology may elicit different conclusions. Complementary lines of inquiry may explore a variety of antecedents to the (suitable) use and ideal design of blockchains, and, in particular (1) the conditions under which blockchains are the most efficient mode of governance relative to market, hierarchy, or hybrid forms; (2) how asset specificity, uncertainty, and frequency influence the blockchain design (e.g., permissioned or permissionless, type of verification protocol, consensus mechanism, data structure, block size, and frequency of block updates); and (3) how preexisting relational norms and/or contractual relationships between parties influence the design of blockchains as a governance mechanism.

Following the logic used in the majority of empirical (cross-sectional) studies in the field, this article has approached the interplay between governance mechanisms in a static way. We acknowledge that this approach is limited and that more dynamic extensions of our analysis are needed. For instance, parties may have developed relational norms when entering into a contract, which may influence both the design and the implementation of contractual governance (Klein Woolthuis et al. 2005), and, vice versa, preexisting contracts can influence the development of relational norms (Lumineau 2017, Schilke and Cook 2013). In the same way, blockchains imply that certain collaboration and coordination rules are coded into the initial specification, which can have important downstream consequences on the evolution of trust and the usage of contracts. Conversely, the preexisting degree of relational and contractual governance has important implications for the necessity and efficiency of blockchains. We therefore encourage future studies to explore the dynamics of governance mechanisms and their mutual influence over time.

Future studies could also extend our analysis by focusing on how different parties manage the necessary human involvement, overcome their conflicting interests, and engage in joint action to develop a blockchain system. Similarly, we invite scholars to pay attention to how the challenge of integrating blockchains with other IT systems and related infrastructures (e.g., Internet stack) may influence the design and implementation of blockchains as well as their ability to support cooperation and coordination. We also see exciting opportunities to further analyze the supporting role of other IT-based solutions, as they augment the three governance mechanisms discussed here. Indeed, there is much potential for research at the interface of information systems and organization design to illuminate a great variety of blockchain design decisions.

Where. Scholars may also investigate the influence of the external environment on the use of blockchains. For example, the technological maturity of a particular market is apparently relevant since using blockchains will require a certain standard of network and hardware infrastructure. In addition, legal maturity is a potentially important factor to be considered. In countries with weak legal institutions and where the costs of enforcing formal agreements can be very high (Cao et al. 2018), the benefits of using blockchain governance over contractual governance may be larger than in countries where legal institutions are strong. Another question to be answered is, "Will the major dimensions of culture influence the use of blockchains, as they do for contractual and relational governance mechanisms?" For example, given the different levels of uncertainty avoidance embedded in a certain culture, will people who are more risk averse favor the use of blockchains for their security and autonomous nature, or will such people oppose blockchains to avoid unlikely but still plausible hacks?

How. For the "how" questions, we direct attention to the underlying processes that help explain how the use of blockchains impacts relevant outcomes. The first question is, "How do blockchains influence the performance of collaborations?" We clearly lack empirical evidence on the impact of blockchains on relevant performance indicators, such as cost overruns, delays, quality control, or partner satisfaction.

Beyond performance, scholars may also consider how blockchains influence certain organizational and interorganizational processes, such as learning or knowledge transfer.

We also see the possibility of blockchains having implications for the classical boundary-of-the-firm problem, raising the question of "How do blockchains influence the scope of organizations?" Boundaries of the firm, or how firms establish their scope, have been a central issue in the economic and organization literature (Poppo and Zenger 1998). Scholars have developed different theories and approaches to analyzing this problem; among them, transaction cost economics (TCE) and the resource-based view (RBV) have been widely used (e.g., Holcomb and Hitt 2007, Leiblein and Miller 2003). Importantly, advancements in IT can substantially reduce transaction costs, potentially promoting the efficiency of market exchanges (Clemons et al. 1993, Malone et al. 1987). At least under certain conditions, blockchain governance may incur lower transaction costs than those incurred by contractual and relational governance. Therefore, blockchain governance may act as a driving force that pulls the "make-or-buy" decision towards the market (Catalini and Boslego 2019).

Interesting opportunities also reside in further disentangling the dynamic interdependence between the social and technical dimensions of blockchains. This mutually reinforcing interplay influences organizational outcomes (Orlikowski and Scott 2008) and may even redefine the rules of exchange (Gal et al. 2014). The reciprocal relationship between the social and technical features of blockchains is likely to support the development of new affordances (Yoo et al. 2012, Zammuto et al. 2007). Future studies could pay attention to the way the blockchain technology is adopted, diffused, and used in practice. We see particular interest in analyzing the social construction of blockchain governance and in studying how different stakeholders shape their design and meaning across specific contexts as a function of their resources, powers, or capabilities. With blockchains, new combinations of technological and organizational features are likely to enable original social behaviors and innovative exchange patterns.

We also see many opportunities at the intersection of these key questions. For instance, the "Why" question must be considered in conjunction with the "Who" question, as the goals of blockchains may differ as a function of the different actors involved. The "How" question should be addressed together with the

"Where" and "When" questions to untangle the contingent effects of blockchains on performance in different settings. Our discussion of future research opportunities also shows the importance of blockchains in expanding our understanding of traditional theoretical predictions. For instance, how different factors influence the structure of blockchains and how the boundary of firms will be impacted reflect potential modifications of TCE predictions on the determinants of governance mechanisms. The investigation of the heterogeneous characteristics of the entities adopting blockchains may generate conclusions that are complementary to the RBV. How blockchains impact the information and knowledge diffusion between collaborating parties illustrates an expansion of the knowledge-based view of the firm. With regard to intraorganizational issues, blockchains could allow us to revisit corporate governance problems, including the monitoring of principal-agent relationships from an agency-based perspective. Going beyond dyadic collaborative relationships, we can also consider how, at a higher level, blockchains connect and organize relevant stakeholders from a network perspective. Such a reflection on classical theories shows the important potential of blockchains to reshape our understanding of the traditional assumptions, relationships, and predictions suggested in the extant literature.

Conclusion

In this article, we advance blockchain governance as a new way of organizing collaborations to achieve both cooperation and coordination. We suggest that, in many ways, blockchain governance works differently than traditional contractual and relational governance. Such differences generate rich possible avenues for organization scholars to investigate how blockchains are used to organize collaborations. We hope that this article represents a useful starting point to study the many futures of blockchains from an organization science perspective.

Endnotes

1. In our analysis, we adopt a broad approach to conceptualizing blockchain technology, which encompasses both the distributed ledger itself and the preprogrammed algorithms commonly referred to as smart contracts (Murray et al. 2020). However, we acknowledge that blockchains come in various forms, such as permissioned vs. permissionless, and rely on different consensus types, such as proof-of-work, proof-of-stake, and delegated proof-of-stake. In the main part of the article, we refer to the most common forms of blockchains, but the Discussion section highlights some of the opportunities associated with developing a more nuanced understanding of the diverse features of blockchains along several dimensions.
2. We have discussed each type of cost separately for analytical purposes, but we acknowledge that they are interdependent and that transaction costs should be assessed in a comparative way across governance choices.
3. To ameliorate the first mile/last mile problem, at least two approaches might be useful. The first is the development of Internet-of-Things devices and sensors, which can help to collect information automatically without human interference. The other is to complement the deficiency of blockchain governance by using other mechanisms. Especially with permissioned blockchains, trust is a central mechanism for reducing opportunism and lessening the potential hazard of the first mile/last mile problem (Halaburda 2018).

REFERENCES

Achrol RS, Gundlach GT (1999) Legal and social safeguards against opportunism in exchange. *J. Retailing* 75(1):107-124.

Aitken R (2018) IBM forges global joint venture with Maersk applying blockchain to 'digitize' global trade. Accessed Mar 25, 2020, https://www.forbes.com/sites/rogeraitken/2018/01/16/ibm-forges-global-joint-venture-with-maersk-applying-blockchain-to-digitize-global-trade/#b232864547e8.

Allison I (2018) IBM's food blockchain is going live with a supermarket giant on board. Accessed Feb 6, 2020, https://www.coindesk.com/ibm-food-supply-chain-blockchain-carrefour-live-production.

Argyres N, Mayer KJ (2007) Contract design as a firm capability: An integration of learning and transaction cost perspectives. *Acad. Management Rev.* 32(4):1060-1077.

Arruñada B (2018) Blockchain's struggle to deliver impersonal exchange. *Minnesota J. Law Sci. Tech.* 19:55-105.

Baker G, Gibbons R, Murphy K (2002) Relational contracts and the theory of the firm. *Quart. J. Econom.* 117(1):39-84.

Bakos JY, Brynjolfsson E (1993) Information technology, incentives, and the optimal number of suppliers. *J. Management Inform. Systems* 10(2):37-53.

Balconi M (2002) Tacitness, codification of technological knowledge and the organisation of industry. *Res. Policy* 31(3):357-379.

Barney JB, Hansen MH (1994) Trustworthiness as a source of competitive advantage. *Strategic Management J.* 15(8):175-190.

Barrett M, Oborn E, Orlikowski W (2016) Creating value in online communities: The sociomaterial configuring of strategy, platform, and stakeholder engagement. *Inform. Systems Res.* 27(4):704-723.

Baumard P (1999) *Tacit Knowledge in Organizations* (Sage, London).

Baur D, Van Quaquebeke N (2017) The blockchain does not eliminate the need for trust. Accessed Mar 25, 2020, http://theconversation.com/the-blockchain-does-not-eliminate-the-need-for-trust-86481.

Beck R, Müller-Bloch C, King JL (2018) Governance in the blockchain economy: A framework and research agenda. *J. Association Inform. Systems* 19(10):1020-1034.

Bell SJ, Tracey P, Heide JB (2009) The organization of regional clusters. *Acad. Management Rev.* 34(4):623-642.

Botsman R (2017) How the blockchain is redefining trust. Accessed Mar 25, 2020, https://www.wired.com/story/how-the-blockchain-is-redefining-trust.

Brown R (2016) On distributed database and distributed ledgers. Accessed Mar 25, 2020, https://gendal.me/2016/11/08/on-distributed-databases-and-distributed-ledgers/.

Cao Z, Li Y, Jayaram J, Liu Y, Lumineau F (2018) A meta-analysis of the exchange hazards–interfirm governance relationship: An informal institutions perspective. *J. Internat. Bus. Stud.* 49(3):303-323.

Cao Z, Lumineau F (2015) Revisiting the interplay between contractual and relational governance: A qualitative and meta-analytic investigation. *J. Oper. Management* 33-34(January):15-42.

Catalini C (2017) How blockchain applications will move beyond finance. *Harvard Bus. Rev.* (March 2), https://hbr.org/2017/03/how-blockchain-applications-will-move-beyond-finance.

Catalini C, Boslego J (2019) Blockchain technology and organization science: Decentralization theatre or novel organizational form? Working Paper, Massachusetts Institute of Technology, Cambridge.

Catalini C, Gans JS (2020) Some simple economics of the blockchain. *Communications of the ACM* Forthcoming.

CBInsights (2020) Investment to blockchain startups slips in 2019. Accessed Mar 25, 2020, https://www.cbinsights.com/research/blockchain-investment-trends-2019/.

Chen Y, Wang W, Zhang S, You J (2018) Understanding the multiple functions of construction contracts: The anatomy of FIDIC model contracts. *Construction Management and Econom*. 36(8):472-485.

Clemons EK, Reddi SP, Row MC (1993) The impact of information technology on the organization of economic activity: The "move to the middle" hypothesis. *J. Management Inform. Systems* 10(2):9-35.

Cole R, Stevenson M, Aitken J (2019) Blockchain technology: Implications for operations and supply chain

management. *Supply Chain Management* 24(4):469-483.
Constantinides P, Henfridsson O, Parker GG (2018) Introduction—Platforms and infrastructures in the digital age. *Inform. Systems Res.* 29(2):381-400.
Dai F, Shi Y, Meng N, Wei L, Ye Z (2017) From Bitcoin to cybersecurity: A comparative study of blockchain application and security issues. *Proc. 4th Internat. Conf. Systems Informatics 2017* (Institute of Electrical and Electronics Engineers, MA), 975-979.
Damsgaard J, Lyytinen K (1998) Contours of diffusion of electronic data interchange in Finland: Overcoming technological barriers and collaborating to make it happen. *J. Strategic Inform. Systems* 7(4):275-297.
Das TK, Teng BS (1998) Resource and risk management in the strategic alliance making process. *J. Management* 24(1):21-42.
Davidson S, De Filippi P, Potts J (2018) Blockchains and the economic institutions of capitalism. *J. Institutional Econom*. 14(4):639-658.
De Figueiredo JM, Silverman BS (2017) On the genesis of interfirm relational contracts. *Strategy Sci.* 2(4):234-245.
De Filippi P, Wright A (2018) *Blockchain and the Law: The Rule of Code* (Harvard University Press, Cambridge, MA).
De Vaujany, FX, Fomin VV, Haefliger S, Lyytinen K (2018) Rules, practices, and information technology: A trifecta of organizational regulation. *Inform. Systems Res.* 29(3):755-773.
del Castillo M (2017) United Nations sends aid to 10,000 Syrian refugees using Ethereum blockchain. Accessed Mar 25, 2020, https://www.coindesk.com/united-nations-sends-aid-to-10000-syrian-refugees-using-ethereum-blockchain.
Drnevich PL, Croson DC (2013) Information technology and business-level strategy: Toward an integrated theoretical perspective. *MIS Quart.* 37(2):483-509.
Dubin R (1978) *Theory Development* (Free Press, New York).
Dulleck U, Kerschbamer R, Sutter M (2011) The economics of credence goods: An experiment on the role of liability, verifiability, reputation, and competition. *American Econom. Rev.* 101(2):526-55.
Dutra A, Tumasjan A, Welpe IM (2018) Blockchain is changing how media and entertainment companies compete. *MIT Sloan Management Rev.* 60(1):39-45.
Dyer JH (1997) Effective interfirm collaboration: How firms minimize transaction costs and maximize transaction value. *Strategic Management J.* 18(7):535–556.
Dyer JH, Singh H (1998) The relational view: Cooperative strategy and sources of interorganizational competitive advantage. *Acad. Management Rev.* 23(4):660-679.
Eisenhardt KM (1989) Agency theory: An assessment and review. *Acad. Management Rev.* 14(1):57-74.
Faems D, Janssens M, Madhok A, Looy BV (2008) Toward an integrative perspective on alliance governance: Connecting contract design, trust dynamics, and contract application. *Acad. Management J.* 51(6):1053-1078.
Felin T, Lakhani K (2018) What problems will you solve with blockchain? *MIT Sloan Management Rev.* 60(1):32-38.
Fiaidhi J, Mohammed S, Mohammed S (2018) EDI with blockchain as an enabler for extreme automation. *IT Professional* 20(4):66-72.
Friedlmaier M, Tumasjan A, Welpe IM (2018) Disrupting industries with blockchain: The industry, venture capital funding, and regional distribution of blockchain ventures. Presentation, the 51st Annual Hawaii International Conference on System Sciences, Waikoloa, Hawaii.
Friedman S (2018) GSA expands blockchain procurement pilot. Accessed Mar 25, 2020, https://gcn.com/articles/2018/11/15/gsa-blockchain-mas.aspx.
Furmston M, Tolhurst GJ (2016) *Contract Formation: Law and Practice*, 2nd ed. (Oxford University Press, Oxford).
Gal U, Jensen TB, Lyytinen K (2014) Identity orientation, social exchange, and information technology use in interorganizational collaborations. *Organ. Sci.* 25(5):1372-1390.
Gaskin J, Berente N, Lyytinen K, Yoo Y (2014) Toward generalizable sociomaterial inquiry. *MIS Quart.*

38(3):849-872.

Ghoshal S, Moran P (1996) Bad for practice: A critique of the transaction cost theory. *Acad. Management Rev.* 21(1):13-47.

Gibbons R, Henderson R (2012) Relational contracts and organizational capabilities. *Organ. Sci.* 23(5):1350-1364.

Gil R, Zanarone G (2017) Formal and informal contracting: Theory and evidence. *Annual Rev. Law Social Sci.* 13:141-159.

Gimeno J, Hoskisson RE, Beal BD, Wan WP (2005) Explaining the clustering of international expansion moves: A critical test in the US telecommunications industry. *Acad. Management J.* 48(2):297-319.

Giustiniano L, Griffith TL, Majchrzak A (2019) Crowd-open and crowd-based collaborations: Facilitating the emergence of organization design. *Res. Sociology Organ.* 64:271-292.

Gompers P, Lerner J, Scharfstein D (2005) Entrepreneurial spawning: Public corporations and the genesis of new ventures, 1986 to 1999. *J. Finance* 60(2):577-614.

Greenspan G (2017) Three (non-pointless) permissioned blockchains in production. Accessed Mar 25, 2020, https://www.multichain.com/blog/2017/11/three-non-pointless-blockchains-production/.

Griffith TL, Sawyer JE, Neale MA (2003) Virtualness and knowledge in teams: Managing the love triangle of organizations, individuals, and information technology. *MIS Quart.* 27(2):265-287.

Gulati R, Lawrence PR, Puranam P (2005) Adaptation in vertical relationships: Beyond incentive conflict. *Strategic Management J.* 26(5):415-440.

Gulati R, Wohlgezogen F, Zhelyazkov P (2012) The two facets of collaboration: Cooperation and coordination in strategic alliances. *Acad. Management Ann.* 6(1):531-583.

Haber S, Stornetta WS (1991) How to time-stamp a digital document. *J. Cryptology* 3(2):99-111.

Haig S (2018) Central bank-issued cryptocurrency round up: IMF, BoE, Hong Kong. Accessed Mar 25, 2020, https://news.bitcoin.com/central-bank-issued-cryptocurrency-round-up-imf-boe-hong-kong/.

Halaburda H (2018) Blockchain revolution without the blockchain. *Communications of the ACM* 61(7):27-29.

Halac M (2012) Relational contracts and the value of relationships. *American Econom. Rev.* 102(2):750-79.

Hanseth O, Lyytinen K (2010) Design theory for dynamic complexity in information infrastructures: The case of building internet. *J. Inform. Tech.* 25(1):1-19.

Heide JB, John G (1992) Do norms matter in marketing relationships? *J. Marketing* 56(2):32-44.

Heide JB (1994) Interorganizational governance in marketing channels. *J. Marketing* 58(1):71-85.

Heiman B, Nickerson JA (2002) Towards reconciling transaction cost economics and the knowledge-based view of the firm: The context of interfirm collaborations. *Internat. J. Econom. Bus.* 9(1):97-116.

Henderson RM, Clark KB (1990) Architectural innovation: The reconfiguration of existing product technologies and the failure of established firms. *Admin. Sci. Quart.* 35(1):9-30.

Hennart JF (1988) A transaction costs theory of equity joint ventures. *Strategic Management J.* 9(4):361-374.

Hoetker G, Mellewigt T (2009) Choice and performance of governance mechanisms: Matching alliance governance to asset type. *Strategic Management J.* 30(10):1025-1044.

Holcomb TR, Hitt MA (2007) Toward a model of strategic outsourcing. *J. Oper. Management* 25(2):464-481.

Hsieh YY, Vergne JP (2018) The rise of decentralized autonomous organizations: new forms of task coordination and the growth of cryptocurrency. Working Paper, Imperial College London, London.

Hsieh YY, Vergne JP, Anderson P, Lakhani K, Reitzig, M (2018) Bitcoin and the rise of decentralized autonomous organizations. *J. Organ. Design* 7(1):14.

Huber TL, Fischer TA, Dibbern J, Hirschheim R (2013) A process model of complementarity and substitution of contractual and relational governance in IS outsourcing. *J. Management Inform. Systems* 30(3):81-114.

Iansiti M, Lakhani KR (2017) The truth about blockchain. *Harvard Bus. Rev.* 95(1):118-127.

IBM (2017) IBM Global Financing uses blockchain technology to quickly resolve financial disputes. Accessed Nov 5, 2019, https://www.ibm.com/blockchain/in-en/infographic/finance.html.

IBM (2018a) AIG, IBM, Standard Chartered deliver first multinational insurance policy powered by blockchain. Accessed Mar 25, 2020, https://www-03.ibm.com/press/us/en/pressrelease/52607.wss.

IBM (2018b) TradeLens, a Maersk and IBM solution, delivers a blockchain-enabled visibility and document management solution for container shipping that promotes more efficient and secure global trade. Accessed Mar 25, 2020, https://www-01.ibm.com/common/ssi/cgi-bin/ssialias?htmlfid=872/ENUSAP18-0503&infotype=AN&subtype=CA.

Kim H, Laskowski M (2017) A perspective on blockchain smart contracts: Reducing uncertainty and complexity in value exchange. *Proc. 26th Internat. Conf. Computer Communication Networks 2017* (Institute of Electrical and Electronics Engineers, MA), 1-6.

Klein Woolthuis RK, Hillebrand B, Nooteboom B (2005) Trust, contract and relationship development. *Organ. Stud.* 26(6):813-840.

Kleindorfer PR, Wu DJ (2003) Integrating long-and short-term contracting via business-to-business exchanges for capital-intensive industries. *Management Sci.* 49(11):1597-1615.

Kogut B, Zander U (1992) Knowledge of the firm, combinative capabilities, and the replication of technology. *Organ. Sci.* 3(3):383-397.

Larson A (1992) Network dyads in entrepreneurial settings: a study of the governance of exchange relationships. *Admin. Sci. Quart.* 37(1):76–104.

Leiblein MJ, Miller DJ (2003) An empirical examination of transaction- and firm-level influences on the vertical boundaries of the firm. *Strategic Management J.* 24(9):839-859.

Levi M, Kleindorfer PR, Wu DJ (2003) Codifiability, relationship-specific IT investment, and optimal contracting. *Proc. 36th annual Hawaii Internat. Conf. System Sci. 2003* (Institute of Electrical and Electronics Engineers, MA), 1-10.

Lewicki RJ, McAllister DJ, Bies RJ (1998) Trust and distrust: New relationships and realities. *Acad. Management Rev.* 23(3):438-458.

Li JJ, Poppo L, Zhou KZ (2010) Relational mechanisms, formal contracts, and local knowledge acquisition by international subsidiaries. *Strategic Management J.* 31(4):349-370.

Loten A (2018) The morning download: Walmart makes blockchain a requirement for veggie suppliers. *Wall Street Journal* (September 25), https://blogs.wsj.com/cio/2018/09/25/the-morning-download-walmart-makes-blockchain-a-requirement-for-veggie-suppliers/?guid=BL-CIOB-14457&mod=searchresults&page=1&pos=6&dsk=y.

Lui SS, Ngo HY (2004) The role of trust and contractual safeguards on cooperation in non-equity alliances. *J. Management* 30(4):471-485.

Luo Y (2006) Opportunism in inter-firm exchanges in emerging markets. *Management Organ. Rev.* 2(1):121-147.

Lumineau F (2017) How contracts influence trust and distrust. *J. Management* 43(5):1553-1577.

Lumineau F, Malhotra D (2011) Shadow of the contract: How contract structure shapes inter-firm dispute resolution. *Strategic Management J.* 32(5):532-555.

Lumineau F, Oliveira N (2020) Reinvigorating the study of opportunism in supply chain management. *J. Supply Chain Management*, 56(1):73-87.

Lyytinen JDK (2001) The role of intermediating institutions in the diffusion of electronic data interchange (EDI): How industry associations intervened in Denmark, Finland, and Hong Kong. *Inform. Society* 17(3):195-210.

Lyytinen K, Damsgaard J (2011) Inter-organizational information systems adoption–A configuration analysis approach. *European J. Inform. Systems* 20(5):496-509.

Macho-Stadler I, Martinez-Giralt X, Perez-Castrillo JD (1996) The role of information in licensing contract design. *Res. Policy* 25(1):43-57.

Macneil I (1978) Contracts: adjustment of long-term economic relations under classical, neoclassical, and relational contract law. *Northwestern Univ. Law Rev.* 72(6):854-902.

Macneil I (1980) *The New Social Contract: An Inquiry Into Modern Contractual Relations* (Yale University Press, New Haven, CT).

Majchrzak A, Griffith TL, Reetz DK, Alexy O (2018) Catalyst organizations as a new organization design for innovation: The case of hyperloop transportation technologies. *Acad. Management Discoveries* 4(4):472-496.

Malhotra D, Lumineau F (2011) Trust and collaboration in the aftermath of conflict: The effects of contract structure. *Acad. Management J.* 54(5):981-998.

Malone TW, Yates J, Benjamin RI (1987) Electronic markets and electronic hierarchies. *Communications of the ACM* 30(6):484-497.

Marchesoni E (2019) Hyperloop will run on blockchain instead of rails: Tokenization of the ticketing system. Accessed Mar 25, 2020, https://irishtechnews.ie/hyperloop-will-run-on-blockchain-instead-of-rails-tokenization-of-the-ticketing-system/.

Marr B (2018) 30+ real examples of blockchain technology in practice. *Forbes* (May 14), https://www.forbes.com/sites/bernardmarr/2018/05/14/30-real-examples-of-blockchain-technology-in-practice/#32451682740d.

Masten SE (1993) Transaction costs, mistakes, and performance: Assessing the importance of governance. *Managerial Decision Econom.* 14(2):119-129.

Masten SE, Meehan Jr, JW, Snyder EA (1991) The costs of organization. *J. Econom. Organ.* 7(1):1-25.

Mayer KJ, Argyres NS (2004) Learning to contract: Evidence from the personal computer industry. *Organ. Sci.* 15(4):394-410.

McEvily B, Perrone V, Zaheer A (2003) Trust as an organizing principle. *Organ. Sci.* 14(1):91-103.

Ménard S (2000) Enforcement procedures and governance structures: What relationship? Ménard S ed. *Institutions, Contracts, and Organizations* (Edward Elgar Publishing, MA), 234-253.

Mesquita LF, Brush TH (2008) Untangling safeguard and production coordination effects in long-term buyer-supplier relationships. *Acad. Management J.* 51(4):785-807.

Mishkin FS (1995) Symposium on the monetary transmission mechanism. *J. Econom. Perspect.* 9(4):3-10.

Murray A, Kuban S, Josefy M, Anderson J (2020) Contracting in the smart era: The implications of blockchain and Decentralized Autonomous Organizations for contracting and corporate governance. *Acad. Management Perspect.* Forthcoming.

Nakamoto S (2008) Bitcoin: A peer-to-peer electronic cash system. Accessed Mar 25, 2020, https://bitcoin.org/bitcoin.pdf.

Narayanan A, Clark J (2017) Bitcoin's academic pedigree. *Communications of the ACM* 60(12):36-45.

Nayak N, Nguyen DT (2018) Blockchain, AI and robotics: How future tech will simplify federal procurement. Accessed Mar 25, 2020, https://www.federaltimes.com/acquisition/2018/03/23/blockchain-ai-and-robotics-how-future-tech-will-simplify-federal-procurement/

Nee V, Holm HJ, Opper S (2018) Learning to trust: From relational exchange to generalized trust in China. *Organ. Sci.* 29(5):969-986.

Nooteboom B (1992) Towards a dynamic theory of transactions. *J. Evolutionary Econom.* 2(4):281-299.

Okhuysen GA, Bechky BA (2009) Coordination in organizations: An integrative perspective. *Acad. Management Ann.* 3(1):463-502.

Olenski S (2018) What the blockchain revolution means for CMOs. *Forbes* (March 12), https://www.forbes.com/sites/steveolenski/2018/03/12/what-the-blockchain-revolution-means-for-cmos/#713754b96f5d.

Oliveira N, Lumineau F (2017) How coordination trajectories influence the performance of interorganizational project networks. *Organ. Sci.* 28(6):1029-1060.

Orlikowski W, Scott S. (2008) Sociomateriality: Challenging the separation of technology, work and organization. *Acad. Management Ann.* 2:433-474.

Oxley JE (1999) Institutional environment and the mechanisms of governance: The impact of intellectual property protection on the structure of inter-firm alliances. *J. Econom. Behav. Organ.* 38(3):283-309.

Parmigiani A, Rivera-Santos M (2011) Clearing a path through the forest: A meta-review of interorganizational relationships. *J. Management* 37(4):1108-1136.

Parkhe A (1993) Strategic alliance structuring: A game theoretic and transaction cost examination of interfirm cooperation. *Acad. Management J.* 36(4):794-829.

Polanyi M (1958) *Personal Knowledge: Towards a Post Critical Philosophy* (University of Chicago Press, Chicago).

Poole J (2016) *Textbook on Contract Law* (Oxford University Press, New York).

Poppo N (2018) The people leading the blockchain revolution. *New York Times* (June 27), https://www.nytimes.com/2018/06/27/business/dealbook/blockchain-stars.html.

Poppo L, Cheng Z (2018) Trust and contracts: Complements versus substitutes in business-to-business exchanges. Searle RH, Nienaber AMI, Sitkin SB, eds. *The Routledge Companion to Trust* (Routledge, London), 228-244.

Poppo L, Zenger T (1998) Testing alternative theories of the firm: Transaction cost, knowledge-based, and measurement explanations for make-or-buy decisions in information services. *Strategic Management J.* 19(9):853-877.

Poppo L, Zenger T (2002) Do formal contracts and relational governance function as substitutes or complements? *Strategic Management J.* 23(8):707-725.

Poppo L, Zhou KZ, Ryu S (2008a) Alternative origins to interorganizational trust: An interdependence perspective on the shadow of the past and the shadow of the future. *Organ. Sci.* 19(1):39-55.

Poppo L, Zhou KZ, Zenger TR (2008b) Examining the conditional limits of relational governance: Specialized assets, performance ambiguity, and long-standing ties. *J. Management Stud.* 45(7):1195-1216.

Prencipe A, Tell F (2001) Inter-project learning: Processes and outcomes of knowledge codification in project-based firms. *Res. Policy* 30(9):1373-1394.

Reed R, DeFillippi RJ (1990) Causal ambiguity, barriers to imitation, and sustainable competitive advantage. *Acad. Management Rev.* 15(1):88-102.

Resnick P, Kuwabara K, Zeckhauser R, Friedman E. (2000) Reputation systems. *Communications of the ACM* 43(12):45-48.

Reuer JJ, Ariño A (2002) Contractual renegotiations in strategic alliances. *J. Management* 28(1):47-68.

Reuer JJ, Ariño A (2007) Strategic alliance contracts: Dimensions and determinants of contractual complexity. *Strategic Management J.* 28(3):313-330.

Reuer JJ, Devarakonda S, Klijn E (2010) *Cooperative Strategies: Alliance Governance* (Edward Elgar, London).

Ring PS, Van de Ven AH (1992) Structuring cooperative relationships between organizations. *Strategic Management J.* 13(7):483-498.

Roeck D, Sternberg H, Hofmann E (2019) Distributed ledger technology in supply chains: A transaction cost perspective. *Internat. J. Production Res.* 1-18.

Ryall MD, Sampson RC (2009) Formal contracts in the presence of relational enforcement mechanisms: Evidence from technology development projects. *Management Sci.* 55(6):906-925.

Salvato C, Reuer JJ, Battigalli P (2017) Cooperation across disciplines: A multilevel perspective on cooperative behavior in governing interfirm relations. *Acad. Management Ann.* 11(2):960-1004.

Schepker DJ, Oh WY, Martynov A, Poppo L (2014) The many futures of contracts: Moving beyond structure and safeguarding to coordination and adaptation. *J. Management* 40(1):193-225.

Schilke O, Cook KS (2013) A cross-level process theory of trust development in interorganizational relationships. *Strategic Organ.* 11(3):281-303.

Schilke O, Cook KS (2015) Sources of alliance partner trustworthiness: Integrating calculative and relational perspectives. *Strategic Management J.* 36(2):276-297.

Schilke O, Lumineau F (2018) The double-edged effect of contracts on alliance performance. *J. Management* 44(7):2827-2858.

Schueffel P, Groeneweg N, Baldegger R (2019) *The Crypto Encyclopedia: Coins, Tokens, and Digital Assets from A to Z* (Growth Publisher, Bern).

Siegel D (2016) Understanding the DAO attack. Accessed Mar 25, 2020, https://www.coindesk.com/understanding-dao-hack-journalists/.

Siggelkow N (2002) Misperceiving interactions among complements and substitutes: Organizational consequences. *Management Sci.* 48(7):900-916.

Simon HA (1957) *Models of Man: Social and Rational* (Wiley, New York).

Simonin BL (1999) Ambiguity and the process of knowledge transfer in strategic alliances. *Strategic Management J.* 20(7):595-623.

Sorkin AR (2018) Demystifying the blockchain. *New York Times* (June 27), https://www.nytimes.com/2018/06/27/business/dealbook/blockchain-technology.html.

Souza J (2018) 94% of Fortune 500 execs have blockchain project plans—do you? Accessed Mar 25, 2020, https://medium.com/@kingsland/94-of-fortune-500-execs-have-blockchain-project-plans-do-you-d53278ffb8d4.

Srinivasan R, Brush TH (2006) Supplier performance in vertical alliances: The effects of self-enforcing agreements and enforceable contracts. *Organ. Sci.* 17(4):436-452.

Telser LG (1980) A theory of self-enforcing agreements. *J. Bus.* 53(1):27-44.

Tilson D, Lyytinen K, Sørensen C (2010) Research commentary—Digital infrastructures: The missing IS research agenda. *Inform. Systems Res.* 21(4):748-759.

U.S. General Service Administration (2018) *2018 agency financial report: Service, accountability, innovation.* Report, U.S General Service Administration, Washington, DC.

Voss T (2003) The rational choice approach to an analysis of intra-and interorganizational governance. Buskens V, Raub W, Snijders C eds. *Research in the Sociology of Organizations* (Emerald, Bingley), 21-46.

Wall Street Journal (2018) Blockchain has power to transform (March 12), B4.

Wikipedia (2020) Enforcement, Accessed Mar 25, 2020, https://en.wikipedia.org/wiki/Enforcement#cite_ref-1.

Werbach K (2018) *The Blockchain and the New Architecture of Trust* (MIT Press, Cambridge, MA).

Whetten DA (1989) What constitutes a theoretical contribution? *Acad. Management Rev.* 14(4):490-495.

Williamson OE (1985) *The Economic Institutions of Capitalism* (Free Press, New York).

Williamson OE (1996) *The Mechanisms of Governance* (Oxford University Press, New York).

Williamson OE, Ouchi WG (1981) The markets and hierarchies and visible hand perspectives. Van de van AH, Joyce WF, eds. *Perspectives on Organizational Design and Behavior* (Wiley, New York), 347-370.

Wirtz BW, Schilke O, Ullrich S (2010). Strategic development of business models: Implications of the Web 2.0 for creating value on the Internet. *Long Range Planning* 43(2-3):272-290.

Xu JJ (2016) Are blockchains immune to all malicious attacks? *Financial Innovation* 2(1):25.

Xu X, Weber I, Staples M, Zhu L, Bosch J, Bass L, … Rimba P (2017) A taxonomy of blockchain-based systems for architecture design. *Proc. IEEE Internat. Conf. Software Architecture, 2017* (Institute of Electrical and Electronics Engineers, MA), 243-252.

Yermack D (2017) Corporate governance and blockchains. *Rev. Finance* 21(1):7-31.

Yoo Y, Boland Jr RJ, Lyytinen K (2006) From organization design to organization designing. *Organ. Sci.* 17(2):215-229.

Yoo Y, Boland RJ Jr, Lyytinen K, Majchrzak A (2012) Organizing innovation in the digitized world. *Organ. Sci.* 23(5):1389–1408.

Yoo Y, Lyytinen K, Yang H (2005) The role of standards in innovation and diffusion of broadband mobile services: The case of South Korea. *J. Strategic Inform. Systems* 14(3):323-353.

Yuan Y, Wang FY (2018) Blockchain and cryptocurrencies: Model, techniques, and applications. *IEEE Transactions Systems, Man, Cybernetics: Systems* 48(9):1421-1428.

Zammuto RF, Griffith TL, Majchrzak A, Dougherty DJ, Faraj S (2007) Information technology and the changing fabric of organization. *Organ. Sci.* 18(5):749-762.

Zander U, Kogut B (1995) Knowledge and the speed of the transfer and imitation of organizational capabilities: An empirical test. *Organ. Sci.* 6(1):76-92.

Zhang C, Cavusgil ST, Roath AS (2003) Manufacturer governance of foreign distributor relationships: Do relational norms enhance competitiveness in the export market? *J. Internat. Bus. Stud.* 34(6):550-566.

Zhou KZ, Poppo L (2010) Exchange hazards, relational reliability, and contracts in China: The contingent role of legal enforceability. *J. Internat. Bus. Stud.* 41(5):861-881.

Zhou KZ, Xu D (2012) How foreign firms curtail local supplier opportunism in China: Detailed contracts, centralized control, and relational governance. *J. Internat. Bus. Stud.* 43(7):677-692.

Zuboff S (1988) *In the Age of the Smart Machine: The Future and Power of Work* (Basic Books, New York).

Figure 1: The Functioning of Blockchains

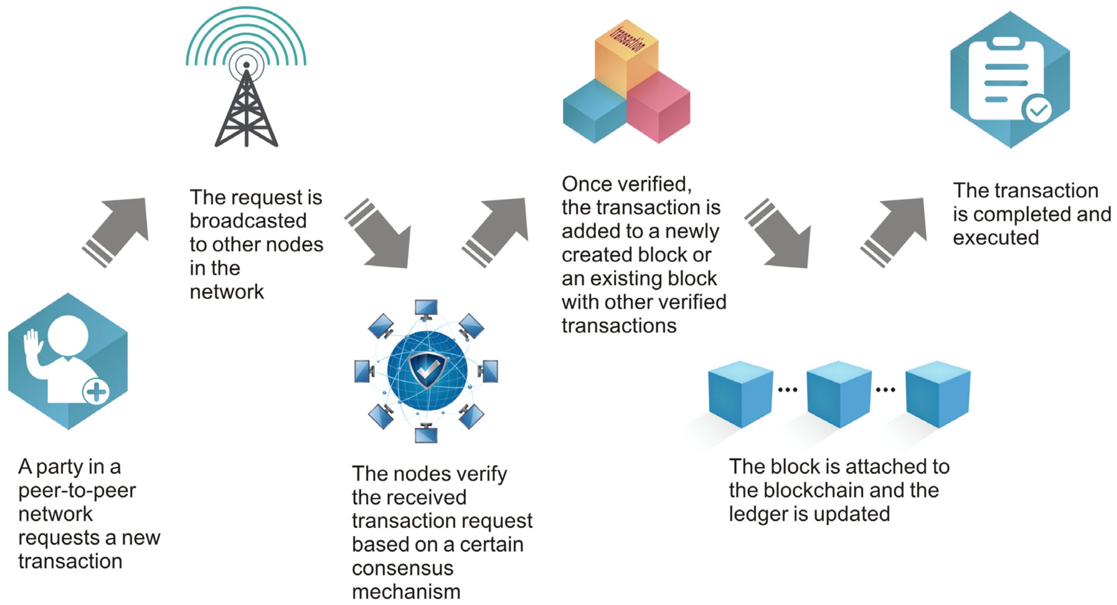

Table 1: A Comparison of the Different Governance Mechanisms

	Contractual governance	**Relational governance**	**Blockchain governance**
Defining feature	Enforceable promises defining the rights and obligations of the parties	Set of patterns of behavior to which parties are expected to conform	Self-contained and autonomous system of rules
Regulatory principles	Law	Social norms and "shadow of the future"	Protocols and code-based rules
Mode of enforcement	Enforcement through third parties (court, arbitrator)/government authorities	Enforcement through the parties themselves	Automatic enforcement by the underlying blockchain-based network
Form	Typically legal prose	Mostly informal	Formal programming language

Table 2: Domain of Relevance of Blockchains

	Searching stage	Designing stage	Monitoring stage	Enforcing stage
Tacit transactions *(low codifiability and verifiability)*	++	--	0	0
Explicit transactions *(high codifiability and verifiability)*	++	+	++	+++

Notes: Symbols denote the efficiency/applicability of blockchain governance in relation to contractual/relational governance. Depending on both the stage (searching, designing, monitoring, or enforcing) and the nature of the transaction (highly tacit vs. explicit), blockchains range from being rather inefficient (e.g., "--" in the designing stage of highly tacit transactions; that is, either it is irrelevant to use blockchains, or their use involves very high transaction costs compared to that of contractual and relational governance mechanisms) to highly efficient (e.g., "+++" in the enforcing stage of highly explicit transactions; that is, it is particularly relevant to use blockchains, or their use involves very low transaction costs compared to those of contractual and relational governance mechanisms).