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Agency in the algorithmic age: The mechanisms and structures of blockchain-based organizing

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ABSTRACT

Firms are increasingly adopting blockchains as a form of knowledge engineering to align their internal processes, share information, and improve oversight. We study intraorganizational blockchains from an agency perspective to understand how the distributed, sequenced, and consensus-based nature of blockchains mitigates information asymmetries and affects organizational structures. First, we explain how blockchains differ from conventional relational, contractual, and system-based mechanisms to address three pertinent information challenges—concentration, continuity, and conflict. Subsequently, we address the consequences of introducing such blockchains, arguing that they create both direct and sequenced information channels among principals and agents, which elicit an organizational reconfiguration via vertical disintermediation and lateral reintermediation. Finally, we theorize the implications of blockchain-based organizing for agency theory regarding the chain of command, the unity of direction, and the span of control. Overall, we show how blockchains for intra-organizational governance can mitigate principal-agent problems and impact organizational design in profound ways.

1. Introduction

Blockchains are being increasingly recognized as a governance mechanism in various contexts, encompassing both permissioned and permissionless networks (Beck et al., 2018; Cennamo et al., 2020). On the one hand, permissionless blockchains, including decentralized autonomous organizations (DAOs) and cryptocurrencies, rely on radical decentralization to establish systems without (or very limited) hierarchical structures, providing anonymity and unrestricted access to all transactions (Goldberg & Schär, 2023; Zhao et al., 2022). On the other hand, permissioned blockchains, such as IBM Food Trust and PharmaLedger, have garnered significant attention due to their efficacy in regulating interorganizational relationships and optimizing supply chain management through partial automation while preserving a level of security requisite for safeguarding the confidential and proprietary data of participating entities (Hanisch et al., 2023; Treiblmaier, 2018). As of late 2021, 81 of the 100 largest publicly traded companies have been using (mostly permissioned) blockchains (Blockdata, 2021). Both permissioned and permissionless blockchains have thus emerged as potential solutions to governance problems of accountability, transparency, and trust in different domains, offering the potential for novel forms of governance that can enhance existing structures or create entirely new systems of governance (Rossi et al., 2019). As such, the study of blockchain technology from a governance perspective represents a burgeoning field of research, with implications for a broad array of fields and industries (Lumineau et al., 2021; Tan & Saraniemi, 2022).

One area of blockchain governance that has received surprisingly little attention is its use within single organizations. Indeed, most of the literature on blockchain governance has focused on permissionless networks (e.g., Hsieh & Vergne, 2023) or permissioned interorganizational networks (e.g., Shew et al., 2022), but few studies have examined how blockchains can be deployed within organizations (e.g., Murray et al., 2021; Sharif & Ghodoosi, 2022; Yermack, 2017). However, as mentioned by the founder of Advatech Pacific, Deepanshu Khandelwal, "before thinking of achieving interorganizational efficiencies using blockchain, companies should look at leveraging blockchain for intra-organizational efficiencies, which will be a tremendous use of this technology." Studying how blockchains integrate within hierarchical organizations is of considerable conceptual interest due to the clash between the decentralized nature of blockchains and the centralized structure of hierarchies. Additionally, hierarchical organizations scale vertically by adding more layers to the chain of command (Astley, 1985;

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March & Simon, 1958), while blockchains scale laterally by adding more blocks to a chain of data validated by network nodes, a fundamental difference in the scaling mechanisms of these two systems. In view of the technology's potential for intraorganizational governance and the inherent theoretical tension, there is a clear need for theoretical advancement that integrates blockchain into the debates on intraorganizational governance while studying the implications for organizational design.

Agency theory offers a suitable lens for examining blockchain technology in terms of intraorganizational governance by studying the potential conflicts and misalignments from information asymmetries between principals and agents. Through this theoretical lens, we provide a nuanced study of blockchain governance in intraorganizational settings, shedding light on its potential to reduce information asymmetries, complement and even substitute hierarchy-based process controls and fiat through its transparent and decentralized nature. We thus conceptualize blockchains as an algorithmic form of process control and argue that they can facilitate information distribution and sequencing, enabling organizational members to avoid information concentration while ensuring a continuous record of information. Additionally, we suggest that the blockchain consensus mechanism can alleviate the pressure on organizational supervisors to exercise hierarchical authority, that is, the formal authority that principals have over agents (Reitzig & Maciejovsky, 2015) to resolve conflicts via fiat, resulting in a potent form of internal digital governance (Hanisch et al., 2023). Our microlevel perspective of intraorganizational blockchain governance therefore suggests that blockchains can enable direct vertical information channels, flatten organizational hierarchy through *vertical disintermediation*, and create a process-oriented alignment based on a strict sequencing of agent tasks that can cause inefficient *lateral reintermediation*. Thus, blockchain technology can address crucial governance issues within organizations and facilitate new organizational structures, which come with potential downsides.

Our paper makes three main contributions to the field of blockchain research in business and management (e.g., Hsieh & Vergne, 2023; Lumineau et al., 2021; Zhao et al., 2022). First, we provide a microlevel theory of how intraorganizational blockchains impact the principal-agent relationship, focusing on the unique governance mechanisms within organizations. We explore the implications of introducing a peer-to-peer system in hierarchical settings, examining the role redefinition of intermediaries such as middle managers in a digital governance context. Second, we advance discussions of blockchain governance by investigating how blockchains facilitate information channeling and rechanneling within organizations (Murray et al., 2021; Sharif & Ghodoosi, 2022; Yermack, 2017). Specifically, we address information distribution in hierarchical settings and highlight the benefits of reducing reliance on information aggregators through direct chains between principals and agents. Third, we contribute to the literature on organizational design (e.g., Huber, 1990; Puranam et al., 2014; Zammuto et al., 2007) by demonstrating how blockchains reshape organizational structures, connecting actors in direct ways that align with organizational processes and transcend traditional hierarchies. Overall, our paper deepens the understanding of how firms can leverage decentralized technologies such as blockchains to enhance accountability, transparency, and trust while retaining the benefits of hierarchical organizing.

2. Blockchains and information asymmetry in organizations

Governance in organizations refer to the rules, procedures, and processes that are used to control and coordinate the actions of its members—namely, principals and agents—to achieve their goals and objectives amid asymmetric information (Aguilera et al., 2015; Jensen & Meckling, 1976). Thus, the need for governance aimed at effective control and coordination stems from the prevalence of information asymmetries and agent opportunism present in organizations (Gittell, 2000; Moon et al., 2004; Sharma, 1997; Sundaramurthy & Lewis, 2003). In organizational settings, information asymmetries result from the division of labor between task-giver (principal) and task-performer (agent), creating monitoring difficulties and potential incentive misalignments (Eisenhardt, 1989; Thiel et al., 2021). Information asymmetries can significantly harm organizations. For instance, *information concentration*, which can occur when "those who have valuable information are incentivized to invest in safeguards" to advance their self-interests (Bergh et al., 2019, p. p. 134), may lead to biased decision-making or suboptimal strategic decisions (Beck & Plowman, 2009). Similarly, the absence of *information continuity* across organizational silos and functions may result in organizational inefficiencies (Lessard & Zaheer, 1996), such as duplicate work and misunderstandings. *Information conflict*, whereby actors face contradicting information and disagreements on how to interpret it (Cronin & Weingart, 2007), can lead to erroneous communication or biases that influence the effectiveness of strategic decision-making (Nguyen, 2007; Papadakis et al., 1998).[1] Amidst these information asymmetries within hierarchies, governance is a countervailing force that aligns interests, fosters cooperation, and enables coordination among organizational actors.

2.1. Blockchains as algorithmic process controls

In light of the governance challenges in organizations, blockchains offer an enticing opportunity to partially or fully automate governance and address the critical problems of information concentration, continuity, and conflict via algorithmic process controls (Hanisch et al., 2023). Blockchains are characterized by peer-to-peer validation and the immutable storage of transactions in a shared, distributed ledger (Schmeiss et al., 2019; Yuan & Wang, 2016). The *distributed* nature of blockchains reduces the likelihood of information concentration and tampering by storing information in a network-managed database accessible on every node in an organization's network (Chod et al., 2020; Vergne, 2020). Additionally, blockchains *sequence* information and thus track missing data, ensuring an immutable and append-only database that facilitates sequenced workflows (Clohessy et al., 2020). Finally, the *consensus-based* approach of blockchains enhances process monitoring via agreement across the nodes in a system, verifying information and executing smart contracts programmatically (Murray et al., 2021). Notably, to achieve such automated governance, blockchains require explicit information, such as financial data, contracts, and formal workflows, but have lesser utility for tacit information that involves context-specific knowledge or interpretation (Lumineau et al., 2021).

BMW's collaboration with DHL on an internal blockchain project provides a practical example of how blockchains can automate internal governance through process controls (BMW, 2020). Specifically, BMW sought to address the concentration of information on parts supply in certain departments and the lack of communication regarding supply disruptions across all its production units. By using blockchain technology to track such internal processes, BMW enhanced the visibility of

[1] These terms related to information asymmetry are similarly used in the extant agency theory literature. For example, "information concentration" has been studied in the agency context using the concept of "information diffusion" (Altay & Pal, 2014) and "information distribution" (Parks & Conlon, 1995) as the opposite effect to concentration. Moreover, "information continuity" has been commonly referred to as "information flow," which can describe *hierarchical* information flow (Sundaramurthy & Lewis, 2003), or *horizontal* information flow (Jacobides & Croson, 2001), the latter of which refers to our choice of term. Finally, "information conflict" is often synonymously referred to as "objective conflicts" that stem from highly subjective information (Cuevas-Rodríguez et al., 2012), "inaccurate" and "malevolent" information (Altay & Pal, 2014), and "information congruence" as the opposite effect of information conflict (Jacobides & Croson, 2001). As these papers related to agency theory have not used these terms consistently, we introduce a simplified convention.

its Asia Pacific supply chain operations, reducing the need for manual reporting, especially concerning delayed part shipments. This meant that stakeholders could access the data they needed, resulting in improved process transparency and faster problem resolution. This successful implementation highlights the potential of blockchains to improve information sharing and organizational efficiency (Ledger Insights, 2019).

Fig. 1 illustrates the contrast between traditional governance at the top and blockchain governance at the bottom conceptually. Specifically, it presents the theoretical logic of how blockchains can help address the information challenges encountered by organizations, such as concentration, continuity, and conflict, stemming from their distinctive characteristics of distribution, sequencing, and consensus. The shift towards blockchain governance chiefly affects those who act as "agent-principals" (e.g., middle managers) who report up and delegate work down the hierarchy (Dutton & Ashford, 1993; Van Doorn et al., 2022). These roles serve as human process controls that aggregate, filter, and transmit information between the principal and the agent; all of these functions are increasingly transferred to blockchain technology. Although blockchains can enhance accountability and transparency within organizations, it cannot alter the intrinsic motivations of principals and agents, such as self-interest and opportunism. Nonetheless, it can introduce an algorithmic process control that reduces the wiggle room for action on tangential motives. By offering an immutable record of transactions and interactions, blockchains can expose and thereby prevent fraudulent or unethical conduct. As a result, agents may be encouraged to share even more information to demonstrate compliance and diligence in their duties. Furthermore, the blockchain's smart contract capabilities can provide a level of automation and transparency that can reduce the potential for errors or intentional misrepresentations. Thus, while blockchain technology cannot alter individual motives, it provides a digital governance layer that can help curb the consequences of self-interested and opportunistic behavior.

The case of Ericsson—a communications company based in Stockholm—is especially apt to explain how blockchains can be used to solve efficiency issues internally (Day, 2023). Ericsson deployed an internal blockchain to facilitate the invoice process across the company's units. Specifically, the company encountered inconsistencies in the flow of purchase orders against the flow of invoices, which had been cumbersome given the many legal entities under the same corporate umbrella: "Basically, there are two flows of information that at the end have to reconcile somehow," in the words of the head of blockchain at Ericsson, Giovanni Franzese. An internal blockchain allowed various entities within Ericsson to increase trust among each other and improve the traceability and visibility of the inter-company invoice process. "For the first application we developed, it was 95 % of savings by lead time," explained Giovanni Franzese. What stands out in the Ericsson case is their decision to use blockchain internally: "There is a level of centralization. But this is perfectly right because otherwise you could not prevent a loss of control if you had full decentralization within companies where you're using a blockchain solution." Similar to the Advatech Pacific case above, Ericsson is currently leveraging blockchain governance internally with plans to expand the technology to an inter-organizational network in the future: "You need to start humble; you need to start with some control and then as long as you take heart, then you release control in a more decentralized way.".

2.2. How blockchains rechannel information

The blockchain's unique characteristics offer new ways of addressing the information challenges that arise between principals and agents that are not possible when employing traditional approaches to governance based on relational mechanisms, contracts, or enterprise resource planning (ERP) systems. In this section, we emphasize the ways in which the distributed, sequenced, and consensus-based nature of blockchains differs substantially from the diffused, disconnected, and fiat-based mechanisms of relational and contractual governance in the context of principal-agent exchanges. Similarly, we contrast the features of blockchains to those of ERP systems and demonstrate how the former's consolidated, interfaced, and synchronization-based nature nonetheless allows for information asymmetries in organizations. For instance, our discussions with managers indicated that blockchains can "make the exchange of information between participants more efficient," (manager of a blockchain in an electrical company), which sparked our interest in how blockchains differ from other forms of governance. In the following section, we incorporate relevant quotations from our interviews with managers of internal enterprise blockchain networks to illustrate the mechanisms underlying the use of blockchains in organizations and support our theorizing, highlighting the key differences between blockchains and traditional governance approaches.[2]

2.3. Information concentration: Distributed information dispersed across nodes

In practice, managers often struggle with the problem that information is scattered throughout the organization and is thus difficult to access reliably; it is also challenging to determine whether the stored information is accurate and up to date. This problem can be solved through the blockchain's distribution of information (Akoramurthy & Kumar, 2020). For example, one manager of a blockchain in the oil and gas industry mentioned how "the idea was a reduction in the existing processes and hydrocarbon reconciliation time and then, more importantly, to secure an immutable ledger of all quantities that are recorded in the distributed ledger." Another manager of a blockchain for military purposes explained how "[the blockchain] was tracking aircraft parts across internal organizations and systems as they moved throughout their lifecycle to provide a single source of truth regarding the status and life span of an aircraft part at any given time to relevant parties and to secure the audit trail for an aircraft part.".

From a conceptual perspective, when organizations rely primarily on relational (e.g., Claggett & Karahanna, 2018; Fahn & Zanarone, 2021) and contractual governance mechanisms (e.g., Jensen & Meckling, 1976; Magelssen et al., 2022), information is *diffused* in the form of organizational routines and experiences and stored in procedural memory (Cohen & Bacdayan, 1994; Howard-Grenville, 2005; Omidvar et al., 2022), which can be supplemented by *consolidated* and centralized records in ERP systems that store, integrate, and control certain kinds of information (Berente et al., 2016; Morton & Hu, 2008). A negative consequence of these two mechanisms is that information can be transmitted inaccurately (e.g., parties can have their own interpretation of information), or it can be manipulated in centralized systems by authorized actors (e.g., data can be overwritten). In contrast, blockchains offer a solution to concerns regarding such information concentration because the information is *distributed* across multiple nodes in the system, thus eliminating the need to rely on widely diffused and inaccurate experiences or information contained in centralized systems that are prone to tampering.

Such a blockchain has been deployed by Coca-Cola, which depends on the reliable exchange of information among bottling companies to fulfill orders (Business Insider, 2021). Together with the technology

[2] From July 2019 to March 2023, we conducted managerial interviews regarding 18 projects on internal enterprise blockchain solutions to identify the specific governance mechanisms that are relevant in our theoretical context. Moreover, we have conducted an extensive search of leading blockchain outlets (e.g., Ledger Insights, CoinDesk) and scanned press releases of Global 500 companies (e.g., Allianz, Coca-Cola, Ericsson, IBM) to include cases of internal blockchain governance that are valuable for our theoretical context. Although our paper is primarily conceptual in nature, we found it useful to include the voices of practitioners to establish common ground and showcase the growing cross-industry interest in this novel topic.

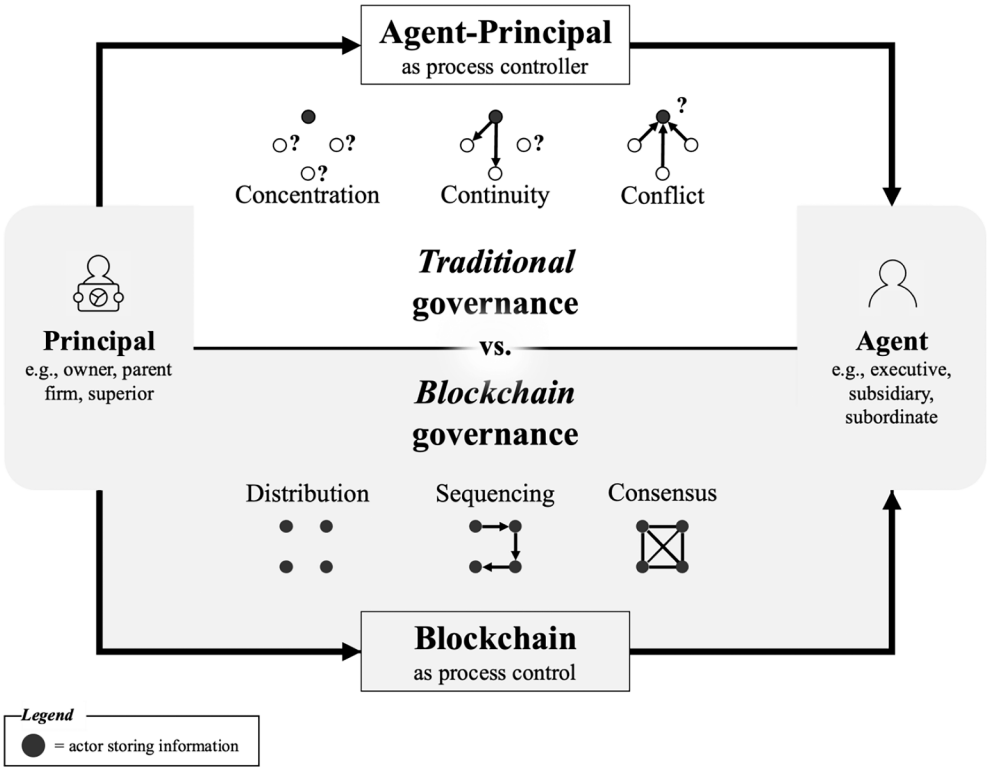


Fig. 1. Blockchain vs. Traditional Governance.

provider SAP, Coca-Cola has created a platform that enables the sharing of stock supply, order information, and delivery times in a transparent and immutable manner. By testing this platform with Coke One North America (CONA), Coca-Cola aimed to reduce its reconciliation times from an average of 50 days to less than a week (Bitvalex, 2019). The success of this implementation has led CONA to extend its use of blockchain technology to a larger audience. The company now utilizes the Baseline Protocol to establish a frictionless network joining process among Coca-Cola Bottling's suppliers, providing benefits not only to internal bottlers-suppliers but also to external suppliers of raw material. The Baseline Protocol heavily relies on Zero-Knowledge Proofs (ZKP), a type of encryption that verifies information without exposing it, ensuring that competitors cannot access smart contract contents or volume discount details (Cacioli, 2020). Hence, by using blockchain technology, Coca-Cola has created tamper-evident records of all transactions, providing efficient and cost-effective algorithmic process controls.

2.4. *Information continuity: Sequenced state-based information across units*

In addition to addressing the challenge of information concentration, blockchain technology can facilitate coordination within organizations that have internal boundaries separating different departments and functions (Wang et al., 2022). By using blockchain technology, organizations can create a shared, tamper-proof ledger that all parties can trust and use to track their interactions. This can help to break down organizational silos and promote transparency, accountability, and collaboration across different units. With the use of blockchain technology, managers can ensure that information flows accurately from one unit to another and leaves a comprehensive audit trail that is accessible by all parties involved. Accordingly, this can help prevent information leakage or quality deficiency and provide a secure channel for organizations to collaborate and improve their processes.

From a theoretical perspective, information continuity in analog organizations is complicated by the facts that information is often *fragmented* across compartmentalized organizational units and that such organizations require dedicated *interfaces* in the case of ERP-based information sharing (Barki & Pinsonneault, 2005; Garvin, 1998; Morton & Hu, 2008). Blockchains solve the problem of information gaps because different pieces of information build sequentially on top of each other (i.e., the input order is controlled). Thus, the order, adherence, and interdependence of processes can more easily be controlled. For example, Chem-Corp (a pseudonym), a medium-sized chemical company in the northern Netherlands, implemented a blockchain solution to organize its internal processes based on the internal blockchain technology developed by NorthChain (2021).[3] Part of this solution involved modeling Chem-Corp's internal processes through a flowchart and using a proprietary blockchain code compiler to translate this process diagram automatically into blockchain code. An immediate consequence of using a blockchain and the strict control, transparency, and immutability that this approach facilitates was the realization that production frequently deviated from the laboratory's chemical formulations, resulting in more than ten percent of production going to waste. With the introduction of the immutable logs recorded by the blockchain, these issues were quickly detected and traced to their origin, and production waste was reduced to zero after production fully adhered to the laboratory's prescriptions.

[3] In the following, we continue to intersperse quotations and anecdotal evidence drawn from NorthChain, a pioneer in the design and implementation of internal blockchains, to make our ideas more tangible and to shed light on a relatively recent phenomenon. These quotations serve as examples and illustrations rather than a case study, as we wish to emphasize the conceptual rather than the empirical contributions of our study. The interviews were conducted in person over three rounds to gather comprehensive information. To ensure accuracy, the interviews were recorded, transcribed verbatim, and reviewed by our interviewees to verify the quotes.

2.5. Information conflict: Automatically enforced consensus-based resolutions

Third, managers tend to face conflicts when multiple records of information exist and they are unsure which information to believe in. Blockchains can create machine-based consensus (Lumineau et al., 2021), which helps resolve conflicts and misalignments. In one interview, it became apparent that NorthChain had improved the way one of its construction clients addresses information conflicts. Previously, the client had relied on inefficient weekly management meetings to review project status, during which "the CEO would ask middle managers questions like 'are there any problems?', and these middle managers would go to their project managers and ask [the same question]." This led to delayed, conflicting, and vague information sharing regarding all the client's projects. Instead, the construction client "wanted to have real-time information on the status of each project at all times, and [it] wanted to prevent issues exceeding time and budget," according to Herman Balsters from NorthChain. Thus, by using blockchain-based smart contracts that automatically execute payment transfers once specific milestones in the construction process are reached, the construction firm could rely less on conflicting information from middle managers and, rather, ensure that payments were made directly, promptly, and accurately, reducing the risk of payment dispute and promoting timely project completion.

In conceptual terms, information conflicts in the organizational hierarchy are resolved through *fiat* (Williamson, 1991), such that the principal enforces the information record based on authority or via centralized ERP systems that *synchronize* information, which can reveal conflicts but nevertheless require decisions concerning how to resolve those conflicts. Blockchains resolve information conflicts such as double-spending problems (e.g., a budget is inadvertently expended twice by different individuals) because each transaction on the blockchain is validated by a peer-to-peer network that by design prevents a transaction from being executed twice. This blockchain-native feature is already being used in many interorganizational contexts. For example, the blockchain-based solution for automotive supply parts, Vinturas, solves the problem of information conflicts between automotive suppliers and original equipment manufacturers (OEMs) by producing an immutable log of parts logistics, which is updated in real-time and communicated between logistic service providers and OEMs (Vels, 2021). The fact that all information is recorded in the Vinturas blockchain improves the reliability of the data as well as the transparency of the business process for all involved parties. In Table 1, we offer a comprehensive overview of this situation, illustrating the fundamental differences of blockchains from relational, contractual, and ERP-based governance mechanisms.

As an additional, practical example, HerenBouw, an Amsterdam-based building company, has leveraged blockchain-based project management to improve its building development efficiency in commercial real estate (Blockchain Magazine, 2022; Tapscott & Vargas, 2019). Particularly, blockchain was used in a large harbor development project to register transactions and ensure accuracy and auditability. One of the challenges in the sector is the management of large teams of contractors and subcontractors, building codes, safety regulations, and standards. To address this, HerenBouw used a blockchain to track subcontractors and their tasks through a "reputation ledger," which served as a benchmark for the recruitment process. Moreover, a lifecycle ledger was used to store warranties and certifications, protect the construction process from tampering and fraud, and maintain a record of events in the lifecycle of the building. As Bassem Hamdy, CEO of Brickschain Construction Blockchain Inc., noted, "the power of [the] blockchain is that it creates very powerful standards, in a simple-to-adopt way that doesn't interfere with current processes" (Lopes, 2019).

3. Blockchain-induced mechanisms of disintermediation and reintermediation

We continue our theorizing by examining the ways in which the implementation of intraorganizational blockchains affects the information channels between principal and agents and, consequently, the organizational configuration in which these actors operate. Specifically, internal blockchains introduce vertical information channels that link principals and agents directly, as well as sequenced horizontal information channels that arrange agent tasks in a chained lateral process. These omnidirectional information channels (Romme, 1999, 2004) are expected to reconfigure the focal organization in terms of *vertical disintermediation* and *lateral reintermediation*, respectively. We demonstrate how, taken together, these two reconfigurations create a structure that facilitates *organization-wide consensus*. By connecting the organizational information channels enabled by blockchains with organizational structure, we lay the foundation for a more profound understanding of the implications of blockchains for organizations. In the following, we describe the reasoning underlying our claims and display the identified mechanisms visually in Fig. 2.

3.1. Direct information channels and vertical disintermediation

To study the implications of blockchains for organizations, we must first understand the prevalent information channels in archetypical hierarchical organizations. Conventionally speaking, a hierarchy is constructed in a way that enables "top down" information channeling across multiple actors. Information channeling refers to the active, bidirectional provision of information and its subsequent receipt, processing, and storing in the relationship between principal and agent. For instance, a typical hierarchy includes a principal, such as a superior, who transmits information (e.g., work, tasks, states) to an agent. As the amount and scope of such information grows, a typical organizational response is to institute additional levels of the hierarchy, thereby simultaneously introducing more intermediary principals and agents to manage the newly emerging complexity (Astley, 1985; Lawrence & Poliquin, 2023). As a result, hierarchical growth inevitably leads to an "agent-principal duality" among some roles, e.g., for middle managers (Dutton & Ashford, 1993; Van Doorn et al., 2022), who report to *their* superior (the principal) and simultaneously delegate work to subordinate agents, e.g., regional sales managers or plant managers. The hierarchical organization embeds such dual roles as critical nodes to process information provided by principals and to translate it into coordinated work for agents as well as to communicate aggregate status and process information from the agent back to the principal to facilitate further review and decision-making (Rouleau, 2005). Hence, hierarchies tend to create top-down information channels flowing from principals who assign the task to agent-principals who assume responsibility for bidirectional information processing and then to the agents who ultimately carry out the work.

Blockchain enables principals and agents to exchange information directly, reducing the need for human-mediated information processing and providing the capacity to eliminate information asymmetries. Typically, "agent–principal" roles are responsible for information processing as well as gathering and interpreting agent information, in addition to translating principal information into manageable tasks for agents to accomplish. These roles thus become increasingly obsolete when the blockchain stores all relevant information in a tamper-evident, distributed ledger, which entails that principals can retrieve status-related information and validate it directly in the blockchain (e.g., quality gate approvals, legal signatures), while the agents input information directly to the blockchain as their work progresses. In doing so, the blockchain guarantees that information is channeled directly between principals and agents, even in large organizations (Tourish, 2005; Tourish & Robson, 2006). The use of an internal blockchain without intermediaries grants the principal access to an unbiased and

Table 1
How Blockchains Address Three Central Information Challenges.

		Relational / Contractual	Traditional ERP *	Blockchain
Information challenges	**(1) Concentration**	**Diffused** information stored in memory and documents	**Consolidated** information stored in central systems	**Distributed** information dispersed across nodes
	(2) Continuity	**Disconnected** information dispersed across units	**Interfaced** information shared through dedicated interfaces	**Sequenced** information ordered across units on a state-by-state basis
	(3) Conflict	**Fiat-based** resolutions enforced via principals by matching information	**Synchronization-based** resolutions enforced via centralized updates after entering information	**Consensus-based** resolutions enforced automatically before entering information

Notes: * Enterprise Resource Planning.

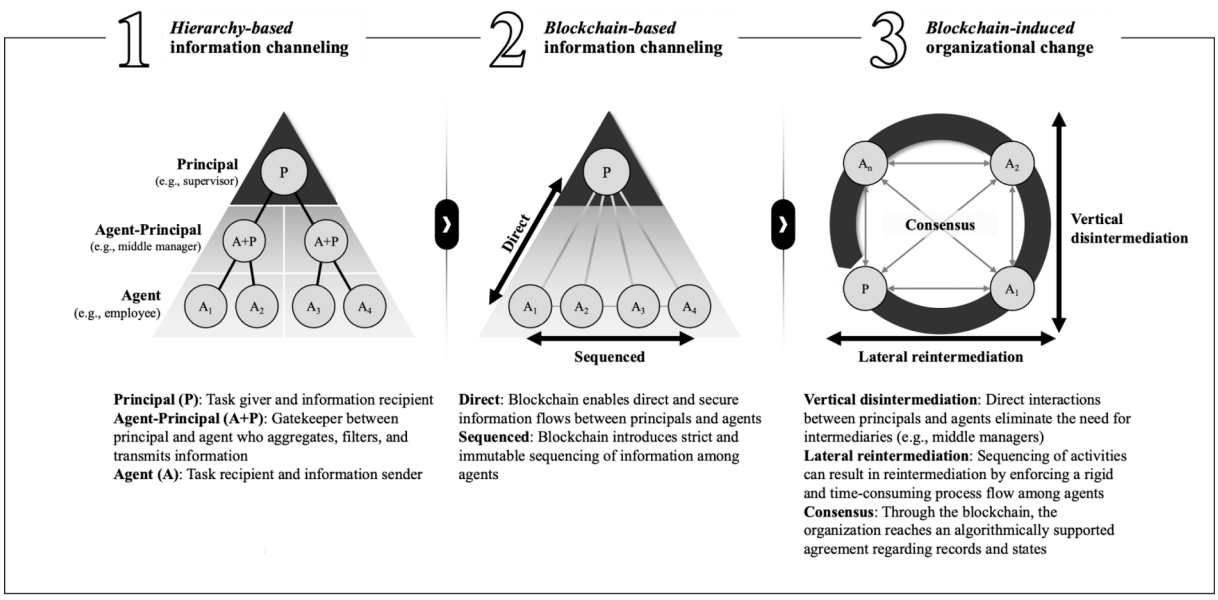


Fig. 2. Information Channeling and the Resultant Organizational Reconfiguration.

undistorted view of the organization's state, facilitating processes or the reconstruction of events during crises (e.g., product recalls, customer complaints). One partner at NorthChain, Herman Balsters, expressed this situation as follows:

> In a certain way, the blockchain *is* the middle manager. Because the blockchain is consistently controlling and steering what happened and will happen. […] Middle managers tasked with coordination and control responsibilities for these types of activities and processes can be replaced to a certain extent.

Blockchains therefore enable improved vertical information channels, which in turn leads to a reconfiguration process of vertical disintermediation (Chircu & Kauffman, 1999; Clohessy et al., 2020). Two areas of such disintermediation can be expected. First, blockchains render dual agent-principal roles, such as middle managers as information processors, obsolete, leading to the downsizing of organizational hierarchy (Balogun & Johnson, 2004; Kohli & Liang, 2021). Second, by translating all information for storage into blockchain records, organizations can identify and address structural gaps that produce redundancies, leading to the elimination of inefficient or useless roles or groups of roles (Pinsonneault & Kraemer, 1997). This transparency achieved through direct information channels allows organizations to uncover redundant roles and departments, such as those that exist solely for the purpose of auditing the practices of other departments. As Stefan de Ruiter, partner at NorthChain, explained, these direct, peer-to-peer connections among agents could eliminate certain business functions:

> [Using the blockchain], it is easier for higher managers (e.g., the CEO or line managers) to get their KPIs and other management information directly. It is easier for them to acquire that information. And, depending on the firm's needs and wants, it is no longer required for subordinates to report to managers, as managers automatically have access to this information. […] We did see the elimination of almost an entire department.

However, while blockchain-induced vertical disintermediation provides transparency and efficiency benefits, its append-only and immutable nature may cause information overload, leading to decision paralysis and negatively affecting decision-making processes (Junge et al., 2023; Reutskaja et al., 2020). That is, as Simon (1971, pp. pp. 40-41) famously indicated, "what information consumes is […] the attention of its recipients." By eliminating the role of information processors, who filter and transmit relevant information (Beck & Plowman, 2009; Guth & Macmillan, 1986; Schilt, 1987), a blockchain thus transmits all information in an unfiltered fashion. According to NorthChain, this impairment can only be resolved at the application level: "managers only see the actual workflow being done; not the technical details of the underlying blockchain implementation." Failure to address this issue could obstruct decision-making by increasing the difficulty for managers to acquire and process the most relevant information, which could impact strategic, private, or political decision-making (Aldrich & Herker, 1977; Stevenson & Gilly, 1991). Additionally, the lack of middle management for information filtering and transmission may impede agent execution at the operational levels of the focal organization

because agents often rely on intermediary roles for clear and prioritized instruction to achieve strategic goals (Shi et al., 2009). Finally, downsizing the organization can result in less "issue selling" from middle management toward top management (Dutton & Ashford, 1993, p. 407), which, in a blockchain scenario, rests solely on agents or principals that might lack the time, resources, knowledge, skill, or motivation to drive strategic initiatives themselves. Ultimately, while blockchain-induced vertical disintermediation holds promise for a flatter and more efficient organizational structure, it may come at the cost of increased cognitive load for organizational actors due to its higher information volume.

3.2. Sequenced information and lateral reintermediation

The top-down, vertical information channeling that occurs in the hierarchy discussed previously demonstrates a second important characteristic of hierarchies, namely, the fact that the hierarchy is structured in a way that constrains *horizontal* information channeling (Knight, 1976; Lu & Wedig, 2013). Because the hierarchy relies on information channels between principals and agents and because agent information needs to be reported back to principals, the archetypical hierarchy does not facilitate or reward sideways information channeling among agents. This lack of communication can result in missed opportunities for synergistic agent-to-agent exchange, which could improve the overall process. Even though the principal may assume that they know all the information that is required to make the best decision for both agents, the principal cannot know what is not shared or what is withheld by noncollaborating agents or what those agents may have gained by working with each other. Since they tend to facilitate top-down and bottom-up information channels, hierarchies tend to understimulate the diversified information sharing among agents that is necessary for cross-functional alignment (Aalbers et al., 2016).

A blockchain has the potential to connect agents directly via a peer-to-peer network, which can promote horizontal information channeling across functional silos (Akoramurthy & Kumar, 2020). Specifically, blockchains connect each actor involved in a given process using "permissions," which are programmatic ways of assigning roles, responsibilities, procedures, and objectives to physical human agents via the blockchain. In our interviews with NorthChain, such permissions in the internal blockchain context were viewed as "a certain authorization to perform some step in the process." By connecting agents directly and enabling the required level of agent authority, the blockchain improves the channeling of horizontal information, as agents are not disconnected via the mediation of a principal but are rather tied together systemically for equivalent or related business processes. Herman Balsters further explained that "the process model will be the organizational blueprint of how you are going to work […]. So, the process model is going to be all-important if you are going to do this horizontal integration." This horizontal agent tie in the context of common business processes is particularly valuable when the agents could benefit from project-specific but relevant knowledge (Hansen, 2002), when agents are associated with competing units (Tsai, 2002), to reduce the distortions in communication between various units (Albaum, 1964), or simply when increased information diversity is a relevant aim (Aalbers et al., 2016). A blockchain can even automate step-by-step progression from agent to agent, e.g., when a task is verified as complete and not missing additional input, which renders agent communication near-autonomous (e.g., via smart contracts that are automatically executed given predefined conditions). Thereby, the blockchain improves agent information channeling and interdependence in a horizontal fashion and reduces the need to assign this capability of facilitating information flows among agents to a middleman.

Paradoxically, while vertical disintermediation results from direct information channels, a blockchain can introduce a novel form of *lateral reintermediation* among agents who are separated by mediating agents in the context of a formalized workflow. Lateral reintermediation occurs when agents in the blockchain are obligated to collaborate due to the rigid programming of the blockchain, even if the agents in question are organizationally separated by their inclusion in different segments of the hierarchical strata (Dahlander & O'Mahony, 2011; Galbraith, 1994; Hinds & Kiesler, 1995). This situation occurs because a blockchain operates in sequential phases, such that each task performed and recorded by one agent is reviewed and continued by other agents. Herman Balsters from NorthChain explained this rigidity as follows: "everybody involved agrees on how the process is to be executed […] and no deviation from the agreed upon process is possible." In some instances, such horizontal ties may facilitate peer-to-peer interactions that would not have occurred naturally, which may prove to be useful. For example, if agents work in different geographical locations and if the output of one production plant serves as input for another, a blockchain could provide a reliable line of rich information exchange among agents, whereby prior to the implementation of the blockchain, direct interactions would have been rare. Although a blockchain can be used to transmit richer information from agent to agent, which offers clear benefits, an inflexible development process may emerge, such that it is difficult for agents to skip steps in the process and thereby bypass predesignated agents (Downs, 1967; MacCormack et al., 2001). In neglecting these often invisible and informal "behind the scenes" processes, blockchains fail to account for informal organizational structures (Soda & Zaheer, 2012). Consequently, blockchain-induced lateral reintermediation can ultimately prolong organizational processes and increase inefficiencies.

While lateral reintermediation has certain downsides in terms of the rigidity and strict lateral channeling of information, the blockchain that enables it provides new ways of monitoring and enables novel incentives for information sharing among agents. On the one hand, blockchain-induced lateral reintermediation facilitates a form of "agent-to-agent" monitoring (Homburg et al., 2020; Varian, 1990) that shifts monitoring activities away from principals and toward agents who have a clear stake in the information chain. This can lead to an increase in agent accountability and reduce monitoring costs for principals. On the other hand, blockchain technology allows for clear identification of which agent contributed what information, promoting transparency, reducing subjective performance measures on which agent incentives are based (e.g., Baker et al., 1994), and reducing wiggle room for free riding (e.g., Jones, 1984). For example, the use of smart contracts in a blockchain can incentivize agents to share information by automatically rewarding them for their contributions to the collective effort (i.e., "who did what and at which time," in the words of Herman Balsters). Hence, by facilitating diversified information sharing among agents, the lateral reintermediation of blockchains can help achieve cross-functional alignment, which is essential for the efficient and effective functioning of an organization (Aalbers et al., 2016).

3.3. Organization-wide consensus

As a result of vertical disintermediation and lateral reintermediation, the blockchain's algorithmic transaction protocol increases organization-wide consensus (i.e., an algorithmically supported agreement regarding records and states), ultimately contributing to the alignment of organizational processes and facilitating goal pursuit. On the one hand, vertical disintermediation produces a bidirectional line of reporting that principals can use to align and update information. Vertical disintermediation creates consensus because the relevant information becomes more transparent, reliable, and constantly monitorable by all parties (we illustrate this point in the networked structure displayed on the right side of Fig. 2). On the other hand, lateral reintermediation establishes a sequenced flow of information among agents, which the principal can use to initiate a workflow and agents can use to advance the workflow in a sustained matter without having to rely on further guidance or approval from principals. Similarly, lateral reintermediation contributes to the organization's level of consensus because

the desired workflow is programmed into the blockchain, which limits deviations from the intended processes. In simple terms, a blockchain increases organization-wide consensus because it distributes information and reorders the ways in which organizational actors work to achieve a common outcome. In the words of Herman Balsters from NorthChain, "[the blockchain] amounts to a transparent, traceable, safe, and logged process. The involved parties work in networked setting, with no need for hierarchy.".

We conclude our argument with the example of Allianz, a global insurance company that has successfully implemented enterprise blockchain technology to improve its claims management processes (Ledger Insights, 2021). This insurer chose blockchain technology because it provides controls that naturally align with its needs in internal claims processes, e.g., to codify, audit, and mandate the reconciliation of claims. For example, without the blockchain, a customer insured by Allianz Hungary involved in a car accident in France would trigger a cumbersome back-and-forth email process among Allianz' legal entities taking weeks to resolve. With its blockchain technology, when a customer submits an automobile accident insurance claim, Allianz can log data such as policy number, claim number, countries involved, and other details on the international claims portal connected to the country's node on the blockchain network, spurring cross-border collaboration and breaking down otherwise siloed entities. The blockchain also streamlines governance among legal entities through smart contracts, which automatically determine how claim costs are to be shared across organizations (i.e., "burden-sharing") in accordance with local tax law. By deploying Hyperledger Fabric across 23 internal companies, Allianz has thus ensured a single source record of any decision on each claim, significantly reducing administration times from weeks to minutes and providing faster claim settlement for customers. While introducing this technology has presented several challenges to Allianz, such as ensuring internal stakeholder alignment and raising awareness for the technology, the company intends to open its blockchain network to external organizations in the future.

4. Implications for agency theory

In the previous section, we explored the ways in which blockchains facilitate unobstructed channels of information within the organization, thereby enabling an organizational reconfiguration that features elements of vertical disintermediation and lateral reintermediation. We now examine how blockchain-based organizing may advance, challenge, or extend agency theory, which has focused on the hierarchical and bureaucratic organization as the predominant organizational form (Monteiro & Adler, 2022). Because organizations are essentially multi-agent systems that have system-level goals, it is important to understand the context in which principals and agents work together to achieve their systemic goals (Puranam et al., 2014). Extending our prior arguments, we explore three possible changes with respect to the organization's (1) *chain of command*, (2) *unity of direction*, and (3) *span of control*. Fig. 3 presents these implications visually.

First, a blockchain-based perspective on organizing deviates from the traditional view of organizing proposed by agency theory in that the *chain of command* becomes significantly flatter in the former case, thus reducing the number of contracts that govern the individuals within the organization (Dutton & Ashford, 1993; Jensen & Meckling, 1976). By definition, the chain of command in an organization ensures that principals can divide and assign tasks to agents and provide the information necessary to complete these tasks. In conventional hierarchies, the chain of command is constructed to contain intermediary roles, such as those of middle managers, who are responsible for aggregating and disseminating information (in both top-down and bottom-up ways), which is an important aspect of such hierarchies that allows them to manage complexity. In contrast, the blockchain's chain of command contains the principal and agent roles only due to vertical disintermediation. Accordingly, principals and agents can interact directly without any intermediaries. The upside of this difference is that information can be transmitted in an unfiltered way to allow the principal to select the information on which they should act. The downside is that the principal's cognitive load increases with each additional agent reporting to them via the blockchain, hence slowing both strategic and tactical decision making. Overall, the chain of command becomes flatter following the implementation of a blockchain since fewer intermediary roles are required to reach the same organizational outcome.

Second, a blockchain-based perspective on organizing presents a challenge to agency theory because the *unity of direction* in blockchain-based organizations is far more autonomous and less dependent on principal intervention. The unity of direction ensures that agents work together cross-functionally to reach a desired organizational outcome. In a prototypical hierarchy, the unity of direction is established by the

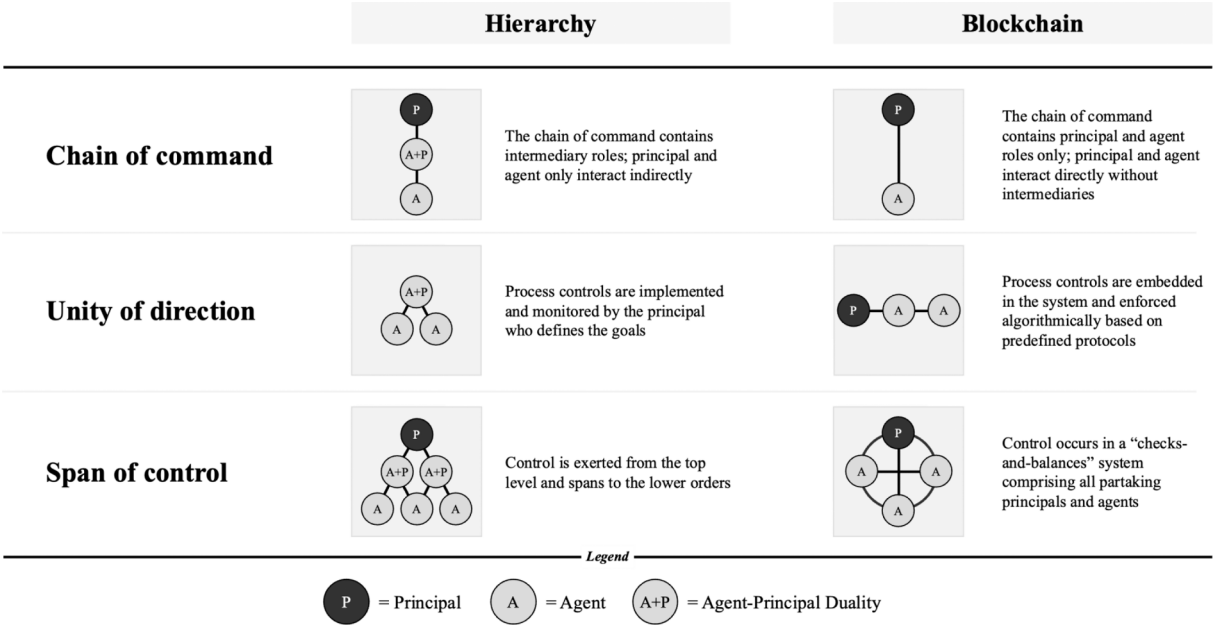


Fig. 3. Implications of Blockchain-based Organizing for Agency Theory.

principal, who institutes process controls that are continuously monitored (Wiseman & Gomez-Mejia, 1998). Ultimately, it is the principal who monitors the progression and alignment of agents within the hierarchy and who shares with agents a variety of information that is necessary for cross-functional alignment (Aalbers et al., 2016). By introducing a blockchain-enabled process, the unity of direction is embedded in the system directly and enforced algorithmically based on predefined protocols. Accordingly, agents are incentivized by blockchain-based controls to act responsibly, as the embedded contract becomes more process-oriented. The upside of the blockchain in this context is that agents are connected to one another directly (i.e., due to lateral reintermediation) and hence do not require constant input from the principal to complete tasks and pass on state-based information. A critical downside is that agents rely less on human interaction and thus may become repetitive with regard to their routines, leading to a more monotonous, less creative organizational environment. In summary, the unity of direction becomes more self-sustaining due to the implementation of a blockchain because less direction from principal roles is required for agents to sustain their workflow and reach outcomes in a self-sufficient manner.

Finally, a blockchain-based perspective on organizing extends agency theory by demonstrating how the *span of control* in organizations governed by blockchains can reduce principals' control and increase agents' control in the form of a peer-to-peer network. The span of control refers to the way in which control is exerted to ensure that principal and agent outcomes and behaviors are consistently optimal. Hierarchies typically allow principals to exert control from the top, which extends to the lower orders of the hierarchy and ensures that agents comply with the principals' expectations. Blockchain-based organizing enables both principals *and* agents to exert control in the form of a "checks-and-balances" system in which all relevant actors participate, demonstrating the fact that this logic does not apply exclusively to principals. A checks-and-balances system emerges because the blockchain includes embedded consensus mechanisms that must operate over multiple nodes, and principal nodes alone would likely not suffice to meet the verification needs of an entire organization. The upside of such blockchain-based organizing is that the organization, as the sum of its actors (principal and agent nodes), is constantly monitored by all participants regardless of their rank in the organization, which can reveal suboptimal behaviors at all levels. The downside is that accountability in a blockchain-based organization can continue to be unequally distributed (e.g., via a proof-of-authority consensus mechanism), which gives higher weight to principals' votes and lower weight to agents' votes and effectively preserves an unbalanced hierarchy in the design of the organization's consensus mechanism. In fact, a senior manager implementing an internal blockchain for an automotive client highlighted the "challenges of identifying neutral nodes required for consensus mechanisms within the hierarchy" due to status and role identities and questioned whether "[…] neutrality is even wanted by managers." Overall, however, the span of control becomes more multilateral following the implementation of a blockchain, giving less voice to principals alone and offering more room for agents to hold principals and peers accountable.

5. Discussion and implications

Our theorizing has highlighted the implications of using blockchain in organizations for their governance and design. Broadly speaking, we build on the notion that the distributed, sequenced, and consensus-based nature of blockchains has the potential to reduce information asymmetries within the organization, which in turn mitigates principal-agent problems and enables new organizational structures. Building upon agency theory (Eisenhardt, 1989; Jensen & Meckling, 1976; Mitnick, 2021), we propose a fresh interpretation of blockchains that shifts the focus from the conventional interorganizational perspective to a microlevel, intraorganizational outlook, which distinguishes our work from previous blockchain-related research. We demonstrate how blockchains can resolve specific challenges related to information concentration, continuity, and conflict and explain the ways in which these challenges are provoked through principal-agent information asymmetries (Fig. 1). We also elaborate on how blockchains can address governance-related information challenges differently compared to relational/contractual and ERP-based governance mechanisms (Table 1). On this basis, we show how principal-agent information channels change due to the blockchain's distributed and sequenced nature and demonstrate how these changes ultimately lead to organization-wide information consensus among principals and agents and impact organizational design (Fig. 2). As our final contribution, we highlight the key implications of blockchain-based organizing for agency theory (Fig. 3).

5.1. Theoretical implications

Most importantly, our study extends the conceptual foundation for enterprise blockchains, an emerging and impactful technology (Lacity, 2018; Lumineau et al., 2021), by examining the mechanisms underlying the use of blockchains for organizational governance. We justify this extension on the grounds that most blockchain research has thus far focused on cryptocurrencies and interorganizational applications (Cheng et al., 2019; Chod et al., 2020); insufficient consideration has been given to understanding the governance mechanisms involved in the use of blockchains for intraorganizational purposes (Goldsby & Hanisch, 2022; Murray et al., 2021). We wish to draw attention to the theoretical mechanisms associated with internal blockchains as a specific and less understood application of that technology by focusing on internal processes and governance of the hierarchical firm. As blockchain technology matures, we also expect to see an increasing number of applications of internal blockchains in the business world with potentially significant implications for organizational structures. By linking blockchains to firm-internal governance problems, we also transform our understanding of governance as a "nexus of contracts" (Jensen & Meckling, 1976, p. p. 311) by developing the conceptual basis for an interpretation according to which blockchains can form the basis for a "nexus of smart contracts" that mitigates alignment and contract enforceability problems (Magelssen et al., 2022).

On a broader note, blockchains are part of a larger trend of digital transformation driven by a variety of different and complementary technologies (Hanelt et al., 2020, p. 13). Next to blockchain, AI is another example of how digital transformation is shaping organizations. For example, Dixon et al. (2021) have studied how adoption of automated processes inside organizations can lead to a decrease in the total number of managers, and that those managers who are retained in the organization increase their span of control, which speaks to our propositions of vertical disintermediation, and opposes our propositions with regard to the span of control, which shifts toward agents and does not solely rest on managers. Moreover, new forms of opportunism are set to emerge in the AI context as well. For example, Kellogg et al. (2020) study the concept of noncooperation in the AI context, by which employees develop new ways of engaging in psychological, social, temporal, or physical niches in their workplace to avoid algorithmic control. The authors discuss the opportunistic notions of foot-dragging, gaming the system, open critique, and leveraging or bypassing algorithms to resist control, which speak to the blockchain's new forms of opportunism regarding algorithm tricking, validator persuasion, and off-chain foregoing (we expand on these terms in our detailed research agenda as part of our Online Appendix). Despite their potential to yield similar outcomes, AI and blockchain are characterized by different technological attributes, with AI being a probabilistic technology and blockchain a deterministic one. Especially in governance context, where control and certainty are paramount, blockchains have the potential to cultivate stability and predictability—an aspect that probabilistic AI models inherently lack.

Table 2
Avenues for Future Research.

Blockchains Inside Organizations	*(1) Individuals*	■ ***Blockchains as a superseding role***: What are the factors that determine the suitability of human tasks for blockchain governance? What are the implications of blockchain governance for task performance and outcomes? ■ ***Blockchains as an incentive scheme***: How do intraorganizational blockchains enable agents to monitor whether principals honor their incentive agreements? ■ ***Blockchains as a breeding ground for new forms of opportunism***: How do intraorganizational blockchains entice employees to engage in new forms of opportunism (e.g., algorithm tricking, validator persuasion, off-chain foregoing) that pose threats for principal monitoring?
	(2) Teams	■ ***Blockchains for team organizing***: How do intraorganizational blockchains influence the dynamics of lateral team relationships? ■ ***Blockchains for interteam coordination***: When and why do blockchains improve interteam coordination? How do blockchains complement or substitute for the roles of lateral and hierarchical authority? ■ ***Blockchains for team performance***: Under which conditions do intraorganizational blockchains improve team performance?
	(3) Organizations	■ ***Blockchains and organization design***: How do intraorganizational blockchains change the design of organizations? ■ ***Blockchains and stakeholder transparency***: To what extent do intraorganizational blockchains prevent potential negative societal effects (e.g., insider trading, top management scandals, structural exclusions) that result from a lack of stakeholder transparency? ■ ***Blockchains and information processing***: Under what circumstances do blockchains complement and substitute for managerial experience and intuition? How do blockchains as information structuring tools and artificial intelligence as information processing tools influence strategic decision-making in firms?

5.2. Blockchains inside organizations: Avenues for future research

We recommend several important avenues for future research that connect fundamental concepts in the organization literature and the recent phenomenon of the use of blockchains for internal purposes. In our Online Appendix and summarized in Table 2, we offer a research agenda for blockchains in organizations that is organized into three levels of inquiry: (1) Individuals, (2) Teams, and (3) Organizations. Even though our theory focuses most prominently on the organizational level of inquiry, we see clear implications for related issues at the individual and group levels. Specifically, the network perspective that we propose on the organizational level can similarly be used at all other levels (individual, group), meaning that multiple units of analysis are theoretically compatible when studying blockchains. In the Online Appendix, we elaborate on each avenue and provide examples.

Future research could leverage our conceptual framework through various empirical methods. To study the impact of intraorganizational blockchains on the relationship between principals and agents, researchers can use experimental research methods to understand the behavioral patterns, responses, and changes of employees who use blockchains in their work flows compared to a control group that does not use blockchains. Such experiments may shed light on the techno-stress that blockchains create (e.g., cognitive load) in contrast to the value that they add (e.g., efficient routines). Additionally, researchers can use blockchain transaction data within organizations to track the flow of information. This analysis can provide insights into the patterns of information distribution, sequencing, and access on the blockchain, as well as identify potential issues or conflicts that arise. By combining qualitative and quantitative data, researchers can gain a comprehensive understanding of the effects of intraorganizational blockchains on governance and organizational design.

Overall, our paper offers a new perspective on governance in the algorithmic age. We show how blockchains are a valuable tool that allows managers to make organizational processes more transparent and secure, which has implications for both organizational structures and for an organization's relationship with its stakeholders. Hence, we view our paper as a starting point for a fruitful debate concerning blockchains as forms of organizational knowledge engineering, with ample opportunity to connect with various academic conversations in the field of management.

CRediT authorship contribution statement

Curtis Goldsby: Writing – review & editing, Writing – original draft, Project administration, Conceptualization. **Marvin Hanisch:** Writing – review & editing, Writing – original draft, Project administration, Conceptualization.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary material

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