frontiers in Blockchain

POLICY AND PRACTICE REVIEWS
published: 24 November 2021
doi: 10.3389/fbloc.2021.613115

Organizational Building Blocks for Blockchain Governance: A Survey of 241 Blockchain White Papers

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Governance for centralized organizational structures has long roots and well-developed frameworks, including for various specialty areas, such as IT or data governance. However, the introduction of blockchain technology as a supportive tool for implementing decentralized organizations requires a renewed focus for research in the area. The paper utilizes empirical data from blockchain ecosystems in the form of white papers (public communique of intention) to analyze their governance intentions. The empirical findings are based on a review of 241 blockchains and distributed ledger technology white papers, out of which 67 include explicit descriptions of how governance should be organized in the ecosystem. Our empirical research distinguishes between three categories of governance: objectives, mechanisms, and stakeholders. We further identify 28 features for these categories, which are described in an open encoding format. Hence, the paper contributes to the emerging blockchain research field, particularly to the decentralized aspects of blockchain governance research. This research also reveals that blockchain governance does not receive the attention it should as a large majority of ecosystems have not disclosed their governance intentions. The results can be utilized as a framework for future research. The results can also be helpful for industry when designing and developing governance systems.

Keywords: blockchain, white paper, governance, decentralized ecosystems, decentralized governance, distributed ledger technology

OPEN ACCESS

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Specialty section:
This article was submitted to Blockchain for Good, a section of the journal Frontiers in Blockchain

Received: *01 October 2020*
Accepted: *20 October 2021*
Published: *24 November 2021*

Citation:
Honkanen P, Nylund M and Westerlund M (2021) Organizational Building Blocks for Blockchain Governance: A Survey of 241 Blockchain White Papers. Front. Blockchain 4:613115. doi: 10.3389/fbloc.2021.613115

INTRODUCTION

A blockchain is essentially a cryptographically secured record-keeping system (Nakamoto 2008). It is a distributed ledger that promises an immutable record of all transactions that have taken place across a peer-to-peer network. The potential of the technology becomes evident when considering the immense role transactions, contracts, and records have in organizations, businesses, and society (Iansiti and Lakhani 2017). Furthermore, blockchain, a technology part of a family classified as distributed ledger technology (DLT), assists in securing communication and commoditizing data processing by facilitating distributed edge clouds (Westerlund and Kratzke 2018).

Blockchain technology was introduced in the Bitcoin whitepaper by a developer(s) using the pseudonym Satoshi Nakamoto (2008). The technology includes four key features: 1) transparency, 2) redundancy, 3) immutability, and 4) disintermediation (Savelyev 2018, p. 551). Transparency implies that transaction data is public, cannot be arbitrarily tampered with, and is auditable and traceable. Redundancy relates to that blockchain peers maintain and share a constantly updated copy of the ledger; thus, it offers resilience to system malfunction and toward malicious actions of third parties. Immutability means that changing ledger records is prohibitively difficult and requires a consensus in accordance with an unambiguously defined protocol. The integrity of records is, thus, ensured by the intrinsic properties of the underlying code. Disintermediation is achieved by the elimination of trusted middlemen, such as banks. Disintermediation aims to decrease transaction costs and risks associated with the presence of trusted intermediaries. As a consequence of disintermediation, blockchain communication occurs directly between networking peers instead of through a centralized controlled node. In its open form (public or consortia), blockchain's decentralized nature squarely aims to facilitate the existence of decentralized organizations. However, we show later that disintermediation may create new kinds of intermediaries as a result of a deeper implementation of blockchain technologies in the social fabric.

Blockchain is not a mere technological subject, and Rossi et al. (2019) highlight the need for research that studies the forces that affect the degree of decentralization. The implementation of the technology raises several difficult questions regarding organization and governance. The very definition of blockchain control includes some decentralization of power; however, it is becoming increasingly evident that there is no shared understanding of the exact definition of decentralization. Indeed, some have even concluded that complete decentralization in permissionless blockchains is impossible (Kwon et al., 2019) or have proposed that we should ditch the concept (Walch, 2019).

We define an ecosystem as a constantly evolving network of stakeholders involved in the creating, sharing, consuming, and trading of information through competition and cooperation. The traditional ecosystem tends to focus on a centralized authority that facilitates the information dissemination process by supplying a platform in exchange for money or data. The governance of such a platform can, thus, be considered centralized. On the other hand, a decentralized ecosystem needs to maintain a level of nonhierarchical dependence and utilize an open-access platform. Blockchain technology can be used to maintain such a platform. However, the technology itself does not hinder that peers collude to create a *de facto* centralized authority. Thus, the study of blockchain governance is crucial to understanding the complexities of decentralized ecosystems and how to maintain such ecosystems over time.

On the grounds of an intensifying discussion about governance of decentralized ecosystems, there seem to be certain challenges in organizing appropriate governance for ecosystems. The pros and cons of different governance solutions are presented in a multitude of papers (Rikken et al., 2019; Schmeiss et al., 2019; Lumineau et al., 2021; Van Pelt et al., 2021). These writings can be well grounded theoretically, but most lack empirical analysis and illustration of use cases. Our study is carried out to clarify and discover the organizational dimensions and characteristics of governance in blockchain ecosystems. We also concretely demonstrate how governance is included in the development of blockchain ecosystems.

The paper is structured as follows. Section two provides a description of research questions and methods, and section three reviews governance theory for blockchain ecosystems. The empirical analysis is then presented in three consecutive parts, starting with the categorization of governance discourses to objectives (*Objectives of Governance*), mechanisms (*Mechanisms of Governance*), and stakeholders (*Governance Stakeholders*). To improve research transparency, each of these three sections contains details in an open encoding format. The final section concludes the paper.

RESEARCH QUESTIONS AND METHODS

Over the last decade, we have seen significant advancements in blockchain and other DLTs, including differentiation of governance for these ecosystems. However, despite these advancements, systematic empirical research concerning blockchain governance has just begun. Only by introducing a research setting that analyzes a significant number of diverse ecosystems can we learn the dimensions and characteristics of governance. Furthermore, by studying these ecosystems and their intentions and choices, we can learn to compare the completeness of designs.

In this paper, based on empirical data, we present how decentralized governance is considered and what type of governance blockchain ecosystems utilize. Furthermore, we consider the included features and dimensions that are essential for viable governance models. Finally, to assess the relevance and applicability of decentralized governance for blockchain ecosystems, we pose two main research questions:

RQ 1. How are blockchain ecosystems governed according to white papers?

RQ 2. What are the key features of operating blockchain governance systems?

For this study, we collected multidimensional primary data in the form of 241 white papers selected to achieve broad representativeness of blockchain and other distributed ledger ecosystem solutions. White papers refer to publicly available design and implementation proposals provided by blockchain ecosystems that represent an intent. From a methodological point of view, white papers are documents that can be approached and systematically reviewed through document analysis. Organizational and institutional documents, printed or, increasingly, published online, have been a staple in empirical qualitative research. The analytic procedure entails finding, selecting, appraising (making sense of), and synthesizing data contained in documents. Document analysis yields data—excerpts, quotations, or entire passages—organized into major themes, categories, and case examples through content analysis (Bowen 2009, pp. 27–28).

Data collection was based on convenience sampling, a qualitative nonprobability-based sampling technique suitable for unstructured data for which probability-based samples cannot be obtained (MacNealy 1999; Burnard 2004; Benoit 2010). In **Figure 1**, we illustrate the described data collection and processing method. All 241 white papers cover and describe blockchain- or other DLT-based projects. The role of releasing white papers has become the *de facto* norm when ecosystems are conceptualized. The white papers include different types of projects, for example, protocols, platforms, or applications,

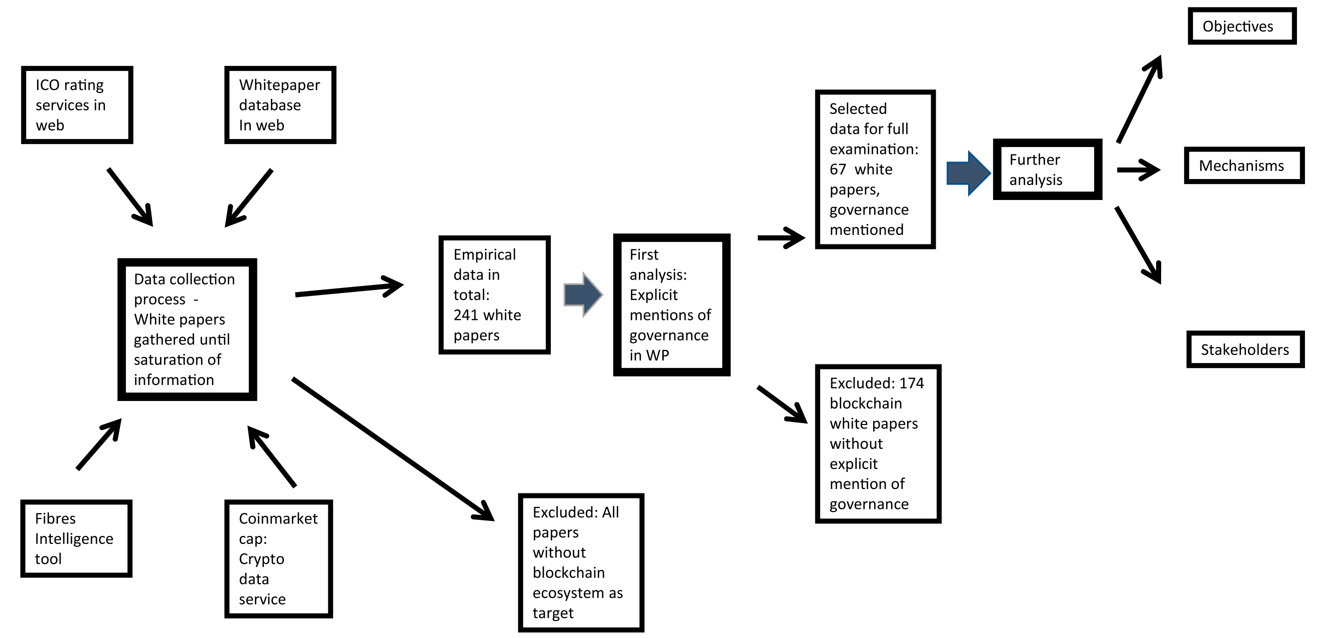

FIGURE 1 | Illustration of data collection and processing method.

which are referred to in a common term as ecosystems. The corpus was selected through nonprobabilistic and convenience sampling from various sources that were found through search engines and various relevant websites. Although governance is considered important as a decision-making structure and an internal process (human activity) of a decentralized ecosystem, governance is missing in the large majority of the examined white papers. We found 67 (28%) relevant white papers to use as data in this study based on the described selection methodology.

We use content analysis to identify explicit and implicit references to governance in the data. The content analysis is in a qualitative sense based on the interpretation of content. A primary segment of the content is a discourse unit (Degand and Simon 2009), which refers directly to the use of the word as a meaning (Wittgenstein 1953).

We performed the content analysis in three phases. First, content characterized by governance discourse units was extracted from the white papers to a first level of data storage. Because all the white papers are independent of each other, references to governance are treated as separate governance discourses. Content from the first-level storage was analyzed as discourse, and relevant groupings were extracted for second-level data storage. Then, second-level data storage was created to introduce and demonstrate features and dimensions of governance. After analyzing the first-level data, organized according to ecosystems (such as EOS or Aragon), citations in the second-level storage were sorted by themes (such as democracy or reputation). Hence, the second-level data storage was used as the location and source for extracting meanings and features of governance. By further analyzing first-level data, new themes and features were recognized and stored in the second-level storage. The third phase, including a third-level data storage, induced the three major categories: governance objectives, mechanisms, and stakeholders. In **Figure 2**, we present the analytic procedure of document analysis of blockchain whitepapers.

The analysis embraced an open coding style to improve research transparency. In the empirical sections, we include citations to illustrate the multidimensionality of white paper data and ecosystems concerning governance features. The citations are also crucial for providing a historical record as various ecosystems may dissolve and with them the official record of the white paper. Furthermore, in an online world, white papers may be continuously updated, and thereby the citations provide a record of the situation at the time of analysis.

APPLYING GOVERNANCE THEORY TO BLOCKCHAIN ECOSYSTEMS

The notion of governance is deeply intertwined with changes in the nature and the role of the state through the rule of law. However, the literature on the *new governance* also highlights the role of markets, networks, and nonstate actors and entities. All social and political regimes appear to depend on a pattern of rule or a form of governance, no matter how informal. Hence, the term “governance” has also come to refer to social, technical, and political orders other than the state (Bevir 2009, p. 14).

Formalized organizational structures for managing IT resources have long been recognized as a requirement for achieving process maturity. IT governance, emerging from corporate governance (Weill and Ross, 2004), focuses on IT as a strategic asset, i.e., helping IT managers to demonstrate a return on investment. Khatri and Brown (2010) part with the view that

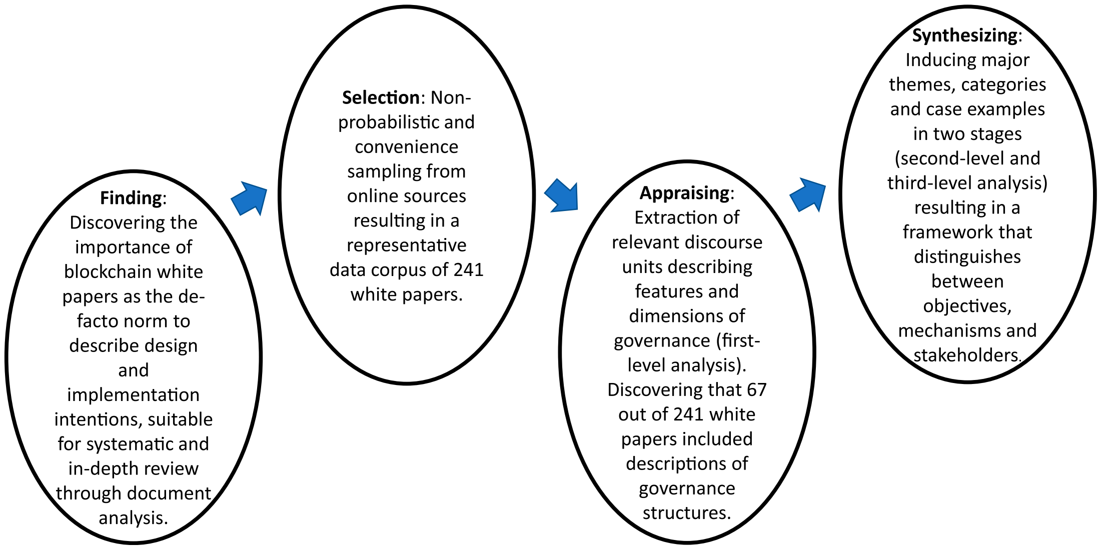

FIGURE 2 | The analytic procedure of document analysis of blockchain whitepapers.

governance is directly linked with an investment return when they introduce data governance that focused on standards for data quality. Later, Tamburri et al. (2013) recognize that informal networks within software engineering exist that do not adhere to common governance practices, which they find rather depends on an emergent cohesion between members. However, with the development of blockchain technologies, we must return to the question of governance for informal networks or, as we today call them, decentralized organizations. Such development is required by a regulatory pressure on decentralized blockchain ecosystems for showing some form of governance. An ecosystem involved in financial transactions (e.g., using their own coins or tokens as a payment solution) must be a recognized entity, accountable under the rule of law (Ganado 2019). This tension between maintaining decentralized organizational structures and centrally defined accountability under the law remains an issue of concern.

Hofmann et al. (2017) propose a concept of Internet governance as reflexive coordination that highlights *critical moments* when routine coordination fails and the (implicit) expectations of the actors involved collide, leading to contradictory interests or evaluations becoming visible. Coordination, thus, turns into governance in conflict situations when the involved parties must enter into a debate about the relevant rules, norms, and understandings underpinning their practices. Hence, Internet governance may refer to addressing, questioning, and renegotiating digital coordination practices (Hofmann et al., 2017, p. 1418).

In the blockchain context, governance is defined as the process, rules, and procedures relied on to maintain the protocol. This encompasses actual protocol modification as well as the deliberation and decision-making processes that precede and inform that act. Without governance, technology can never improve or react to the unexpected circumstances that inevitably arise (Finck 2019, pp. 183–184).

In a blockchain context, such a governance perspective underlines.

“That code isn’t a God-given entity, but something created by humans, which articulates the assumptions and goals of its creators … blockchain technology is merely a means of human expression rather than an alternative capable of replacing human decision-making.” (Finck 2019, p. 183, p. 183).

However, blockchain governance processes comprise two dimensions: on- and off-chain deliberations and decisions. Although not strictly required for most blockchain networks, on-chain decisions are taken via a consensus protocol (e.g., proof of work or stake) that enables actors (e.g., miners or validators) to vote on which transactions to include in a block (De Filippi and McMullen 2018, p. 29).

In on-chain decisions, stakeholders participate in decisions through the protocol itself, whereas off-chain governance refers to the processes around the protocol. In on-chain governance, a decision is reached on the blockchain, and consequently, the protocol adapts automatically. For instance, coin holders vote on-chain, and as a consequence of that vote, nodes automatically install the endorsed update (Finck 2019, p. 192).

Debate and research tend to focus on determining how we can replace slow and inefficient off-chain governance structures that often require human activity with fully automated on-chain governance systems. On-chain governance is often considered more transparent and efficient than off-chain. De Filippi and McMullen (2018) (p. 29), state that, when on-chain governance fails because of a technical issue or a lack of legitimacy, a critical moment emerges, and off-chain governance might be the only viable way out. Furthermore, it is debatable if on-chain governance can stand on its own or depends on off-chain governance rules to stipulate unforeseen activities over time.

Any study on blockchain governance must also acknowledge the differences between permissioned and permissionless blockchains. The terms refer to who is allowed to become a validator or a miner, and permissioned blockchain ecosystems control these nodes; permissionless do not. Permissionless systems include an extensive repertoire of stakeholders, whereas permissioned systems, incorporated based on a consortia model, offer a hybrid governance model in which the system owners play a central function. Given sufficient diversity among the consortia stakeholders, we can still consider such ecosystems to have a decentralized control function. Finck (2019) (p. 185), argues that adopting DLT governed by a single party for private purposes has little benefit as more efficient immutable record-keeping systems exist. Such statements may appear true, but there may be more technical reasons for turning to private DLT solutions, for example, improving IoT security through chain authentication or zero trust authorization solutions.

In an effort to provide a much-needed framework for the analysis of blockchain governance, Beck et al. (2019) identify three key dimensions: decision rights, accountability, and incentives.

Decision rights, in general, refer to what decisions need to be made, how these decisions are made, and who has the right to make these decisions (Abraham et al., 2019, p. 426). We can distinguish between two types of decision rights: decision management rights that allow the generation of decision proposals and execution or implementation of decisions and decision control rights that allow the ratification of decisions and monitoring of decisions. Decision rights determine a degree of centralization, that is, whether decision-making power is concentrated in a single person or small group (centralized) or dispersed (decentralized) (Beck et al., 2019).

Accountability is linked to the rights or possibility to monitor decisions (Bevir 2009; Lindberg 2013). Accountability is usually specified, enacted, and enforced through contracts and legal frameworks governed by institutions, but it can also be enacted through IT infrastructures (Beck et al., 2019). Theoretical approaches emphasizing decision rights and accountability can also be found in studies on data governance (Abraham et al., 2019) and platform governance (Martin et al., 2017). Blockchain governance emphasizes reorganizing decision rights and a technical enactment (on-chain) of accountability. Together these two tendencies underscore the importance of incentive alignment (Beck et al., 2019).

The framework presented by Beck et al. (2019) loosely builds on the principal–agent theory. Economists have extensively employed principal–agent theory to address information asymmetry problems between two contracting parties in a hierarchical relationship. The basic structure is that a principal hires an agent to do some task. The agency problem is that it is in the agent's self-interest to pursue the directed task only to the extent that it is beneficial to the agent. Thus, the principal tries to design an incentive structure to get the agent to pursue the principal's interests. However, in addition to this conflict of individual interests, the agent typically has more information about the agent's own actions related to task performance. In short, the agent knows what it is doing at work, but the principal does not because monitoring is costly. Thus, information asymmetry (see also Bergh et al., 2019) and conflict of interests produce the basic agency problem (Gerber and Teske, 2000, pp. 853–854).

Conflict of interests related to different roles and diverging goals is common in social systems, and the blockchain context is no exception. For instance, token holders may be more interested in seeing the price of their tokens rise, whereas users would rather see a decrease in the price of using a decentralized application (DApp) service. Therefore, on-chain governance suffers from the same challenges as the centralized web. Actors behaving in a manner that serves their own self-interest can exploit DApp rules technically or economically regardless of whether these users qualify as malicious (De Filippi and McMullen 2018, p. 29).

The notion of *incentive* is also highly relevant in the blockchain context. Beck et al. (2019) stress the need for incentive alignment. A system with aligned incentives makes agents free to choose their own behavior, but they are inclined to choose actions that coincide with the goals of the system's design. Incentive alignment occurs when the system's embedded features induce users to employ a system and behavior consistent with the design objective.

However, in other respects, the principal–agent theory seems to fail in explaining a decentralized blockchain system. The theory suggests a hierarchical or superior–subordinate relationship between the principal and the agent, centering around how the principal can maintain control over the agent in an efficient manner (Selden et al., 1999, p. 125). The theory has also been criticized for being a simplistic dyadic model (Gerber and Teske 2000, p. 854). The difficulty in answering who is the agent and who is the principal in staking-based blockchain ecosystems suggests that a new analysis approach is needed.

Decentralization in governance seems to represent a challenge for research. In governance literature, decentralization is defined as a process that reallocates resources from a higher, more central authority to a lower one. The aim of administrative decentralization is to redistribute tasks and duties in a bureaucracy to lower levels, to special agencies or local bodies. In general terms, decentralization refers to a process by which power and authority are brought closer to the affected citizens to promote more efficient and democratic politics (Bevir 2009, p. 64, p. 64).

From a blockchain perspective, such definitions seem very limited as such a definition indicates only a reallocation of resources while maintaining the central authority as well as the hierarchical system. In this respect, system theory is attractive given an absence of a dominant center and its emphasis on self-organizing networks. However, system theory is very abstract and often little more than a metaphor (Bevir 2009, pp. 202–204). To Beck et al. (2019), consensus-making seems to represent decentralized record-keeping and decision-making regarding the records. They suggest that consensus-making or forking *de facto* works as a novel way of resolving disagreements in a decentralized manner. However, beyond forking, concrete models for decentralizing decision rights are still under development (Beck et al., 2019, p. 27).

Forking arguably illustrates a key feature of governance in blockchain systems by ensuring that the governing power rests with individual miners or token holders. In a reasonably large

TABLE 1 | Objectives of decentralized governance.

Method	Description
Governance as a guarantee against the centralization of a network	One stakeholder or actor should not achieve a position of centralized power over others.
Governance as an arbitration process	To resolve disputes, a neutral arbitration process is a requirement in governance
Governance as a resource and reward allocator or incentive enabler and creator	An ecosystem's common decisions and economic resources are decided through formal decentralized governance.
Governance as content control	Moderating content before data is recorded on the ledger, thereby accepting a publisher responsibility.
Democracy as a target in itself	Societal participation and democratic decision making for a more equal society.
Decentralization as a target	Decentralized governance as a target when some implicit future goal has been achieved.

permissionless ecosystem, such as Bitcoin, a centralized authority cannot subvert the system using coercive force. The governance system cannot impose a protocol change that goes against the will of the network. Although rudimentary, even if some parts of the network may approve a protocol change, others may exit by forking into a new network (De Filippi and McMullen 2018, p. 29, p. 29).

OBJECTIVES OF GOVERNANCE

In a permissionless blockchain-based ecosystem, governance is considered decentralized by definition. This implies that decentralized governance is an indispensable part of an ecosystem, and it cannot be substituted with a third party or a centralized mechanism that is responsible for governance functions. Naturally, there are counterarguments against the potential benefits and indispensability of decentralized governance for blockchains. The objectives, mechanisms, and stakeholders by which blockchain-based decentralized ecosystems are governed or planned to be governed are further explored and presented in this study. **Table 1** provides a concise view of the governance objectives we identify.

Although a white paper is rarely deployed literally, it can be assumed to unveil and align the most important dimensions of an ecosystem. Due to this, provided decentralization has been presented as a final state of an ecosystem and its governance, then the ecosystem is anticipated to make efforts to reach a decentralized state. In the Artis white paper, the future aspect is articulated as follows:

"The ARTIS ecosystem will be completely public and permission-less as soon as the Growth Phase starts. During the Bootstrap Phase, the parameters for the network infrastructure will be fine-tuned to allow the best possible decentralized governance." (Artis, p. 7).

A starting point is to look for governance objectives and ask, why is decentralized governance needed in an ecosystem, and why should it be an indispensable part of a blockchain ecosystem? Why can, for instance, a decentralized ecosystem not be robustly compatible with centralized governance? The first part of the empirical analysis describes the objectives of governance. Categories of objectives are formed as an explicit result of the study. The categories are built in accordance with the empirical data to introduce issues that are emphasized or mentioned in the data. The categories are not exclusive, which means that each ecosystem can have many objectives for its governance.

Governance as a Guarantee Against the Centralization of a Network

The first category of objectives includes features of governance that guarantee decentralization in any situation. None of the stakeholder types (miners, developers, etc.) can have majority power over the others. This type of objective, or components of it, can be found, for example, in the Aragon Network:

"Actions that require high authority, such as upgradeability, should ensure that all stakeholders have some way to check the power of other stakeholders. In the case of an upgrade of the Aragon Network we should consider: users of agreements, ANT holders, and Jurors. While the exact processes for governance of network upgrades has not been defined and will ultimately be decided through a series of experimental deployments, a reasonable process that incorporates checks and balances would look something like this." (Aragon, pp. 6–7).

In the Hedera Hashgraph white paper, a guarantee against centralization is presented as follows:

"A governance model for a public ledger will define the rules and policies that control the evolution of the node software, issuance of coins, and the reward model by which participants are incentivized. The stakeholders whose interests and motivations must be balanced are those running the consensus nodes, those building applications on the platform, those businesses relying on those applications, the end-users of those applications, and relevant regulatory bodies." (Hedera, p. 19).

Governance as an Arbitration Process

Occasionally, ecosystem processes can become disturbed by malicious actors or through a technical conflict concerning, for example, smart contracts. A neutral arbitration process to resolve different types of disputes is considered a requirement for a prudent organization implementing governance. In Papyrus and PopulStay ecosystems, dispute resolutions are included in governance.

"The Papyrus DAO dispute resolution process will enforce actions most suitable for the given case, punishing either the party proven to have abused the system or the party who issued a false or inappropriate claim should the evidence of these motivations be deemed credible." (Papyrus, p. 28).

"We believe that the individuals who have contributed the most to Populstay's growth should be partaking in the decision-making process of how the ecosystem is governed. A DAO (Decentralized Autonomous Organization) is elected to resolve disputes, verify listings, filter out malicious users and vote on upcoming laws and regulations." (PopulStay, p. 14).

Governance as a Resource and Reward Allocator or Incentive Enabler and Creator

In principle, all common decisions of an ecosystem can be processed through a form of governance. This means that the ecosystem's economic resources are also allocated through governance processes. Such allocation can comprise issues from incentives, such as mining rewards, to financing relevant development projects. When deciding economic rewards, the game-theoretical settings become important to incentivize an ecosystem to run simultaneously in an effective, attractive, and sustainable way.

In the Phore masternode model and the Talao white papers, the allocation is part of the governance as follows:

"This system provides a decentralized method to determine how to best allocate funds for Phore Blockchain's development on an ongoing basis. Masternode owners decide who is paid and how much (whether it's the core team or not), and for which changes or feature additions." (Phore, p. 25).

"Talao is governed by a Chairman and a Board.... Consequently, any profit allocation is subject to a Board decision requiring the vote of the DAO representatives." (Talao, pp. 35–36).

Papyrus has also set up rules for incentives:

"Papyrus will be an all-new global ecosystem committed to forward-thinking technology and transparency in the form of a global decentralized autonomous organization (DAO) governed by token-holders and developed by the Papyrus Foundation"... "Papyrus DAO is responsible for: Distribution of the Papyrus DAO token fund, including incentives and bounties for ecosystem participants." (Papyrus, p. 3).

Governance as Content Control

In many decentralized ecosystems, users record or, rather, hash their content on the ledger. In these cases, the role of a blockchain-based ecosystem is not to be a direct publisher, but a technical platform for the distribution of content that provides an immutable record after a transaction is added to the blockchain. Furthermore, some ecosystems accept the procedure of reviewing or moderating content before recording a transaction to the blockchain. In these ecosystems, content moderation is an essential objective of governance.

In the POP Network white paper, content moderation is emphasized very clearly:

"Generalized blockchain governance refers to providing a transparent mechanism for major decision making about how the network functions. On a video distribution network, the most important element of governance is content moderation. The purpose of content moderation is to enforce community standards and provide guidelines of what is and is not acceptable on the network." (p. 19).

In the Publiq white paper, governance is given a role as a protector of readers:

"PUBLIQ Foundation values diversity, freedom of speech, and respect for others. It wants to avoid offending readers with inappropriate articles and ads. To reach this objective, PUBLIQ Foundation introduces a mechanism of community governance to make sure the readers are protected from undesirable contents." (p. 18).

Democracy as a Target in Itself

In recent years, blockchain enthusiasts have underlined the role of blockchain technology as a tool for establishing broader societal participation and equal society. Blockchain ecosystems, if designed correctly, may advance democratic and incorruptible governance. In many white papers, democracy is seen explicitly as an essential governance target.

Democracy targets can be found in the white papers of Hashnet, Minds, and SingularityNET in the following way:

"One of the central features of HashNET design is a democratic governance system which allows for involvement the entire community and is open to everyone." (Hashnet, pp. 10–11).

"Minds is attempting to build a fair and democratic system by tying the token distribution directly to the demand and activity of the network and by giving all users equal opportunity to contribute and earn." (Minds, p. 33).

"As a decentralized organization, the ongoing health and growth of SingularityNET will rely on democratic decision making among the network participants." (SingularityNET, p. 31).

Decentralization as a Target

A common objective for the examined ecosystems is that decentralization is a primary target of governance. There are numerous suitable examples of how decentralized features of governance have been presented in empirical data. However, the abstract nature of these features makes them challenging to operationalize. For example, the Artis white paper (p. 7) states that parameters will, at a later date, be fine-tuned to allow the best possible decentralized governance. Following are some other examples:

"With IPDB, we developed the methods to deploy a global database network and design appropriate governance models that can stay true to the values and intent of decentralization, where power should be spread to the community." (Ocean Protocol, p. 31).

"ICON essentially aims for a decentralized governance." (ICON, p. 20).

The most apparent sign of decentralization as a target is a reference to a decentralized autonomous organization (DAO) as a destination, such as in the Talao white paper:

"Governance is a key issue especially when migrating from a commercial entity to a DAO. Several Blockchain projects are currently seriously weakened due to governance mismanagement." (Talao, p. 20).

TABLE 2 | Mechanisms for attaining decentralised governance.

Method	Description
Token as a governance mechanism	The number of tokens a token holder has determines the share of voting power.
Constitution	A predetermined set of rules for handling conflicts concerning rights and responsibilities.
Reputation	A reputation-based system with incentives and penalties for stakeholders to act in a desirable way.
Participation and incentives	Users can receive influence in relation to their level of participation as defined by a smart contract.
Mining, staking, and validating	For some consensus models (e.g., PoW) block miners and transaction validators have an important governance role, although they do not participate in other activities. Miners can also advance or prevent development or changes in the ecosystem through pooling.
Stakeholder sanctions	Ecosystems can sanction stakeholders based on constitutional rules or ledger-based activity. The effect of sanctions can be connected to governance, e.g., that the right to vote can be suspended.
Voting processes and rights	Suffrage is an essential part of governance. Technically, voting is a repertoire of various mechanisms and offers new avenues to achieve consensus while sustaining the blockchain ecosystem.
Proposals	Ecosystems can define a procedure for handling improvement proposals and stakeholder involvement in the development process.
Forking	The ability to fork is often seen as a fundamental governance process. Forking can be used for indicating both agreement and dissent.

MECHANISMS OF GOVERNANCE

In our paper, "mechanisms of governance" refers to instruments of putting governance into practice. One or more mechanisms of governance must be implemented to operationalize and reach the desired decentralized objectives. The role and significance of the used mechanism depend on the structure and functionality of the ecosystem. A particular mechanism may have a more important role in one ecosystem than it has in another. Furthermore, governance mechanisms are not exclusive, and there are ecosystems that utilize a wide range of mechanisms to reach an optimal governance model.

In the following analysis, a *smart contract* is not categorized as a mechanism because it is considered a fundamental and necessary feature of blockchain technology in the same way as code. However, most current ecosystems are based on off-chain governance and forego the optionality of smart contracts for the purpose of enforcing governance on-chain. When ecosystems are built, governance is often developed and organized in informal real-world contexts (e.g., Bitcoin and Ethereum). At the same time, there is a growing interest in the on-chain model of governance (e.g., Tezos). In pure on-chain governance, all the governance is carried out transparently on-chain without off-chain parties or connections. In on-chain governance, rules for potential changes are encoded in the protocol. Off- and on-chain models of governance are not categorized as mechanisms because both are tools to perceive a level of automation in an ecosystem. **Table 2** provides a condensed view of governance mechanisms.

Token as a Governance Mechanism

A token can be a basic mechanism of governance. In some ecosystems, the number of tokens a token holder carries determines the holder's share of voting influence.

"On the BitShares Blockchain, decisions are made by the holders of BTS core native token weighted by the amount of BTS owned." (BitShares, p. 3).

However, the voting power of tokens can be defined in other ways as well. There are examples of ecosystems in which having one additional token does not mean an additional vote for the token holder.

"Success on Minds is measured by unique daily interaction for maximum fairness and reward integrity as opposed to other models that give the users with a higher token balance more voting power." (Minds, p. 33).

According to the white papers, there are also numerous ecosystems in which a token has no governance rights at all.

"CTY Token confers no direct or indirect right to the Company's capital or income, nor does it confer any governance right within the Company." (Connecty, p. 67).

Constitution

In the constitution of an ecosystem, there are set rules for the governance and decision-making of the ecosystem to avoid later conflicts concerning rights and responsibilities. In practice, some type of constitution is used or is planned to be used, for example, in EOS, Tezos, Cosmos, Civil (Ethereum based), and PreSearch:

"The consensus model and constitution are absolutely the foundation upon which the entire project is created." (Presearch, p. 22).

"Governance is the process by which people in a community: Reach consensus on subjective matters of collective action that cannot be captured entirely by software algorithms; Carry out the decisions they reach; and Alter the governance rules themselves via Constitutional amendments." (EOS, p. 16).

"For instance, if the stakeholder desire they may pass an amendment that will require further amendments to provide a computer checkable proof that the new amendment respects certain properties. This is effectively and algorithmic check of 'constitutionality." (Tezos, p. 7).

Reputation

For ecosystems to succeed in the long run, they must make sure that stakeholders behave according to the rules of the ecosystem and do not cause harm to other stakeholders or to the reputation of the ecosystem. As a result, some ecosystems have created reputation-based rule systems with incentives for stakeholders to act desirably.

"FRN can play a crucial role in off-chain governance of FBC and other Cosmos ecosystem projects as the users who have made endorsements, recommendations and referrals to other users are in fact staking their own reputations." (Forbole, p. 10).

The ecosystem can, for example, reward stakeholders by giving them more stakes in the governance process.

"In order to run Talao as a Decentralized Autonomous Organization, token holders and active members can call for objections, dispute and votes to make decisions. The voting power is based on the reputation of talent within the DAO." (Talao, p. 19).

"Reputation holders in the supreme court vote to approve the proposal." (Aragon, p. 9).

Participation and Incentives

Participation in ecosystem activities can be used as an incentive for users and participants to earn influence in the governing process. With this mechanism, each user can, e.g., receive influence in correlation with their level of participation as defined by the smart contract.

"The Gilgamesh token, or GIL, represents influence on the platform, and will primarily earn influence for users and participants in the governing process. Each user will receive and disburse GIL in correlation with their level of participation as defined by the smart contract." (Gilgamesh, pp. 24–25).

"WINGS platform employs a reward-based governance model for participating in the governance process of DAO projects, in order to encourage both submissions of well planned DAO propositions and healthy discussions and forecasts, leading to better DAO management." (WINGS, p. 17).

"One of our challenges ahead is to educate and encourage users of FRN to participate the governance of FBC by earning, owning and delegating Desmo to their preferred validator candidates. We need to promote civic awareness of a decentralized ecosystem." (Forbole, p. 9).

Mining, Staking, and Validating

In proof of work (PoW) ecosystems, miners or other types of block validators have a huge role in governance although they do not participate in any activities other than mining or verifying blocks. Miners are in a key position in ecosystems as they have the final decision on adopting new software changes and forking the ecosystem: a soft fork if they accept the changes or a hard fork by splitting the ledger into two independent paths if they disagree (see *Forking*):

"To some extent, mining nodes constitute the health of the aelf system, so these nodes are responsible for being a ledger and handing out bonuses and feedback values to the stakeholders who entrusted them through Smart Contracts." (Aelf, p. 11).

"Validators and delegators on the Cosmos Hub can vote on proposals that can change preset parameters of the system automatically (such as the block gas limit), coordinate upgrades, as well as vote on amendments to the human-readable constitution that govern the policies of the Cosmos Hub." (Cosmos, p. 7).

Stakeholder Sanctions

On some occasions, ecosystems can sanction stakeholders based on their behavior. In principle, the grounds for the sanctions can be connected to governance, meaning that the right to vote can be suspended. For example, in the Decred (PoS/PoW) ecosystem, other stakeholders can override a miner if 60% or more of the stakeholders vote against a block created by a miner.

"The role of governance within the Livepeer protocol is intended to be three fold: Determine the burning or appropriation of common funds which were slashed from misbehaving nodes." (Livepeer, p. 16).

"The ARTIS ecosystem forms a web of trust and therefore it must also be able to punish malicious behavior and fraud." (Artis, p. 11).

"Misbehaving nodes are punished by losing their staked tokens." (POP Network, p. 15).

Voting Processes and Rights

The right to vote is an essential mechanism of governance. Voting is one part of decentralized governance although not synonymous with it. Technically, voting is not one solution, but a repertoire of various models as seen below. Several decentralized ecosystems are reporting that stakeholders are quite passive when it comes to individual voting, and thus, the model's effectiveness should be considered. From our white paper analysis, the following voting models are identified:

1) Proof of Stake (PoS) model

"Unless otherwise specified, each token-holder's vote is weighted according to the tokens they stake. Unless otherwise specified in this document, all votes require a simple majority (more than 50 percent) to carry." (Civil, p. 6).

2) Progressive PoS system

"However, voting power is progressive. This means that every incremental token from larger holders has less voting power, giving smaller stakeholders more say in aggregate." (Cardstack, p. 47).

3) One individual—one vote

"Every user's vote counts for the same amount, and every voice has equal ability to be heard. . . Success on Minds is measured by unique daily interaction for maximum fairness and reward integrity as opposed to other models that give the users with a higher token balance more voting power." (Minds, p. 33).

4) Voting with expertise

"We enable a voting process that uses voters' expertise in addition to token wealth to make decisions that are best for the project in the long run." (Proffer, p. 13).

5) Voting by participation

"Essentially making each token holder an influencer in the platform in an amount that is directly proportionate to their participation." (Gilgamesh, p. 25).

6) Nonbinding voting:

"Voting results won't be binding, but they will be strongly considered in decision making. We will test and adjust the voting mechanism to make it perfect for future decentralization of the Platform." (Alt.Estate, p. 28).

7) Liquid democracy: Direct or Proxy voting (DPoS)

"On the BitShares Blockchain, decisions are made by the holders of BTS core native token weighted by the amount of BTS owned. In order to improve voting participation and simplify the life of BTS holders, voters can either vote directly or delegate voting power to so called proxies." (Bitshares, p. 3).

Proposals

A fundamental claim for governance participation can be considered the right to give proposals that are considered and concluded within the ecosystem. However, there is no examined knowledge available from a comparative or general perspective concerning proposal processes. According to the white papers, the processing of proposals is organized in various ways in different types of ecosystems:

"Each member of TiiQu will have the right to submit a proposal to the TiiQu community for the purpose of making a change. Changes can be anything from the suggestion of a user interface improvement, to a change in the voting mechanisms, to an ingenious marketing strategy. Every member will have the right to submit a proposal which will be stored as a permanent record on the blockchain for anyone to see. Members will also share in any benefits of a proposal they submitted that is successfully passed review, the general vote and implemented." (Tiiqu, p. 12).

"Any individual will be able to propose a request to the OPUS network. However, proposals will burn 1000 OPT to stop spam. There will be a 1-month period for voting and submissions where the number of Yes/No votes are weighted by the number of OPT tokens the voter holds. Anybody can participate in this voting procedure." (Opus, p. 25).

"Any node in HashNET network can propose tenders, and then Magnus Consilium decides and votes on each such proposal. Magnus Consilium is comprised of all the masternodes with positive reputation in HashNET. Voting is decided by simple majority." (HashNET, pp. 10–11).

"Many of the network parameters referenced in this document such as UnbondingPeriod, RoundLength, ParticipationRate, and VerificationRate are adjustable. Proposals for adjustments to these parameters can be submitted, and the governance process, including voting by transcoders in proportion to their delegated stake, will determine adoption of these changes automatically within the protocol." (Livepeer, p. 16).

Forking

A possibility to fork can be seen as a type of governance mechanism. For example, disagreements between stakeholders can lead to a hard fork and even to the creation of two separate blockchains, which are no longer compatible with each other after the fork. Thus, forking is usually a revolutionary solution for resolving conflicts in decision-making. In the surveyed white papers, there are some references to forking, such as the following:

"A blockchain based on the EOS. IO software recognizes that power originates with the token holders who delegate that power to the block producers. The block producers are given limited and checked authority to freeze accounts, update defective applications, and propose hard forking changes to the underlying protocol." (EOS, p. 16).

"Individuals can host nodes on the network, thereby giving the community the ability to fork the DNN protocol. This can be done by garnering enough support, in cases where the network is compromised or crucial protocol changes are needed." (DNN, p. 48).

GOVERNANCE STAKEHOLDERS

To define decentralized governance, we need to understand the stakeholders involved within the ecosystem. Below, we list the stakeholders by category and describe them to clarify their different roles in ecosystems. Although some stakeholders can have more power in ecosystem governance than others, the power relations of different stakeholders are not analyzed in this context. In **Table 3**, we summarize the stakeholders of blockchain ecosystems.

Mining Nodes (Miners)

In PoW model-based ecosystems, miners validate blockchain transactions by solving puzzles and receive rewards for mining. The role of miners in governance is indirect but crucial. Potential block rewards to miners are decided in the governance process. The rewards should be adequate to incentivize miners to mine blocks to keep the ecosystem going.

"Governance. The majority of current blockchain protocols have issues with administration, growth, modifications, and control. Most blockchains rely on independent miners who have both a large influence on the growth of the protocol as well as conflicts of interest that may impede that growth. As a result, relatively simple but necessary changes to a protocol are often difficult to implement." (Devv, p. 4).

Token and Coin Holders

A simplified separation of *coin* and *token* is that a coin is native to the blockchain and a token tends to be implemented through smart contracts on top of an existing ledger. Both can simultaneously fulfill many roles in the ecosystem, but coins tend to be primarily used as a value store. A token is more dynamic and project-specific, representing a limited thing on-chain, such as value, stake, right to vote, etc. Holders are users who own and control their tokens or coins. Generally, the role of

TABLE 3 | Ecosystem stakeholders.

Stakeholder	Description
Miners (Miner nodes)	Miners validate blockchain transactions by solving puzzles and receive rewards for mining.
Token and coin holders	Token holders are users who own and control their tokens. Tokens are a representation of something on the ledger (value, stake, right to vote, etc.).
Developers	Developers write proposals and program software, trying to improve it continuously. In governance, the role of developers varies between ecosystems, some may receive remuneration, and others may work pro bono.
Users (Content producers, viewers, reviewers)	Blockchain projects target various types of use cases; for some more advanced projects, this includes different types of actor responsibilities.
Delegates	In some consensus protocols, delegates, selected by vote, make decisions in governance processes.
Arbiters	Ledger immutability makes dispute resolution a hard problem. Arbitration requires specific implementation to reverse stored transactions, an action that may present security issues.
Nodes (Full nodes)	Full nodes store a complete and local record of the layer.
Masternodes	Masternodes receive and process transactions in real time. They may also participate in governance and voting and increase the privacy of transactions.
Foundation	During the early stages, a foundation is usually the owner and/or decision maker, especially for ecosystem financing and development. When decentralizing an ecosystem, the foundation cannot remain a centralized instance.
Consortium or federation as a governing unit	A common incorporation for private ledgers involving more than one member organization.
Community as a driver	A community, often an informal social entity, comprises different types of stakeholders, such as developers and enthusiasts, whose views are potentially taken into account when making decisions in ecosystem governance.
Stakers (Validators)	To perform voting, participants can stake a portion of their tokens, by adding them to the voting pool, to gain influence over ballot outcomes.
Projects and DApps operating in the ecosystem	Through the design of intricate smart contracts, new ecosystems can be built on top of an underlaying ledger platform; these DApps may infer their own rules and tokens.

the token holder in governance is tied to the use, which is described in *Token as a Governance Mechanism*. The EOS (DPoS) white paper explicates the role for token holders:

"If the block producers refuse to make changes desired by the token holders then they can be voted out. If the block producers make changes without permission of the token holders then all other non-producing full-node validators (exchanges, etc) will reject the change." (EOS, p. 16).

The NEO white paper emphasizes the role of token holders for on-chain governance:

"Chain governance: NEO token holders are the network owners and managers, managing the network through voting in the network" (NEO, p. 5).

In the POPnetwork white paper, the long-term effects of commitment among token holders are considered important:

"By incentivizing token holders to make decisions about the long-term health of the network, we must insure self-interest and cryptoeconomic dynamics take hold and provide a strong protector of The POP Network." (POPnetwork, p. 18).

Developers

Developers have a significant role in creating and developing ecosystems. They construct the initial software and usually try to improve it continuously. In governance, the roles of developers vary between ecosystems:

"The Ontology Council's governance structure design ensures sustainability, effective management, and fundraising security. The Ontology Council consists of the Developer Committee and the Operations Committee, under which [other committees] fall." (Ontology, p. 22).

"The Papyrus design with DAO governance will be flexible enough to upgrade contracts, protocols, adjust fees and enforce other necessary structures and agreements developed and driven by the community of users and developers." (Papyrus, p. 4).

"To reflect the users' need for development but the developers' need for legitimacy, we expect a reasonable direction would be to form the two chambers from a "user" committee (made up of bonded validators) and a "technical" committee made up of major client developers and ecosystem players." (Polkadot, p. 4).

"The management body will consist of developers and functional committees." (Primas, p. 29).

Users (Content Producers, Viewers, Reviewers)

Decentralized ecosystems are developed and maintained for various types of users. Users can have a role as a permanent token holder or occasional user. However, even occasional users can have a role in governance through participation, recommendation, and reputation processes. For example, voting or recommendation can be used to determine rewards for producers. To implement these as governance processes, the necessity of a decentralized identity must be assessed.

"However, involving end users in governance decisions is extremely hard in decentralized systems: user identities are usually not connected to real-world identities, and digital identities can be easily forged. This issue is usually mitigated by weighting user votes with their stake in the system's currency, at the risk of concentrating power in the hands of a few rich users." (Orbs. pp. 44–45).

Platforms for sharing, selling, and consuming content (data, music, media, video, pictures, etc.) are proposed to function as decentralized ecosystems. Challenges and possibilities for content producers are partly similar to those users who consume content. Users have an incentive to participate in governance when, for example, any maintenance costs or rules for content sharing are decided through ecosystem governance.

"Content creators are core member in the development of the community. They will receive Sugar as rewards according to the quality of generated content." (U-Network, p. 19).

"We are also considering implementing a DAO system within the OPUS code. This system would allow music listeners to vote on what improvements need to be made to OPUS. This democratic system allows agile polling while ensuring that voters are represented and prevents Sybil voting as happens in other non-blockchain products." (Opus, p. 24).

Delegates

In delegated PoS protocols, delegates, selected by vote, make decisions in governance processes.

"In aelf, vital decisions are carried out through a mechanism that resembles representative democracy. Delegated nodes must have enough votes from other stakeholders to participate in aelf governance." (Aelf, p. 11).

Arbiters and Arbitrators

Broadly speaking, it often remains unclear how the dispute-resolution processes function in decentralized ecosystems on a larger scale. Arbiters (legal authority) do potentially have a role in governance. For example, smart contract disputes can be resolved by arbiters as in the Tiiqu white paper:

"The concept of crowd-sourced arbitrage or crowd-arbitrage allows parties of a contract to select a crowd sourced arbiter entity to mediate between parties in the event of a dispute and ultimately give the final word in the event the parties are unable to agree on the dispute." (Tiiqu, p. 12).

However, the term "arbiter" is less familiar in white papers, but the term "arbitration" (a discretionary process) is generally used. In the process of arbitration, an arbitrator is considered, for example, as follows:

"Dispute resolution will be managed through a mechanism that is defined in the project documentation and is standard to any contractual agreement, with nominated arbitrators and jurisdictions as standard dispute resolution clauses." (IXO, p. 12).

Full Nodes

Blockchain ecosystems run on nodes. Any computer that is connected to an ecosystem is a node. A node stores the entire copy of a ledger locally.

"The network of nodes will have between 50–200 independent servers. Therefore, compared with the number of mining pools of systems with Nakamoto consensus (e.g., Bitcoin or Ethereum), the ARTIS network will offer a much higher decentralization and resilience." (Artis, p. 7).

"If the block producers make changes without permission of the token holders then all other nonproducing full-node validators (exchanges, etc) will reject the change." (EOS, p. 16).

Masternodes

Masternodes are nodes that keep a full copy of the blockchain in real time. Masternodes are responsible for facilitating instant transactions, participation in governance, and voting. Because of their unique contribution to the ecosystem, masternodes are given a portion of block rewards. In the process of establishing a masternode, a certain amount of funds needs to be locked away as collateral.

"The funding and direction of Phore Blockchain's funding is governed by those in the Phore Blockchain community with the most stake in enhancing Phore Blockchain's long term value—the masternode owners, who are each staking 10,000 PHR as collateral for their masternode. The mechanism and process behind this governance is built directly into the blockchain code." (Phore, p. 25).

"In order to achieve this, and prepare for mass adoption, PIRL will take the existing framework of the Ethereum network, and further enhance its capabilities, scalability, and stability. A multitiered masternode network will lay the foundation for this process, bringing the concepts of decentralized currency, applications, and governance to a higher echelon." (PIRL, p. 5).

Foundation

A foundation is usually the owner and/or decision-maker, especially in the early stages of an ecosystem's development. When making an ecosystem decentralized, the foundation (or other organization or company) cannot remain as a centralized owner or decision-maker. However, a foundation can change its role to become a more professional unit and/or stakeholder without a monopolized status in the ecosystem.

"The Primas community will be managed by Primas Lab Foundation Ltd. established in Singapore, which as a legal entity, will have full authority over the development, promotion and operation of Primas and take all related responsibilities." (Primas, p. 28).

"The ixo Foundation will have no direct control over this adjudication process, or the execution of the PoS smart contracts." (IXO, p. 31).

"Foundation members provide open-source code and submit new features. Delegates then choose specific features to incorporate based on their needs. If one feature is adopted by enough delegates, it gains approval by the whole system." (Aelf, p. 11).

"As a security measure, the Tezos foundation will have a veto power expiring after 12 months, until we rule out any kinks in the voting procedure)." (Tezos, p. 9).

Consortium or Federation as a Governing Unit

In private or consortium ecosystems, governance may often be different compared with public or permissionless decentralized ecosystems. In a consortium ecosystem, the participating companies or other organizations have an equal role in governance. However, in some cases, it remains unclear how issues such as protocol upgrades or changes in consensus protocols are processed through consortium governance.

"Council Governance Model: Hedera will be governed by up to 39 leading organizations in their respective fields, … The Governing Members will elect the Board of Managers and also contribute expertise through subcommittee membership. The terms of governance ensure that no single member will have control, and no small group of members will have undue influence over the body as a whole." (Hedera Hashgraph, p. 5).

"In addition, our node validation service will provide a more trustless environment for healthcare. This service is also different than Patientory's foundation, in that our consortium is much more decentralized and is more like a governing body than a single entity." (Health Nexus, p. 8).

> "Voting power is distributed between known verifiers that are members of a federation, thus limiting the power held by a single voter." (Orbs, p. 50).

Community as a Driver

In some ecosystems, a community is categorized as its own, usually informal, unit. A community is a social entity that comprises different types of stakeholders, such as developers and enthusiasts, whose views are potentially taken into account when making decisions in ecosystem governance. Some white papers emphasize that the community lies somewhere deep inside the ecosystem.

"The community is the heart of the Presearch ecosystem. In order to be transparent, open and innovative, we need to attract smart people who can jump in and run with the concept and evolve it in ways that a single company or team never could. We believe in the wisdom of the community to solve its own problems, determine what's fair, and create systems and processes that support its ideals and goals." (PreSearch, p. 22).

"Perhaps, most important to our development and success is our thriving and expanding community. PHR is structured to be governed by the community transparently." (Phore, p. 7).

"The success of the platform will depend on a vivid community of users and companies. The token model should reflect and support this community. This community will play a central role in the realignment of incentives. Via tokens, customers can 'own' their insurance. The community model should facilitate the development of future mutuals and P2P-Insurance models. A community cannot be built from the outside, it has to grow from the inside. However, experience shows that there are some success criteria for communities." (Etherisc, p. 17).

Stakers (Validators)

Staking is a process for the PoS consensus protocol. A staker often needs a full node and the ability to maintain and validate transactions on the blockchain. Based on a predefined set of rules and a random factor taken into account, the target is to determine who will be the next to validate a transaction/block and potentially get a reward.

"Participants need to stake a portion of their tokens, by adding them to the voting pool, to gain influence over ballot outcomes. Staked tokens are locked for a period of time, during which they cannot be converted to SSC, circulated through the reward cycle, or traded." (Cardstack, p. 48).

"To organize and maintain a censorship-free and fair voting process, and protect each user's influence during quarterly votes, users will 'lock-in' or stake tokens until the voting period ends or consensus is reached. During voting, users will be unable to spend tokens that are 'locked.'" (Gilgamesh, p. 25).

Projects and DApps Operating in the Ecosystem

Some ecosystems are platforms for other ecosystems or decentralized applications, aka DApps. The interest of these ecosystems toward the governance of others is usually reciprocal. Both are some types of stakeholders in each other's governance. Usually, an ecosystem or DApp, which was built on preexisting blockchain, must comply with the rules of the underlying platform.

"The EPN will be a system of smart contracts on the EOS platform, so users will not be running full nodes of the Everipedia Network. This means users cannot vote on software updates by updating their client software as they do in Bitcoin or Ethereum. Instead, a trustless on-chain consensus process must be designed for deployment of new updates." (Everipedia, pp. 1–2).

CONCLUSION AND DISCUSSION

Our findings show that blockchain governance is significantly different in nature from many other forms of governance. The academic literature lacks a comprehensive practice-oriented approach to blockchain governance to understand how decentralized organizations approach the topic. Previous studies often focus on individual governance building blocks, whereas our contribution identifies numerous building blocks a decentralized organization can employ to achieve governance. Below, we present the main results of the empirical study, discuss the research data, and what is meant by decentralized governance. In this study, we concentrate on two research questions.

RQ1—How are blockchain ecosystems governed according to white papers?

RQ2—What are the key features of operating blockchain governance systems?

Blockchain and DLT white papers from 241 ecosystems are used as research data to address these questions. The white papers are analyzed inductively by emphasizing the role of data as a base of knowledge and as a potential theory for decentralized governance.

Governance, a structure of processes, rules, and procedures (human activity) meant to maintain a decentralized ecosystem, is missing in an explicit form in a large number of the examined white papers. We found 67 relevant white papers to use as primary data in this study. The relevance was determined by the existence or nonexistence of discourses concerning governance. By examining our data closely, the concept of governance was derived as it is represented in the white papers. Basic units of governance are called features. Features were identified and gathered from the empirical data. However, no white paper that was analyzed covers all the discovered features. For technical reasons, this is understandable. There are various choices to be made between alternatives, and a particular feature can exclude another. From the data point of view, ecosystems have a wide range of instruments (as specified in various white papers) to design a decentralized governance entity, but despite this, an all-encompassing examination of descriptions of governance cannot be found in any white paper.

The critique against the governance of early decentralized ecosystems, especially Bitcoin and Ethereum, is a general starting point in the white papers. New ways to organize governance are called for and are also proposed in several white papers. Demands for governance renewal are conveyed as a need for a more formal design of governance and even as a promotion of on-chain governance structures for ecosystems. To elucidate the diversity of reasoning in the white papers, we identify and introduce six types of objectives for governance. Fundamental theoretical distinctions of decentralized governance can be interpreted to lie in these objectives. The following objectives of governance, governance as a guarantee against centralization (*Governance as a Guarantee Against the Centralization of a Network*), democracy as a target itself (*Democracy as a Target in Itself*), and decentralization as a target (*Decentralization as a Target*) can only be implemented without a remnant of centralized power.

However, the objectives are not concrete tools or methods to implement governance. Implementation of governance is carried out by mechanisms of governance, which are also identified from the data. The governance mechanisms we identify (*Mechanisms of Governance*) are setting proposals, voting, tokens, sanctions, reputation or participation records, constitution, consensus, and validating. Governance mechanisms are used to maintain, update, and upgrade the ecosystem and the ledger itself. Although mechanisms are essential for implementation, more research is needed to determine which mechanisms provide conditions for a viable decentralization of ecosystems.

The data analysis also unveils governance stakeholders. Stakeholders may have different interests and values for introducing governance mechanisms, and these interests may be incompatible or competing with each other. Therefore, when establishing a new ecosystem, the mechanisms and stakeholders should be selected with the wanted level of decentralized governance in mind.

Various general features of decentralized blockchain governance are identified by analyzing the data. However, decentralized blockchain-based ecosystems may also, depending on their objectives, require certain specific governance features. General features also do not directly implicate preconditions for indispensable features in every ecosystem. Instead, the general features presented herein provide means for achieving certain objectives in an ecosystem. Our effort to explicate these features is intended for the design of future ecosystems that more clearly handle governance. Because only 67 ecosystems out of 241 (28%) are found to explicitly raise the subject of governance, we consider defining what is meant by blockchain governance for the ecosystem to be prudent and essential.

The collected data shows that a DAO is often considered the ideal state for decentralization. A DAO can be understood as a confluence of governance and ecosystem in which all functionalities run fluently decentralized and potentially on-chain. Compared with the early blockchains, such as Bitcoin, whose governance mechanism can simply be described as accept or fork, more recent ecosystems have begun to show a more nuanced view of governance.

The essence of a decentralized ecosystem implies the existence of stakeholders, who have their own interests and roles in the ecosystem and who cannot, by definition, have an autocratic centralized role in governance. Therefore, a governance design must prevent centralization at both conceptual and practical levels. We found that the objective of governance as a guarantee against centralization is considered indispensable for decentralized governance. To preclude that governance is centralized, there must be a balancing system, such as a principle of separation of powers, a generally known model for state governance. Separation of powers refers to the division of rights and responsibilities into distinct branches (a legislature, an executive, and a judiciary) to limit any branch from exercising another branch's main tasks. Although the expression "separation of powers" is not used in the white papers of our research data, it is used on websites of some ecosystems that have recently emphasized the separation of powers principle as a fundamental component of an ecosystem.

Even though decentralized ecosystems are independently self-governed, changes in external circumstances may force amendments to the ecosystem. To survive in the presence of external challenges, ecosystems must have formal proposing, decision making, and execution mechanisms. Finck (2019) points out that technology can never improve or react to the unexpected circumstances that inevitably arise without governance (Finck 2019, pp. 183–184).

According to the research data, a constitution is an essential mechanism to formalize governance and create trustworthiness for the ecosystem. An example of this process is the constitutionality assessment in Tezos. However, if all the rules of governance are assumed to be coded as smart contracts, ecosystems still have open questions concerning the need for arbitration mechanisms. The research data shows that ecosystems, such as IXO, are prepared to offer mechanisms to resolve disputes between stakeholders through formally defined arbitration processes.

In the third section, we introduce several ways blockchain governance is approached from an academic perspective. Beck et al. (2019) base their paper on an analysis of one ecosystem case study and theories of platform governance. The empirical data of our study shows that the categorization of governance by such traditional and centralized approaches to decision rights, accountability, and incentives may conceal essential features of decentralized governance and, thus, emphasize constancy in ecosystem governance. There are profound differences between centralized and decentralized ecosystems, differences that particularly emerge from a governance perspective. A decentralized ecosystem is a fragile community whose governance components should be balanced with each other. To analyze the community and components further, this balance should be kept as a determinant even under the pressure of external challenges. De Filippi and McMullen (2018) and Finck (2019) emphasize that governance must also cope with an ecosystem's external challenges to survive and evolve.

According to Beck et al. (2019), the central role of incentives is to be a new dimension between the traditional digital economy and the blockchain economy. According to our data, incentives are considered in some ecosystems. However, there are no signs that incentive alignment could be accomplished without decent governance mechanisms, such as proposing, voting, and arbitration. Thus, although economists may see incentives as omnipotent determinants of behavior, governance instruments are also needed to align and regulate the behavior of stakeholders in decentralized ecosystems.

In conclusion, we summarize a descriptive elaboration of decentralized governance for blockchain ecosystems using a novel empirical data set. Further research is needed to propose specific and viable requirements for decentralized blockchain governance. A centralized ecosystem may find it easier to address rapid development issues due to shorter decision flows and clear stakeholder benefits. Hence, blockchain governance must design incentives to align stakeholder views and introduce a sense of urgency or termination. However, if and when an ecosystem has a built-in guarantee against centralization through its governance, mechanisms are indispensably needed to capitalize on the advantages of being a decentralized ecosystem. A balance between powers in decentralized governance is produced by a set of mechanisms of which none can be excluded if the aim is to maintain a viable balance. In this sense, expressive decentralized ecosystems can function like modern democratic societies with power-balancing institutions.

AUTHOR CONTRIBUTIONS

First author has been responsible for data encoding and analyzing. All three authors have contributed equally to the writing.

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