BlockchainGov // Project Liberty Institute

Report on Blockchain Governance Dynamics

BLOCKCHAINGOV

Project Liberty //

May 2024

Better Web, Better World

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Impressum

This report is jointly produced by Project Liberty Institute and BlockchainGov.

About Project Liberty Institute:
Project Liberty Institute, 501(c)(3) founded by Frank McCourt, is building a global alliance for responsible technology and bringing together technologists, academics, policymakers, civil society and citizens to build a safer, healthier tech ecosystem. The Institute has an international partner network that includes Georgetown University, Stanford University, Sciences Po, and other leading academic institutions and civic organizations; and is the steward of the Decentralized Social Networking Protocol (DSNP) which is available as a public utility to serve as the bedrock of a more equitable web and support a new era of innovation that empowers people over platforms and serves the common good.

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About BlockchainGov:
BlockchainGov is a 5-year project (2021-2026) funded by the European Research Council (ERC grant of €2M). The project is directed by Primavera De Filippi and hosted at the Centre National de Recherche Scientifique (France) and the European University Institute (Italy), with Principal Investigator and advisors from the Berkman Klein Center at Harvard University. As an interdisciplinary research team comprising legal scholars, social and political scientists, computer scientists, and blockchain engineers, BlockchainGov focuses on studying the impact of blockchain technology on governance and its consequences for legitimacy and trust.

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Disclaimer

This report has been developed with the help of the Governance Multistakeholder Council (MSH Council). The views expressed in this report do not reflect the views of the organizations with which Council members are affiliated. Any errors or omissions are those of the research team and not the MSH Council members. MSH Council members might not necessarily endorse all views presented in the research report.

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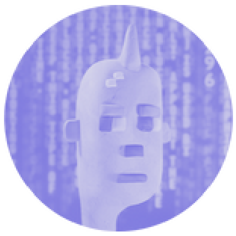

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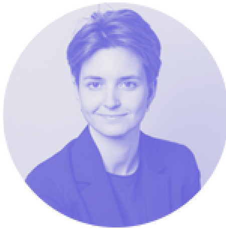

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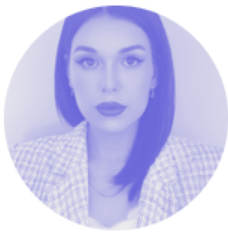

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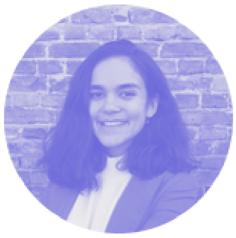

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Executive Summary

While the evolution of the World Wide Web has taken various turns away from its original vision, the advent of Web3 promises a new era focused on user 'ownership' and 'decentralization.' The concept of Web3, introduced in 2014 by Ethereum co-founder and Polkadot creator Gavin Wood, focuses on a new infrastructure based on decentralized networks and technologies. This new infrastructure enhances user ownership and autonomy by moving away from centralized operators and trusted intermediaries.

Blockchain technology is a cornerstone of Web3, initially developed as an innovative means to record transactions digitally. The collective choices of individuals and organizations drive the evolution of blockchain technology and its diverse applications. These entities form what are known as 'blockchain systems': complex techno-social structures that operate across multiple intertwined layers. Beyond the capabilities of blockchain technology to store data across multiple nodes, the governance dynamics within blockchain systems are complex and nuanced. To fully grasp the opportunities and challenges of Web3, it is essential to analyze the governance practices of its fundamental components, including blockchain networks.

This report is a collaborative effort between BlockchainGov and Project Liberty Institute to analyze the governance dynamics of prominent blockchain networks through an interdisciplinary and comparative lens. It focuses on eleven blockchain networks: Avalanche, Bitcoin, Cardano, Cosmos, Ethereum, Filecoin, Optimism, Polygon, Polkadot, Tezos, and Zcash. Through a comprehensive empirical analysis built on previous academic work and practitioners' insights, the report offers six key findings about the governance dynamics of these blockchain systems.

Legal Entities

Most blockchain networks, with the notable exception of Bitcoin, have established legal entities such as non-profit foundations or corporations to manage various aspects of their operations. These entities serve several functions, including providing legal recognition for engaging in off-chain contracts, navigating regulatory uncertainties, enhancing governance sustainability, and supporting ecosystem growth through grants. Although forming these legal entities aims to create greater legal certainty for blockchain networks, this is not always achieved. Such entities, whether founder-led for-profit corporations or non-profit foundations, often hold a significant minority stake in the network's governance through token ownership. However, this stake does not grant them unilateral control over the networks. Instead, they influence the networks in other ways. Concern arises because these entities typically lack open, transparent, and inclusive mechanisms for appointing and holding their board of directors accountable, leading to a mismatch between the public and permissionless nature of the networks and the opacity of the supporting legal entities. This opacity can raise issues such as potential conflicts of interest and lack of disclosure of important information to the community.

Power Distribution

While no blockchain system is ‘centralized’ in the sense that it is governed by one single person or entity, decision-making power is not evenly distributed. The concrete power distribution within these systems varies significantly depending on the specific case. This variation arises due to factors such as the governance areas or types of decisions being made, the diverse array of stakeholders involved, and the mechanisms employed in the governance process. Recognizing blockchain systems' nuanced and multifaceted structure is essential for discerning the actors who shape governance outcomes and the channels through which they exert influence. Blockchain communities can identify governance practices that stray from their foundational values or objectives by examining the complex interplay among governance areas, stakeholders, and mechanisms. This insight is crucial for developing rules, procedures, and mechanisms that better address community concerns and aspirations, ultimately creating governance systems that align more closely with their collective needs.

Planned vs. Actual Decentralization

After launching a blockchain network, community members commonly pledge to progressively decentralize governance. However, while there are many possible approaches to 'decentralization', blockchain communities frequently lack public, clear, and operational definitions. Additionally, several factors impede the actual process of decentralization. On-chain, power tends to consolidate among mining and validator pools, exacerbated by plutocratic token-weighted voting systems. Off-chain, the challenges include escalating governance complexity, early entrenchment of power, and external regulatory pressures. Blockchain communities that genuinely seek to progressively decentralize must adopt precise and operational definitions of what decentralization means in the context of their blockchain system. Additionally, they will need to recognize and address on-chain and off-chain challenges.

Governance Formalization

In recent years, blockchain communities have experienced greater 'formalization,' or a surge in the adoption of online written documents delineating blockchain rules and procedures. These documents play a crucial role in establishing the framework for off-chain and on-chain decision-making, essentially introducing what can be termed 'secondary rules.' However, despite these advancements, the blockchain governance landscape still grapples with a significant gap between these formalized rules and the implicit, often undocumented, practices that shape governance within many blockchain systems. Governance formalization can become an important opportunity for strengthening the legitimacy of blockchain systems. Yet, community members should remain aware of the delicate interplay between on-chain rules, expressed through blockchain code, and off-chain practices, which can never be completely and fully expressed on-chain. Implementing a hybrid of on-chain and off-chain rules makes blockchain governance more flexible and adaptable to the community's evolving needs while preserving the reliability and accountability of code-based mechanisms.

Governance Mechanisms

Certain governance areas within blockchain systems welcome contributions from various stakeholder groups. 'Rough consensus' and 'signaling and voting' represent two governance mechanisms for gathering input and making decisions. Blockchain communities utilize varying degrees of sophistication in these mechanisms and implement them independently or in conjunction, resulting in diverse decision-making processes for each scenario. The distinct characteristics of these mechanisms, alongside factors like the nature of the decision and the stakeholders involved, can give rise to more 'participatory' to more 'expedient' approaches to governance design. Blockchain communities must thoughtfully weigh the implications of adopting rough consensus versus signaling and voting since these can create specific incentives that may either promote advantageous or detrimental behaviors, thus influencing the network's sustainability and resilience. These dynamics invariably shape stakeholders' perceptions of the legitimacy of the blockchain system.

Security Measures and Breaches

Preventive security measures in blockchain networks involve a range of strategies and technologies aimed at thwarting potential threats such as DDoS attacks, '51% attacks,' and vulnerabilities in smart contracts. These measures often rely on the expertise of in-house security teams or third-party contributors incentivized by bug bounty programs. Additionally, third-party security audits are commonplace across various blockchain ecosystems, ensuring an extra layer of protection. While some blockchain communities have established procedures or governance bodies to address unforeseen events, the handling of 'states of exception' continues to be a governance area that sparks controversy within these communities. To maintain community trust, ensuring the security of blockchain networks requires adopting formal and well-understood processes for handling external threats while reducing the likelihood of decision-making centralization for personal gain. Achieving this balance demands a fusion of specialized technical knowledge and an understanding of stakeholders' needs and incentives to define the parameters under which 'states of exception' can, if any, be invoked within a blockchain ecosystem.

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Methodology

This report was produced jointly by Project Liberty Institute and BlockchainGov. It aims to provide a rigorous and granular framework for understanding how governance decisions are made and adopted within the rapidly evolving Web3 ecosystem while helping foster a sustainable and responsible ecosystem for decentralized technologies, ensuring that the benefits of Web3 are accessible to all while minimizing potential risks and challenges.

This publication lays the foundation of a Manual on Best Governance Practices for Blockchain and Decentralized Technologies which will highlight recommendations to build a more responsible ecosystem. This manual will be published in April 2024.

The Project Liberty Institute and BlockchainGov teams express their gratitude to the fifteen experts forming the Governance Multistakeholder Council for their valuable contributions to our work. Their feedback during this iterative process has been instrumental in shaping the qualitative outcomes that can now be showcased publicly.

Introduction

While the evolution of the World Wide Web has taken various turns away from its original vision[1], the advent of Web3 promises a new era focused on user 'ownership' and 'decentralization.' Initially, Web 1.0, often known as the 'static web,' featured read-only pages with limited interactivity or user-generated content. This phase progressed to Web 2.0, or the 'social web,' which enhanced user participation by allowing users to consume ('read') and produce ('write') content. Although they are often used interchangeably, the terms Web3 and Web 3.0 each highlight distinct aspects of the web's ongoing transformation. 'Web 3.0' was used by Tim Berners-Lee, the creator of the World Wide Web, in 2006 to describe a semantic, connected, and open iteration of the web.

This phase envisioned utilizing smarter computer processing through machine-readable data, improving data sharing and linking across various platforms, and relying on open-source standards to foster transparency and inclusivity[2]. In contrast, the concept of Web3, introduced in 2014 by Ethereum co-founder and Polkadot creator Gavin Wood, focuses on a new infrastructure based on decentralized networks and technologies. This new infrastructure enhances user ownership and autonomy by moving away from centralized operators and trusted intermediaries. Blockchain technology is a cornerstone of Web3, initially developed as an innovative means to record transactions digitally[3]. Blockchains and smart contracts have introduced a fundamental shift, eliminating the need for central authorities to facilitate all kinds of interactions.

Today, public and permissionless blockchains are employed across various sectors, including finance, trading, gaming, art, supply chain management, and identity verification. This ushers in an era marked by architectural decentralization, censorship resistance, transparency, and immutability, now considered critical technological infrastructure attributes. The collective choices of individuals and organizations drive the evolution of blockchain technology and its diverse applications. These entities form what are known as 'blockchain systems' or complex techno-social structures that operate across multiple intertwined layers. Beyond the capabilities of blockchain technology to store data across multiple nodes, the governance dynamics within blockchain systems are complex and nuanced. To fully grasp the opportunities and challenges of Web3, it is essential to analyze the governance practices of its fundamental components, including blockchain networks. This report is a collaborative effort between BlockchainGov and Project Liberty's Institute to analyze the governance dynamics of prominent blockchain networks through an interdisciplinary and comparative lens. Our research defines 'governance' as the process through which multiple actors' diverging and sometimes conflicting interests are reconciled, leading to collective action based on shared principles and agreed-upon procedures.

Our analysis of governance processes within blockchain systems builds on our previous work and integrates insights from academic research and practitioner experiences. These insights shed light on the historical and ideological, social and technical aspects, as well as the on-chain and off-chain dynamics of blockchain systems.

Although 'decentralization' is often highlighted as a defining feature of this ecosystem, we aim to delve deeper. We move beyond the common narrative that blockchain communities primarily seek to maximize decentralization and consensus. Instead, we recognize and explore the existing practices of 'governance as conflict.' This report adopts a descriptive ('as is') approach to blockchain governance rather than a prescriptive ('could be' or 'should be') stance. Nevertheless, we hope the findings presented here serve as a reference point for blockchain communities seeking to design governance frameworks that better suit their interests and needs.

Building on a substantial body of empirical research on blockchain governance, this report introduces a multidisciplinary comparative analysis of prominent blockchain networks: **Avalanche, Bitcoin, Cardano, Cosmos, Ethereum, Filecoin, Optimism, Polygon, Polkadot, Tezos, and Zcash.** These networks were selected for their technological innovation, adoption levels, diversity in governance design and operational layers, and their relationships with various legal entities within their communities. While additional networks could have been included, our selection aims to encapsulate the broadest spectrum of governance dynamics significant to the Web3 ecosystem. Our methodology for data collection combined desk research of publicly available materials with detailed semi-structured interviews with key stakeholders from each network.

This dual approach was crucial for gaining a comprehensive understanding of the officially documented procedures and the informal practices vital to the governance of these blockchain networks.

Based on this data, we developed a comprehensive taxonomy for blockchain governance to structure our empirical data collection and analysis. This taxonomy consists of five key dimensions that aid in understanding the operation and evolution of blockchain system governance over time:

// The 'organizational profile' dimension of our blockchain governance taxonomy includes several critical factors: the founding history, purpose, funding mechanisms, legal status, and market dynamics that influence a blockchain system. An essential aspect of this dimension is the technological layer to which each case study belongs. Projects associated with layer 0 blockchains, such as Avalanche, Cosmos, and Polkadot, provide the foundational infrastructure necessary for higher-level blockchains and their potential interoperability. Layer 1 blockchains, including Bitcoin, Cardano, Ethereum, Filecoin, Tezos, Polygon PoS Chain, and Zcash, form the primary networks. These networks consist of the blockchain protocol—the rules and procedures that govern how data is exchanged, verified, and recorded—and the actual ledger of transactions. Layer 2 blockchains, like Optimism and Polygon Rollups, offer scaling solutions that enhance the efficiency and speed of transactions on layer 1 networks.

// The ‘governance areas’ dimension addresses the various types of governance decisions made within blockchain systems. These include how to make rules or ‘secondary rules,’ block production, monetary policy, software updates, treasury allocation, rewards for contributors, standards and interoperability, and security measures and responses to breaches.

// The ‘governance frameworks’ dimension includes all the rules, processes, and tools used to make decisions within various governance areas. It covers entry and exit rules and processes, distribution of decision-making power, the governance mechanisms themselves, enforcement processes, incentives for participation, internal systems for dispute resolution, and amendability rules and processes. The amendability protocols are especially important, as they dictate how to modify or repeal previously established governance rules across different governance areas.

// The ‘governance surfaces’ dimension refers to the ‘places’ where governance frameworks are implemented, which can be categorized as either on-chain or off-chain (written or unwritten).

// Finally, the ‘governance trends’ dimension monitors the evolution of governance dynamics over time. It focuses on trends of power distribution (i.e., who decides), governance scope (i.e., the breadth of governance areas), governance complexity (i.e., the depth and intricacy of governance frameworks), and governance formalization (i.e., changes to the governance surfaces where the governance framework is deployed).

The report reveals six key insights into the governance dynamics of blockchain networks supported by examples from all the case studies we investigated. At the conclusion of each finding, we offer a succinct reflection on the implications for the design of blockchain governance. It is important to understand that while these insights derive from separate dimensions of our governance taxonomy, they are not isolated. Instead, they are interconnected and mutually influential, shedding light on the complex interactions that shape governance within the blockchain ecosystem.

1 The World Wide Web was originally conceived as decentralized, non-discriminating, bottom-up, universal, and consensus-based. See: World Wide Web Foundation, "History of the Web," accessed April 30, 2024, https://webfoundation.org/about/vision/history-of-the-web/.

2 Victoria Shannon, "A 'more Revolutionary' Web," The New York Times, May 23, 2006, accessed April 30, 2024, https://www.nytimes.com/2006/05/23/technology/23iht-web.html.

3 Originally, Wood referred to 'Web 3.0' but the term later on morphed into 'Web3.' See: Gavin Wood, "ĐApps: What Web 3.0 Looks Like," Insights Into a Modern World Blog, April 17, 2014, accessed April 30, 2024, https://gavwood.com/dappsweb3.html.

4 See: Primavera De Filippi et al., "Blockchain Technology, Trust & Confidence: Reinterpreting Trust in a Trustless System?," Social Science Research Network, January 1, 2022, https://doi.org/10.2139/ssrn.4300486; Primavera De Filippi et al., "Report on Blockchain Technology & Legitimacy," Social Science Research Network, January 1, 2022, https://doi.org/10.2139/ssrn.4300502; Primavera De Filippi et al., "Blockchain Constitutionalism: The Role of Legitimacy in Polycentric Systems," EUI Robert Schuman Centre, October 2023, https://blockchaingov.eu/wp-content/uploads/2023/11/EUI-Conference-June-2023-FINAL.pdf; Primavera De Filippi et al., "Report on Blockchain Technology and Polycentricity," forthcoming.

5 Kelsie Nabben, "Cryptoeconomics as Governance: An Intellectual History From 'Crypto Anarchy' to 'Cryptoeconomics,'" Internet Histories 7, no. 3 (March 3, 2023): 254–76, https://doi.org/10.1080/24701475.2023.2183643.

6 Michael Zargham and Kelsie Nabben, "Aligning 'Decentralized Autonomous Organization' to Precedents in Cybernetics," Social Science Research Network, January 1, 2022, https://doi.org/10.2139/ssrn.4077358.

7 Primavera De Filippi and Benjamin Loveluck, "The Invisible Politics of Bitcoin: Governance Crisis of a Decentralised Infrastructure," Internet Policy Review, September 29, 2016, https://hal.science/hal-01382007.

8 Jaya Klara Brekke, Kate Beecroft, and Francesca Pick, "The Dissensus Protocol: Governing Differences in Online Peer Communities," Frontiers in Human Dynamics 3 (May 26, 2021), 5 Kelsie Nabben, "Cryptoeconomics as Governance: An Intellectual History; Eric Alston, "Governance as Conflict: Constitution of Shared Values Defining Future Margins of Disagreement," MIT Computational Law Report (2022), 5 Kelsie Nabben, "Cryptoeconomics as Governance: An Intellectual History.

9 See: Rafael Ziolkowski et al., "Examining Gentle Rivalry: Decision-Making in Blockchain Systems," 52nd Hawaii International Conference on System Sciences (HICSS 2019), 2019, DOI:10.5167/uzh-160377; Lukas Schädler, Michael Lustenberger, and Florian Spychiger, "Analyzing Decision-making in Blockchain Governance," Frontiers in Blockchain 6 (August 21, 2023), DOI:10.3389/fbloc.2023.1256651; Rowan Van Pelt et al., "Defining Blockchain Governance: A Framework for Analysis and Comparison," Information Systems Management 38, no. 1 (March 9, 2020): 21–41, DOI:10.1080/10580530.2020.1720046; Kevin Werbach, "The Siren Song: Algorithmic Governance by Blockchain," Social Science Research Network, September 24, 2018, SSRN Abstract ID: 3578610.

I. Legal Entities

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"The existence of legal entities does not, in itself, mean that a network is 'centralized,' as that legal entity cannot unilaterally impose decisions upon a public, permissionless blockchain network."

Finding

Most blockchain networks have formed legal entities, like non-profit foundations or corporations, to oversee different facets of their activities and operations. The creation of these entities serves multiple purposes: it grants them legal recognition for entering into off-chain contracts, helps navigate regulatory uncertainties, bolsters governance sustainability, and facilitates the growth of blockchain ecosystems, notably through grant issuance. In certain instances, several entities are established to address specific activities separately. However, Bitcoin stands as an exception among the networks we have examined, as it does not rely on legal entities to achieve these goals.

Purpose

Several blockchain networks that were part of this study were initially developed and launched by a small team of founders through a private company (Ava Labs Inc. [Avalanche]; IOHK and EMURGO Group Pte Ltd. [Cardano]; Protocol Labs [Filecoin]; OP Labs [Optimism]; Polygon Labs; Dynamic Ledger Solutions [Tezos]; Electric Coin Company [Zcash]) and/or a foundation (Ethereum Foundation; Interchain Foundation [Cosmos]; Web3 Foundation [Polkadot]; Polygon Foundation; Tezos Foundation; Bootstrap and Zcash Foundation [Zcash]).

In conjunction with a private R&D firm, the promotion and growth of blockchain network ecosystems, such as through the management of community treasuries, developing scaling solutions, funding research, community initiatives, grants, and educational efforts, are typically undertaken by non-profit entities (Avalanche Foundation; Cardano Foundation; Ethereum Foundation; Filecoin Foundation; Optimism Foundation; Web3 Foundation [Polkadot]; Polygon Foundation; Tezos Foundation; and Zcash Foundation) and less commonly by a for-profit corporation (Interchain GmbH and All in Bits, Inc. and New Tendermint Inc. [Cosmos]; Parity Technologies Limited [Polkadot]). While the decisions or operations of several of these foundations are ostensibly shaped by community input, ultimate control over these foundations rests in the hands of a board of directors. Bitcoin is an exception in this regard, as its founding and eventual growth were driven by a diffuse community of volunteers and donors before attracting the support of corporate sponsors, research institutions, and non-governmental organizations for further development and growth[10].

Location

Many of the foundations are registered in Switzerland because of legal certainty, tax exemptions for foundations that serve philanthropic or public purposes, pragmatic business licensing, and a supportive crypto-startup ecosystem. However, the operations of the blockchain networks are more dispersed, with founders, (core) developers[11], miners/validators, and other affiliated persons and corporate entities being spread across the globe.

Governance Dynamics

As previously mentioned, most of the analyzed blockchain networks are supported by both a for-profit corporate entity and a non-profit foundation. In some cases, the relationship between these entities is clearly defined. For example, in the case of the Polygon network, the non-profit foundation is wholly owning the corporate entity. As for Zcash, until the fourth quarter of 2020, the Electric Coin Company (ECC) operated as a for-profit entity dedicated to developing and maintaining the Zcash protocol and its related software. In November 2020, ECC transitioned to being entirely owned by Bootstrap, a 501(c)(3) organization. The cornerstone of Zcash's governance dynamics centers on a legal Trademark Donation and License Agreement, signed in 2019. This agreement gives the Zcash Foundation and ECC the exclusive right to legally determine what chain is called Zcash. This right becomes relevant if a hard fork occurs in the network and a decision has to be made as to which chain is authoritative. Furthermore, all network upgrades must be formally sanctioned by these two organizations via a 2-of-2 multi-signature method, whereby the two entities together decide whether to modify or update the protocol or introduce new features before a chain can use the Zcash trademarks. In other words, the trademark agreement acts as a coordinating mechanism between two entities in a low-trust environment. In other cases, such as the Tezos network, this relationship may be contested, with the founders of Dynamic Ledger Solutions entering into a dispute with a board member of the independent Tezos Foundation.[12]

The existence of legal entities does not, in itself, mean that a network is 'centralized,' as that legal entity cannot unilaterally impose decisions upon a public, permissionless blockchain network. For example, the Ethereum Foundation may propose a roadmap for transitioning from Proof-of-Work to Proof-of-Stake. However, its effective implementation depends on multiple other stakeholders. Even then, the influence of these legal entities on the blockchain network has been a key concern in blockchain communities as it impacts the qualification of network tokens as (unregistered) securities under US federal securities law. The existence of a 'central third party' that undertakes efforts for the benefit of others is a key component of US regulators' and courts' analyses about whether a digital asset represents an investment contract and potentially falls foul of federal securities laws.[13] This has led some regulators to argue that the degree of decentralization in a blockchain network is an important condition for determining whether a digital asset is an investment contract, as decentralization reduces information asymmetries between actors in the network and makes it more difficult and meaningful to identify an 'issuer' or 'promoter' of a purported investment contract.[14]

However, it is necessary to stress that the existence of legal entities that support the activities of a blockchain network does not in and of itself imply the existence of a central third party, issue, or promoter. In 2018, the Bitcoin and Ether cryptocurrencies were deemed as not being securities as the Bitcoin and Ethereum networks were considered to be sufficiently decentralized—even with the existence of, for instance, the Ethereum Foundation.[15]

This concern about network tokens being classified as (unregistered) securities has considerably shaped the governance and strategies of the networks. While it has been acknowledged that it is possible that blockchain networks beyond Bitcoin and Ethereum can also be sufficiently decentralized (with Polkadot, among others, claiming that their native token has achieved this), Cardano's ADA token, Cosmos' ATOM token, Filecoin's FIL token, and Polygon's MATIC token have been alleged to be securities.[16] Following a class action lawsuit that claimed that the Tezos Foundation had illegally sold securities with its XTZ token, the Foundation settled to the tune of $25 million without admitting guilt.

Token Distribution

In some cases, these foundations hold and manage a percentage of the governance tokens issued by these networks, which gives them a significant minority stake in the governance of the network, even if no single actor can unilaterally change a public, permissionless system. In some cases, these tokens were 'pre-mined' as the tokens were created and, at times, distributed before the blockchain network was publicly launched. For instance, the Web3 Foundation, behind the launch of Polkadot, was initially allocated 30% of the total supply of its native DOT token at the time of initial distribution. Similarly, the founders and team/contributors of the Avalanche, Cardano, Ethereum, Filecoin, Optimism, Polygon networks, and Tezos Foundation initially received between 9.9-20% of the network tokens. Zcash launched in 2016 with a distribution scheme where 20% of the mined ZEC was distributed as the 'founders reward.' This percentage was taken from the block rewards, with the remaining 80% going to the miners. Such a mechanism meant miners typically received 80% plus transaction fees for mining blocks.

The remaining 20% of the reward was split among various parties, including 9.85% to ECC founders, 2.2% to the Zcash Foundation, 5.75% to ECC itself, and 2.2% to ECC employee compensation. This reward distribution rationale ended in 2020 with the introduction of the Canopy upgrade. Following the upgrade, miners will continue to receive 80% of the block rewards, but the remaining 20% will be divided among the new Major Grants Fund (8%), ECC (7%), and the Zcash Foundation (5%). Token distributions don't remain static, with vesting rules and distribution agreements diluting the initial concentration of crypto-assets or governance tokens over time. The Ethereum Foundation, for instance, reports that as of 31 March 2022, they held 0.297% of the total ETH supply.

Impact

Although forming these legal entities aims to create greater legal certainty for blockchain networks, this is not always achieved. Such entities, whether founder-led for-profit corporations or non-profit foundations, often hold a significant minority stake in the network's governance through token ownership. However, this stake does not grant them unilateral control over the networks. Instead, they influence the networks in other ways. Concern arises because these entities typically lack open, transparent, and inclusive mechanisms for appointing and holding their board of directors accountable, leading to a mismatch between the public and permissionless nature of the networks and the opacity of the supporting legal entities. This opacity can raise issues such as potential conflicts of interest and lack of disclosure of important information to the community.

10 Note that the Bitcoin Foundation was founded several years after the launch of the Bitcoin network and it is of a different nature than the legal entities this finding refers to.
11 Among academic researchers, there is no unanimous definition of what a "core dev" (core software developer) is. The matter is also subject to contentious debate across different blockchain communities. However, "client devs" are usually considered "core devs." Client devs tend to have a degree of privilege in managing the source code repository of the blockchain system, which translates into being the blockchain systems' client GitHub repository maintainers. However, this does not grant "client devs" discretionary power over the code. See: Jameson Lopp, "Who Controls Bitcoin Core?," Cypherpunk Cogitations, May 5, 2023, https://blog.lopp.net/who-controls-bitcoin-core/; Hudson Jameson, "What Is an Ethereum Core Developer?," Hudson Jameson, June 22, 2020, accessed April 30, 2024, https://hudsonjameson.com/2020-06-22-what-is-an-ethereum-core-developer/#:~:text=Definition,layer%2C%20such%20as%20client%20code.
12 MacDonald v. Dynamic Ledger Sols., Inc., Case No. 17-cv-07095-RS (N.D. Cal., 2017).
13 William Hinman, "SEC.gov | Digital Asset Transactions: When Howey Met Gary (Plastic)," U.S. Securities And Exchange Commission, June 14, 2018, accessed April 30, 2024, https://www.sec.gov/news/speech/speech-hinman-061418. Also see the recent case of SEC v. Ripple for such an analysis where it was held that Ripple's sale of XRP on digital asset exchanges using trading algorithms (i.e., "Programmatic Sales") did not constitute an unlawful sale of investment contracts to the public. This was because, among other things, these sales were "blind bid/ask transactions, and Programmatic Buyers could not have known if their payments of money went to Ripple, or any other seller of XRP" (p. 23). As a consequence, they could not have relied on the efforts of Ripple for a profitable return: Securities and Exchange Commission v. Ripple Labs, Inc., Case 1:20-cv-10832-AT-SN Document 874, (USDC SDNY, July 2023), https://www.nysd.uscourts.gov/sites/default/files/2023-07/SEC%20vs%20Ripple%207-13-23.pdf.
14 Ibid
15 It is worth noting that the current SEC Chairman Gary Gensler has created some ambiguity by not confirming or denying that he agreed with Hinman's position on Ether. See: Nikhilesh De, "SEC Chair Gensler Declines to Say if Ether Is a Security in Contentious Congressional Hearing," CoinDesk, April 19, 2023, accessed April 30, 2024, https://www.coindesk.com/policy/2023/04/19/sec-chair-gensler-declines-to-say-if-ether-is-a-security-in-contentious-congressional-hearing/.
16 Securities and Exchange Commission v. Binance Holdings Limited, BAM Trading Services Inc., BAM Management US Holdings Inc., and Changpeng Zhao, Civil Action Case 1:23-cv-01599 Document 1, (D.D.C., 2023), https://www.sec.gov/files/litigation/complaints/2023/comp-pr2023-101.pdf. Nikhilesh De and Danny Nelson, "Filecoin Price Drops After SEC Asks Grayscale to Withdraw Application to Make Trust Reporting," CoinDesk, May 18, 2023, accessed April 30, 2024, https://www.coindesk.com/policy/2023/05/17/filecoin-price-drops-after-sec-asks-grayscale-to-withdraw-fil-trust-application/.

II. Power Distribution

II. Power Distribution

"Blockchain systems are 'polycentric.' In other words, they are systems comprising relatively autonomous decision-making centers operating under a common system of rules."

Finding

While no blockchain system is 'centralized' in the sense that it is governed by one single person or entity, decision-making power is not evenly distributed. The concrete power distribution within these systems varies significantly depending on the specific case. This variation arises due to factors such as the governance areas or types of decisions being made, the diverse array of stakeholders involved, and the mechanisms employed in the governance process. A detailed understanding of these factors is essential to grasp the nuanced dynamics of power distribution within blockchain systems, revealing how certain actors may exert greater influence over specific aspects of governance.

While blockchains themselves are 'architecturally decentralized' in that transaction ledgers are distributed across numerous network nodes[17], blockchain systems are 'polycentric.' In other words, they are systems comprising relatively autonomous decision-making centers operating under a common system of rules.[18] Blockchain systems are also 'complex'[19] and 'techno-social' because they encompass the underlying blockchain technology and the human input required to develop and maintain the ledger and other integrated software. Consequently, understanding 'who has the power to make governance decisions' depends on the governance area, the stakeholders involved, and the mechanisms implemented.

1) Governance areas

Governing a blockchain system requires making different types of decisions, including rules on how to make rules or 'secondary rules,' block production, monetary policy, software updates, treasury allocation, rewards to contributors, standards and interoperability, and security measures and breaches.

// Secondary rules: Like most complex systems, blockchains have rules on how to make, amend, and repeal governance rules themselves. These are 'process rules' or 'secondary rules' in analogy to the constitutions of nation-states. Making these secondary rules involves different stakeholders and power dynamics depending on whether creating, amending, or repealing governance rules occurs on-chain or off-chain. Virtually every blockchain system stakeholder has an interest in participating in this process. However, founders, wealthy token holders or investors, and high-reputation software developers tend to play a crucial role.

// Block production: In layer 1 blockchains, rules about block production, or how new blocks of transactions are created and added to the ledger, are often predefined on-chain by the blockchain protocol. Consensus algorithms or consensus protocols define the criteria and processes used to achieve agreement among the network's participants about the current state of the blockchain.

Some examples of consensus algorithms across different blockchains include the Avalanche Consensus [Avalanche's Primary Network subnet], Equihash Proof-of-Work [Zcash], Expected Consensus [Filecoin], Liquid Proof-of-Stake [Tezos], Nominated Proof-of-Stake [Polkadot], Ouroboros [Cardano], Proof-of-Stake [Cosmos Hub, Ethereum, Polygon PoS Chain (originally Matic Network)], and Proof-of-Work [Bitcoin]. Founders and early software developers who contributed to the blockchain system usually designed these rules. Still, consensus protocols are executed by miners or validators, with nodes also playing an essential role in maintaining a single, consistent ledger across the network.

// Monetary policy: Rules on monetary policy across layer 1 blockchains are also generally predefined on-chain by the blockchain protocol. These rules are frequently referred to as 'tokenomics,' a portmanteau of token and economics, comprising the principles and characteristics that govern the issuance, distribution, and overall management of a cryptocurrency or digital token within a blockchain ecosystem.[20] Tokenomics encompasses decisions about supply mechanics, such as total supply (e.g., fixed or infinite supply), initial token distribution (e.g., an Initial Coin Offering or an airdrop, where tokens are disbursed to the wallets of the selected recipients, often without needing them to take any proactive steps), and the creation and release of new tokens over time (e.g., through rewards and fees involved in the process of mining or validating new blocks). It also includes mechanisms like 'token burning,' where tokens are permanently removed from circulation, affecting the total supply. While founders and developers are heavily involved in the design of tokenomics, token holders and investors also have a vested interest in voicing their preferences about monetary policy rules.

// Block production: In layer 1 blockchains, rules about block production, or how new blocks of transactions are created and added to the ledger, are often predefined on-chain by the blockchain protocol. Consensus algorithms or consensus protocols define the criteria and processes used to achieve agreement among the network's participants about the current state of the blockchain.

// Software upgrades: Other decisions involve software upgrades or parameter changes to a blockchain protocol, including soft and hard forks.[21] These decisions are among the most contentious because of their implications for the functioning of the entire blockchain ecosystem. Since parameter changes require substantial technical expertise, software developers are naturally given a lot of voice. Still, these decisions need miners/validators and nodes to agree to enforce them. The Tezos network is an exception to this rule, with its blockchain famously popularized as self-amending, given its built-in mechanism for automatically implementing changes to its protocol.

// Treasury allocation: This governance area deals with decisions about spending pooled funds, usually set aside for the development and growth of the blockchain network and ecosystem.

- In some cases, founders make decisions about treasury allocation before the project fundraising event and launch. Non-profit entities generally receive a certain amount of funds they are supposed to distribute progressively to the ecosystem at large (e.g., Avalanche, Ethereum, Filecoin, and Tezos).
- In other cases, blockchain systems devise mechanisms for collecting funds after the project launch based on, for example, block production rewards or transaction fees. Token holders can have a relatively greater (e.g., Polkadot) or lesser (e.g., Zcash) influence in treasury allocation than the founders and their legal entities.
- Finally, some blockchain systems have already implemented collectively managed treasuries, such as Optimism's funds, which are overseen by the Optimism Collective and the Cosmos Hub's Community Pool Fund, where proposals are voted on-chain by ATOM token holders. Other blockchain systems plan to do something similar in the future. Examples include Polygon's Community Treasury or Cardano's CIP-1694, which describes a way for ADA holders to vote on treasury withdrawals, offering a more encompassing model than Cardano's Project Catalyst fund.

// Rewards to contributors: Decisions on how to reward contributors or non-hired volunteers working on aspects other than block production can overlap with decisions on treasury allocation. The difference is that these rewards need not come from pooled funds.

Occasionally, rewards are funneled bottom-up through individual community donations (e.g., donations made by individual Bitcoin community members to engaged software developers or popular public speakers), decisions made by groups of token holders (e.g., Optimism's grants managed by the Token House, or the Polygon's Village Community Grants), or decisions made by representative bodies elected by community members (e.g., the Zcash Community Grants managed by the Zcash Grants Committee, or Optimism's Retroactive Grants managed by the Citizens' House).

In other cases, rewards can be distributed top-down through direct grants or investments issued by non-profit entities (e.g., Avalanche Foundation, Ethereum Foundation, Filecoin Foundation, Interchain Foundation, Optimism Foundation, Web3 Foundation, Polygon Foundation, Tezos Foundation, and Zcash Foundation) or through employment offers from broader ecosystem organizations (e.g., Blockstream and BitPay have hired software developers to continue working on the development of the Bitcoin ecosystem).

// Standard and interoperability: Decisions on standards and interoperability lead to integrations of the blockchain network with third-party applications. These integrations are usually 'permissionless' since they don't require official approval from a central entity, such as in the case of Web2 platforms like Google or Apple. However, for integrations, projects must follow specified technical standards that software developers usually draft with more or less input from the founders and the third-party organizations themselves, frequently also considering the users' preferences.

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2) Stakeholders

Many individuals and organizations play different roles in each governance area. These stakeholders can be categorized as 'insiders' and others as 'outsiders.' 'Insiders' comprise founders, software developers, miners or validators, sequencers and aggregators, non-mining or non-validating nodes, investors, token holders, and users. 'Outsiders' include integrated organizations, competing organizations, and policymakers, lawmakers, and regulators.[22]

// Insiders: Insiders are stakeholders subject to the blockchain system's rules, rights, and obligations. While insiders might not directly control external factors, external factors still affect the blockchain system's operations. [23]

// Founders: Founders are credited for developing the idea behind a blockchain network and, except for Bitcoin's Satoshi Nakamoto, usually remain involved in developing the project and may create and integrate legal entities for this purpose. Some publicly known and active (co)founders include Emin Gün Sirer, Kevin Sekniqi, and Maofan Yin [Avalanche], Charles Hoskinson [Cardano], Jae Kwon and Ethan Buchman [Cosmos], Vitalik Buterin [Ethereum], Juan Benet [Protocol Labs/Filecoin], Jinglan Wang, Karl Floersch, and Kevin Ho [Optimism], Robert Habermeier, Gavin Wood, Peter Czaban [Polkadot], Jaynti Kanani, Sandeep Nailwal, and Anurag Arjun [Polygon], Arthur Breitman and Kathleen Breitman [Tezos], and a group of scientists including Alessandro Chiesa, Christina Garman, Eli Ben-Sasson, Eran Tromer, Ian Miers, Madars Vizra, and Methew Green, who hired Zooko Wilcox as the CEO of the Zcash company (rebranded in 2019 as the Electronic Coin Company) [Zcash].

// Software developers: Software developers may be hired by legal entities related to the blockchain system or may be volunteers. They propose new software rules that affect the blockchain protocol or the applications running on the blockchain network.

// Miners or validators: Miners or validators: In the studied layer 1 blockchains, miners and validators are the stakeholders in charge of producing new blocks of transactions that are added to the blockchain.

// Sequencers, verifiers, and aggregators: In the studied layer 2 blockchains, sequencers, verifiers, and aggregators are responsible for ordering transactions before they are 'finalized' on the Ethereum blockchain.[24]

- In the Optimism Rollups, the network participants involved in block production are 'sequencers' and 'verifiers.' A sequencer is a component responsible for accepting and consolidating both off-chain user transactions and on-chain deposit events from the layer 1 blockchain into specific orderings within layer 2 blocks.

It then propagates these consolidated blocks back to the layer 1 blockchain. A verifier provides users with access to rollup blockchain data, facilitating their interaction with the network, and are responsible for ensuring the integrity of the rollup chain by verifying transactions and challenging any erroneous claims or invalid data assertions. In Optimism Rollups 1.0.0, there is one sequencer under the oversight of the Optimism Foundation and no verifiers yet.[25]

- In the Polygon Hermez is a ZK rollup, the network participants involved in block production are 'sequencers' and 'aggregators.' Aggregators produce proofs attesting to the integrity of the sequencer's proposed state change. At the time of writing, anyone can become a Sequencer or Aggregator in the Polygon Hermez ZK rollup, and there are built-in cryptoeconomic incentives to encourage honest behavior.[26]

// Non-mining or non-validating nodes: These nodes do not produce new blocks of transactions but independently verify all transactions according to the network's consensus rules.

// Investors: Investors are individuals or entities that allocate capital in a blockchain system expecting a future financial return. Investors can acquire financial stakes in blockchain systems in different ways.

- **Public Sales:** Public sales refer to fundraising events where tokens or coins are offered to a broad range of investors, including retail participants, often through mechanisms like Initial Coin Offerings (ICOs) or Initial Exchange Offerings (IEOs). These sales are typically open to the public and allow individuals to purchase tokens in exchange for cryptocurrency or fiat currency. Some blockchain systems, including Cardano in 2015-2017, Cosmos in 2017, Ethereum in 2014, and Filecoin in 2017, launched their projects through novel funding mechanisms known as Initial Coin Offerings (ICOs), which, similarly to Initial Public Offerings (IPOs), allow to raise funds by issuing tokens to purchasers. Others, such as Polygon/Matic Network in 2019, have resorted to an Initial Exchange Offering (IEO), where centralized cryptocurrency exchanges have facilitated the sale of tokens.
- **Private sales:** Private sales, on the other hand, involve selling tokens to a select group of investors, often institutional investors or accredited individuals, before making them available to the general public. Examples of blockchain systems fundraising through private sales include Avalanche in 2020, Optimism/Plasma Group in 2019-2022, Polkadot in 2017, and Zcash in 2016.

// Token holders: Token holders are individuals or entities that hold cryptocurrencies or tokens issued by the blockchain system. They can hold these as investments or use them for utility, such as accessing services related to the blockchain system or staking and on-chain voting in Proof-of-Stake (PoS) blockchain networks.

- **Airdrop:** An airdrop is a mechanism for a blockchain system to distribute tokens. The tokens are disbursed to the wallets of the selected recipients, often without the recipients needing to take any proactive steps. For example, from 2022 onwards, Optimism has conducted a series of airdrops to distribute OP tokens to eligible users.[27]

// Users: Users include individuals and organizations making transactions on the blockchain network of reference, including trading the native cryptocurrency or token.

// Outsiders: Outsiders are not bound by the rules of the blockchain system, either because they decide to do so or because of external limitations or constraints that hinder their participation as insiders. These stakeholders shape regulatory decisions, market dynamics, technological advancements, and broader socio-political factors that affect the blockchain system's operations.[28]

// Integrated organizations: Integrated organizations refer to other networks, applications (i.e., cryptocurrency wallets, cryptocurrency exchanges), and DAOs running on the blockchain network of reference.[29] For instance, because the layer 2 blockchain Optimism operates atop the layer 1 blockchain Ethereum, governance decisions regarding technical standards adopted within the Ethereum ecosystem affect the Optimism ecosystem. This integration gives Optimism stakeholders incentives to engage in these discussions.[30]

// Competing organizations: Competing organizations encompass networks, applications, and DAOs not integrated with the blockchain network of reference, offering similar products or services to a comparable audience. For example, Avalanche often positions itself as a competitor to Ethereum, while Optimism Rollups may be viewed as a competitive alternative to Polygon Rollups. In such instances, governance decisions made within one blockchain system may influence the governance decisions of competitors as they strive to maintain a competitive edge and attract or retain users.[31]

// Policymakers, lawmakers, and regulators: These stakeholders are affiliated with international organizations or governing bodies and agencies within state jurisdictions where blockchain systems operate or are incorporated. They establish and seek to enforce frameworks governing the operation of cryptocurrencies, tokens, and related blockchain projects. Globally, the most influential figures in blockchain regulation often belong to international bodies such as the International Monetary Fund (IMF), the Financial Action Task Force (FATF), and the World Bank (WB). Additionally, agencies and representatives from powerful nation-states and supranational organizations such as the United States, Germany, France, China, and the European Union play significant roles.

It is crucial to understand that the categorization mentioned above pertains to roles and responsibilities, and the same individual or entity can participate in multiple stakeholder roles unless there are rules or mechanisms in place to prevent this overlap. For instance, it is common for active contributors or software developers to also function as validators or for comprehensive ecosystem organizations like cryptocurrency exchanges to operate full nodes. This multifaceted participation can influence the concrete power distribution within a blockchain system.

a. Stakeholders Incentives

In the governance of blockchain systems, the lack of a centralized authority underscores the importance of well-crafted stakeholder incentives to guide the behavior of each group within the ecosystem. Understanding the intricate dynamics and diverse motivations at play, we delineate some of the incentives that propel various stakeholders.[32] While our examples assume that stakeholders act as rational agents, aiming to contribute positively to the blockchain system and derive value without any malicious intent, we recognize that real-world scenarios may entail a broader spectrum of behaviors and objectives.[33]

/ Founders are often driven by non-financial incentives such as the long-term success of their project, the pursuit of innovation, and reputation gain within the ecosystem. However, financial incentives like potential profits from the project's success also play a role.

/ Software developers may be motivated by non-financial incentives, including a commitment to technological excellence, earning community esteem, and a passion for decentralized solutions. Still, financial incentives such as developer grants or employment are also significant.

/ Miners and validators typically prioritize financial incentives. They focus on earning transaction fees and block rewards by enhancing operational efficiency and network security.

/ Non-mining or non-validating nodes are usually motivated by non-financial factors centered around maintaining the network's integrity and supporting a system they rely on, potentially for ideological or intellectual reasons.

/ Investors, driven by the potential for significant financial returns, are strongly motivated through capital appreciation or trading. Market dynamics, project potential, and the health of the broader ecosystem influence their decisions.

/ Token holders can have financial incentives through the potential appreciation of their holdings. Non-financial incentives include participation in governance processes, especially if tokens confer voting or decision-making rights.

/ Users can be driven by functional incentives, such as finding and making use of efficient, secure, and valuable blockchain-related services, as well as ideological ones, motivated by a desire to support value systems behind the development of decentralized technologies.

/ Integrated and competing organizations are mainly motivated by financial incentives linked to user adoption, transaction volume, and ecosystem activity. These entities focus on enhancing user experience and network effects for business growth.

/ Policymakers, lawmakers, and regulators can be incentivized by non-financial goals such as balancing innovation, risk management, and consumer protection while ensuring legal compliance and maintaining traditional financial market stability.

b. Power Distribution

As previously noted, while blockchains are 'architecturally decentralized' and blockchain systems are inherently 'polycentric,' these characteristics do not imply that all 'insiders' wield equal influence over the system's governance outcomes.

/ Within 'insider' stakeholder groups: The distribution of power within each insider stakeholder group is influenced by the characteristics that members exhibit compared to the attributes that the group rewards, including reputation, wealth, contributions, expertise, charisma, or ideological alignment.[34]

/ Founding teams: Within founding teams, some active founders usually retain considerable power based on their reputation, charisma, contributions, or expertise and may be likened to 'benevolent dictators'[35] or 'spiritual leaders.'[36]

/ Software developers: This category generally prioritizes expertise and contributions. Individuals acknowledged by the community for their technical proficiency or significant contributions to advancing the blockchain protocol, smart contracts, or decentralized applications often hold more sway in governance issues.

/ Miners or validators, token holders, and investors: This group tends to behave plutocratically and reward 'wealth.' Those with higher computing power or a more significant number of tokens or equity tend to influence decision-making more.[37]

/ Non-mining or non-validating nodes and regular users: In most blockchain systems, these stakeholder groups represent 'sovereign entities' with equal decision-making power. For nodes, power to decide whether to relay transactions, store ledger data and accept or reject validated transactions not adhering to consensus rules. For users, the power to decide whether to transact over a blockchain network. However, during periods of governance divisiveness, certain nodes and users can emerge as influential voices among their peers. When ideologically aligned with most other nodes and users and backed by their reputation, charisma, contributions, or expertise, specific nodes, and users can become 'Schelling points' of public opinion within a blockchain community.[38]

Across Insider Stakeholder Groups: Blockchain systems, by design, prevent any single group or entity from imposing its will over others to influence governance in a particular direction. Furthermore, compared to more coercive traditional systems like nation-states or companies, blockchain systems offer lower costs for exiting — it is easier to 'leave' them.[39] Consequently, during contentious debates within blockchain communities, such as discussions about changes to block production or monetary policy rules, stakeholder groups possess varying degrees of decision-making power that they can wield through four distinct strategies: voice, self-organization, exit, and exit-and-voice via hard fork.[40]

/ Voice: Voice entails expressing dissatisfaction or advocating for a change in the governance of a blockchain system. All studied blockchain networks provide off-chain or on-chain mechanisms for stakeholders to voice their preferences.

/ Self-Organization: Self-organization empowers system participants to effect changes from within, eliminating the need to exit the system. However, it often comes with higher costs compared to using voice. Specific stakeholders have the credible ability to self-organize and 'counter' governance actions taken by other groups. Miners and validators can oppose changes to a blockchain protocol by choosing not to update their software.

Similarly, non-mining or non-validating nodes may initiate software updates without explicit support from miners or validators. The Bitcoin Improvement Proposal 148 (BIP 148), which introduced the User Activated Soft Fork (UASF), illustrates this strategy. Through UASF, nodes could activate Segregated Witness (SegWit) without requiring explicit miner approval, showcasing the power of self-organization within the Bitcoin community to influence software upgrades.

/ Exit: Exiting entails the decision to no longer participate in a system. All studied blockchain networks allow stakeholders to exit, such as nodes no longer securing a network, token holders selling their tokens, and users switching to competing alternatives.

/ Exit-and-Voice via Hard Fork: Hard forking involves exiting a system and proposing and implementing a ledger split, effectively establishing a new blockchain version that reflects desired governance designs. For example, Bitcoin and Ethereum blockchains have experienced hard forks since their inception.

3) Governance Mechanism

Governance mechanisms refer to the processes, rules, and tools implemented to facilitate decision-making. These mechanisms can be categorized using multiple criteria. Depending on the 'surface' where they are deployed, we can divide them into two groups.

// On-chain governance mechanisms: Also known as 'governance by the infrastructure,' these are embedded directly into the blockchain's code, making them transparent but also rigid and highly resistant to change.[41]

- <u>Ex-ante on-chain mechanisms</u> are those that come 'baked' into the protocol right when a blockchain network launches. Examples include consensus algorithms specifying how to produce and add new transaction blocks.
- <u>Ex-post on-chain mechanisms</u> are those that allow the creation, repeal, and amendment or governance rules. Examples include on-chain signaling and voting mechanisms, which record the preferences expressed by stakeholders on the blockchain itself.

// Off-chain governance mechanisms: Also known as 'governance of the infrastructure,' these encompass any decision-making process that is not automatically recorded on the blockchain, making them more flexible but also less transparent.[42]

- <u>Native off-chain mechanisms</u> are those developed by the 'insiders' of a blockchain community of reference.
    - In-person mechanisms include private stakeholder meetings or public conferences.
    - Online mechanisms include debates on social media and governance forums and off-chain signaling and voting mechanisms that do not record expressed preferences directly on the blockchain.

- <u>Third-party off-chain mechanisms</u> are those developed by 'outsiders,' such as national laws and regulations, contractual agreements, or technology standards.

// Trade-offs: The impact of governance mechanisms on power distribution hinges on their inherent capabilities and specific configurations.

- On-chain mechanisms typically foster oligarchic governance dynamics, where a select few hold considerable influence. Technical experts, such as software developers, play a central role in shaping on-chain mechanisms. On-chain signaling and voting systems are often structured to amplify the influence of wealthier stakeholders.
- Off-chain governance mechanisms can have a dual effect on power distribution. On one hand, they promote greater community involvement and a more participatory governance approach by not requiring stakeholders

to expend resources to participate, such as paying mining or validating costs or transaction fees. On the other hand, the potential for undisclosed off-chain discussions among influential figures, such as private governance conversations among founders or investors unknown to the community, tends to obscure the true power distribution within a blockchain system.

Impact

Recognizing blockchain systems' nuanced and multifaceted structure is essential for discerning the actors who shape governance outcomes and the channels through which they exert influence. Blockchain communities can identify governance practices that stray from their foundational values or objectives by examining the complex interplay among governance areas, stakeholders, and mechanisms. This insight is crucial for developing rules, procedures, and mechanisms that better address community concerns and aspirations, ultimately creating governance systems that align more closely with their collective needs.

17 Vitalik Buterin, "The Meaning of Decentralization," Medium, July 24, 2018, accessed April 30, 2024, https://medium.com/@VitalikButerin/the-meaning-of-decentralization-a0c92b76a274.
18 De Filippi et al., "Report on Blockchain Technology & Polycentricity."
19 Shermin Voshmgir and Michael Zargham, "Foundations of Cryptoeconomic Systems," Research Institute for Cryptoeconomics, Vienna, Working Paper Series 1 (2019), https://assets.pubpub.org/sy02t720/31581340240758.pdf
20 Ralf Wandmacher, "Tokenomics," in Cryptofinance and Mechanisms of Exchange (Springer, 2019), 113–23, https://doi.org/10.1007/978-3-030-30738-7_7.
21 A 'soft fork' is a backward-compatible update to a blockchain protocol that introduces changes without conflicting with existing rules. Nodes (computers) that do not upgrade to the new protocol can still participate in validating and verifying transactions, although they may not be able to access new features. In contrast, a 'hard fork' represents a significant, non-backward-compatible change to the blockchain protocol. This creates a permanent divergence from the previous version, with nodes on the old version unable to accept blocks from the new version, and vice versa. Such changes often lead to the blockchain splitting into two distinct paths, each adhering to its own protocol.
22 De Filippi et al. "Report on Blockchain Technology and Polycentricity."
23 Ibid
24 For differences between different layer 2 solutions and, within this group, between Optimistic rollups and ZK rollups, see: Vitalik Buterin, "An Incomplete Guide to Rollups," Vitalik Buterin's Website, January 5, 2021, accessed April 29, 2024, https://vitalik.eth.limo/general/2021/01/05/rollup.html.
25 The Optimism Collective, "Introduction," OP Stack Specification, accessed April 29, 2024, https://specs.optimism.io/introduction.html#:~:text=The%20sequencer%20is%20the%20primary,oversight%20of%20the%20Optimism%20Foundation; "Can I run a verifier?," OP Mainnet Help Center, June 2023, accessed April 29, 2024, https://help.optimism.io/hc/en-us/articles/4413155125403-Can-I-run-a-verifier.
26 Alchemy, "Polygon ZK Rollups: Everything You Need to Know," May 18, 2022, accessed April 29, 2024, https://www.alchemy.com/overviews/polygon-zk-rollups.
27 Mechanism Institute, "Airdrops," Mechanism Institute Library, accessed April 28, 2024, https://www.mechanism.institute/library/airdrop
28 De Filippi et al. "Report on Blockchain Technology and Polycentricity."
29 While they are connected to blockchain networks, DAOs are governed following special dynamics and, therefore, are out of the scope of this report.
30 An example of this is the role played by developers of layer 2 rollups in the drafting and passing of EIP-7516. See: Christine Kim, "The Ethereum Governance Process," September 29, 2023, accessed April 30, 2024, https://www.youtube.com/watch?v=2T4h-r9wu44.
31 Eric Alston, "Constitutions and Blockchains: Competitive Governance of Fundamental Rule Sets," Case Western Reserve University School of Law Scholarly Commons, October 27, 2020, accessed April 30, 2024, https://scholarlycommons.law.case.edu/jolti/vol11/iss1/6
32 Given the distinct incentive configurations for stakeholders involved in block production within layer 2 blockchains, including the specific cases of Optimism and Polygon rollups, these won't be analyzed in the rest of the insight.
33 Rong Han et al., "How Can Incentive Mechanisms and Blockchain Benefit With Each Other? A Survey," ACM Computing Surveys 55, no. 7 (December 15, 2022): 1–38, https://doi.org/10.1145/3539604.
34 Ibid 32.
35 De Filippi and Loveluck, "The invisible politics of Bitcoin".
36 Sandra Faustino, Inês Faria, and Rafael Marques, "The Myths and Legends of King Satoshi and the Knights of Blockchain," Journal of Cultural Economy 15, no. 1 (May 25, 2021): 67–80, https://doi.org/10.1080/17530350.2021.1921830
37 There have been arguments made that because computing power does not guarantee a Return On Investment (ROI) in mining, whereas, in the absence of slashing, staking does, staking tends to accentuate plutocratic dynamics to a greater extent than mining. See: Alberto Leporati, "Studying the Compounding Effect: The Role of Proof-of-Stake Parameters on Wealth Distribution," Proceedings of the Fifth Distributed Ledger Technology Workshop (DLT 2023), ed. Paolo Mori, Ivan Visconti and Stefano Bistarelli, (2023), https://ceur-ws.org/Vol-3460/papers/DLT_2023_paper_2.pdf; Md Sadek Ferdous et al., "Blockchain Consensus Algorithms: A Survey," arXiv.org, January 20, 2020, https://arxiv.org/abs/2001.07091.
38 Schelling points, named after the Nobel laureate Thomas Schelling, are focal points or solutions that people tend to choose in the absence of explicit coordination or communication. These points arise from shared expectations, common knowledge, or other factors that lead individuals or groups to converge on a particular outcome. To learn more about the role of 'influential figures' within blockchain systems, see: De Filippi et al., "Blockchain Technology, Trust & Confidence: Reinterpreting Trust in a Trustless System?"
39 Alston, "Constitutions and Blockchains."
40 Albert O. Hirschman, "Exit, Voice and Loyalty: Responses to Decline in Firms, Organizations, and States.," The Journal of Finance 25, no. 5 (December 1, 1970): 1194, https://doi.org/10.2307/2325604; De Filippi et al., "Report on Blockchain Technology & Legitimacy"; Jeffery Atik and George Gerro, "Hard Forks on the Bitcoin Blockchain: Reversible Exit, Continuing Voice," Stanford Journal of Blockchain Law & Policy, June 23, 2018, accessed April 30, 2024, https://stanford-jblp.pubpub.org/pub/hard-forks-bitcoin/release/2.
41 Primavera De Filippi and Greg McMullen, "Governance of blockchain systems: Governance of and by Distributed Infrastructure," Blockchain Research Institute and COALA, (2018), https://hal.science/hal-02046787/document.
42 **ibid.**

III. Planned vs. Actual Decentralization

III. Planned vs. Actual Decentralization

“Blockchain systems are ‘polycentric.’ In other words, they are systems comprising relatively autonomous decision-making centers operating under a common system of rules.“

Finding

After launching a blockchain network, community members commonly pledge to progressively decentralize governance. However, while there are many possible approaches to ‘decentralization’, blockchain communities frequently lack public, clear, and operational definitions. Additionally, several factors impede the actual process of decentralization. On-chain, power tends to consolidate among mining and validator pools, exacerbated by plutocratic token-weighted voting systems. Off-chain, the challenges include escalating governance complexity, early entrenchment of power, and external regulatory pressures.

// Multiple Approaches to Decentralization: Several founders and legal entities behind blockchain systems have publicly expressed their ambition to ‘progressively decentralize’ their governance.[43] Decentralization is often viewed with almost mythical reverence in the ecosystem despite being difficult to observe and evaluate.[44] A primary obstacle to effectively decentralizing is the absence of a public, clear, operational definition of decentralization for the respective blockchain network.

Before the advent of blockchain technology, scholars across various disciplines tried to lay the conceptual foundations of decentralization in the context of government institutions,[45] geographic political units,[46] or the governance process itself.[47] When it comes to the decentralization of blockchain systems, one of the first attempts at addressing this question came from Ethereum co-founder Vitalik Buterin in 2017.[48] Buterin distinguished between three types of decentralization. ‘Architectural (de)centralization’ refers to the number of nodes that make up the blockchain network. ‘Political (de)centralization’ describes the number of individuals and organizations that ultimately control these nodes. Finally, ‘logical (de)centralization’ measures the interfaces and data structures presented and maintained by the blockchain system. For Vitalik, while blockchain networks were politically and architecturally decentralized, they were logically centralized as there is “one commonly agreed state [of the blockchain], and the system behaves like a single computer.” In his statement, Buterin presupposes that decentralization means the absence of a single point of control (and failure) —and failure—whether it involves the servers where the blockchain data is stored or the persons or entities managing those servers.[49]

Over time, more nuanced definitions of decentralization have emerged, moving beyond simply a ‘lack of centralization.’

One such concept is the **Nakamoto Coefficient**, introduced by Balaji Srinivasan. This coefficient views decentralization as a spectrum rather than a binary state. It quantifies the decentralization of a blockchain system by determining the smallest number of entities that, if they colluded, could control the system—typically by commanding over 50% of the network's resources or decision-making capacity. In the original article where Srinivasan discussed this concept, he analyzed blockchain networks like Bitcoin and Ethereum, breaking them down into several subsystems, each assessed for decentralization in different ways. **Mining operations**, as both were Proof-of-Work networks at the time, were measured by the amount of computational resources contributed. The diversity of **clients** that could access the network was evaluated based on the number of unique software codebases. The influence of **core software developers** was gauged by their contributions to the main client's GitHub repository. The trading power of various **exchanges** was calculated based on their 24-hour trading volume. The spread of nodes independently verifying transactions was calculated based on their distribution across various countries. Finally, the number of **wealthy token holders** was calculated based on the number of public addresses linked to ownership of Bitcoin or Ether equivalent to USD 500,000 or more. Using this framework, Srinivasan found that Bitcoin's most centralized aspects were its software clients, cryptocurrency exchanges, and network nodes. In contrast, Ethereum showed a higher centralization in the influence of its core developers.[50]

Researchers and practitioners have continued to develop **increasingly comprehensive taxonomies** to measure the decentralization of blockchain systems across various governance areas. One such taxonomy identified six architectural layers—governance, network, consensus, incentive, operational, and application—and thirteen 'aspects of centralization' within them, exemplified using Bitcoin and Ethereum as case studies.[51] A newer taxonomy explores additional blockchain networks such as Avalanche, Cosmos, Cardano, Polkadot, and Zcash. It examines eight layers, including hardware, software, network, consensus, tokenomics, API, governance, and geography. For each layer, the taxonomy identifies one or more 'resources' (the basic 'unit' of the layer) and the relevant 'parties' that control these resources, either directly or indirectly. When control of a resource within a specific layer is centralized, the taxonomy emphasizes the impact of this centralization on key properties of blockchain systems, such as safety, liveness, stability, and privacy.[52]

Other research has focused on **forces that tend to drive (re)centralization in blockchain systems over time.** For instance, the ideological pursuit of 'maximal decentralization' can clash with values such as technical efficiency or governability. Founders and core developers often maintain substantial control over governance by relying on rough consensus as a decision-making mechanism.

The need for external recognition or to connect blockchain systems with the 'outer world' while ensuring legal compliance also tends to lead to recentralization. Furthermore, the impact of incentive mechanisms embedded in blockchain systems, which influence stakeholders' behaviors, can lead to the (re)centralization of power. Interestingly, the aftermath of 'existential threats' such as bugs, hacks, and other security breaches can promote decentralization as a pragmatic means to eliminate single points of failure.[53]

The examples above demonstrate the complexity of defining and operationalizing decentralization in blockchain communities over time. This diversity means that not only may blockchain communities' insiders struggle to define progressive decentralization within their networks, but it also becomes challenging for outsiders to assess which network is closer to achieving the stated goal of 'progressive decentralization.'

// Public Commitments to "Progressive Decentralization":

Nevertheless, numerous blockchain communities have engaged in discussions and, in some cases, have publicly committed to decentralizing decision-making power across various governance areas. Sometimes, progressive decentralization is **initiated and driven by stakeholder groups** besides the network's founders. For instance, the Stratum protocol, widely used in **Bitcoin** mining, was developed collaboratively by several mining pools and other relevant mining enterprises.

In response to concerns about power centralization within mining pools, Stratum V2 introduced several enhancements. These include 'job negotiation,' which allows individual miners to select their own transaction sets for new blocks rather than depending solely on the choices of the mining pools. This innovation increases the decentralization of transaction selection in the mining process.[54]

In other cases, **the broader blockchain community has actively discussed enhancing decentralization**. As noted in findings regarding legal entities, Zcash was launched in 2016 with a distribution scheme known as the 'founders reward,' according to which 20% of Zcash's block rewards were split among various parties, including 9.85% to ECC founders, 2.2% to the Zcash Foundation, 5.75% to ECC itself, and 2.2% to ECC employee compensation. In 2020, a Zcash Improvement Proposal (ZIP) 1014 described a structure for the Zcash Development Fund. After receiving feedback and holding a poll, the Zcash community decided to introduce the Canopy upgrade, which would enforce a different distribution structure to enhance product decentralization. According to this upgrade, miners will continue to receive 80% of the block rewards, but the remaining 20% will be divided among the new Major Grants Fund (8%), ECC (7%), and the Zcash Foundation (5%).

Most of the time, however, progressive decentralization is initiated by founders. For example, following the 'Ethereum Merge' in September 2022, which marked the transition of the **Ethereum network** from Proof-of-Work to Proof-of-Stake, much of the block production has been centralized. During Korea Blockchain Week 2023, Vitalik Buterin highlighted the centralization of block production as a significant issue facing the Ethereum network. He proposed addressing this challenge by reducing the costs and simplifying the process of operating validator nodes. Vitalik pointed out that diminishing reliance on centralized service providers was part of the Ethereum roadmap, but realistically, its full implementation might take decades.[55]

Similarly, with the introduction of the **Optimism (OP) Collective** in April 2022, the Optimism Foundation committed to ensuring 'digital democratic governance' to foster the 'rapid and sustainable growth of a decentralized ecosystem.'[56] The plan introduced a dual-house system, including the Token House—composed of token holders who received OP tokens via airdrop—responsible for voting on various governance areas such as software updates, and the Citizen House—comprising individuals and entities elected based on reputation measured through a series of attestations—charged with overseeing the distribution of retroactive public goods funding. In 2023, OP Labs announced a strategy for 'technical decentralization' of the OP Stack codebase, which underpins Optimism. Among the 'milestones' of this plan, OP Labs proposes creating a Security Council to assist in managing software updates.[57]

In June 2023, **Polkadot** announced the launch of a new governance framework called OpenGov (or Governance V2), catalyzed by a desire to 'further decentralize Polkadot.' This framework involved the dissolution two governance bodies: 'the Council,' whose responsibilities, including the governance of treasury allocation, were to be transferred to 'the public' (i.e., the DOT token holders), and the 'Technical Committee,' previously in charge of fast-tracking 'emergency proposals' submitted by the Council and to be approved by the community, which would be replaced by the 'Polkadot Technical Fellowship' with the power to whitelist proposals based on their urgency.[58]

One month later, **Polygon** presented the Governance 2.0 framework for 'decentralized ownership and decision-making over all Polygon protocols and the ecosystem.' The framework consists of three pillars: (1) protocol governance, which expands the scope of the Polygon Improvement Proposal (PIP) framework to eventually cover the entirety of the Polygon permissionless stack, giving the community a formal way to research and propose upgrades that may eventually become part of protocols; (2) system smart contracts governance, which creates the 'Ecosystem Council' to handle the additional governance steps involved in upgrading smart contracts;

(3) community treasury governance, introducing a funding source for public goods, supporting projects and initiatives in the Polygon ecosystem, governed by an independent Community Treasury Board that community members will eventually elect.[59]

Finally, **Cardano** initially set up a roadmap with three phases of decentralization. The initial 'Byron phase,' during which the Cardano network was federated, was followed by the 'Shelley phase,' which progressively shifted control to the Cardano community by enabling community-run nodes and introducing a delegation and incentives scheme to encourage stake pool participation within Cardano's Proof-of-Stake framework. In 2023, Cardano launched the last phase of its roadmap, called 'Voltaire.' Voltaire introduces an on-chain voting mechanism for ADA holders to present 'governance actions,' which are distinct from Cardano Improvement Proposals (CIPs). Governance actions can be submitted by paying a transaction fee. Voltaire also allows ADA holders to vote on-chain for treasury allocations.[60] The Cardano Improvement Proposal (CIP)-1694 instigated a significant change to governance by introducing two new governance bodies with specific functions, in addition to the already-existing body of stake pool operators (SPOs). Firstly, a constitutional committee—a group of persons and organizations that collectively ensure the Cardano Constitution is respected by voting on the constitutionality of governance actions. Secondly, a group of delegated representatives (DReps) to whom ADA holders generally delegate their voting rights. ADA holders can also register as DReps and delegate voting power to themselves.

// On-chain Challenges:

The efforts to define and measure decentralization, along with actions taken by some blockchain systems, indicate that at least two types of on-chain forces tend towards (re)centralization.

Firstly, there are challenges regarding consensus algorithms over block production (i.e., how consensus over an updated ledger state is achieved). For a consensus algorithm to be decentralized, the probability of producing the next block must be evenly distributed across a large network of independent nodes. In Proof-of-Work (PoW) consensus, this probability can be skewed if miners or mining pools possess outsized computational resources, thereby increasing their chances of mining the next block. Similarly, in many Proof-of-Stake (PoS) consensus algorithms, probabilities become skewed when validators control an outsized stake in the network. Today, as mining and validating have evolved into professionalized industries reliant on specific hardware and often organized into validator or mining pools, PoW, and particularly PoS and Delegated PoS blockchain networks, exhibit significant re-centralization tendencies.[61]

Secondly, **governance via token-weighted on-chain voting** also poses a challenge. In many blockchain systems, token holders influence several governance areas, such as treasury management or protocol upgrades, through various on-chain voting mechanisms. This often leads to a plutocratic governance system ('rule by wealth'), where possessing more tokens equates to having more influence. This can be particularly problematic if the initial token distribution favors a few powerful actors.[62] For instance, Polkadot and Optimism allocated significant governance tokens to early investors and team members. Although these projects are making deliberate efforts to distribute token holdings more broadly over time, governance in these blockchain systems has shown plutocratic tendencies.[63]

// Off-chain Challenges:

Certain off-chain forces may also impact the capacity of a blockchain system to decentralize over time.

Firstly, **the required expertise to participate in governance.** As blockchain projects evolve, their complexity significantly increases, evident in the extensive governance documentation produced and the vast tacit knowledge often necessary for effective participation in the decision-making processes of blockchain networks. This complexity tends to entrench decision-making power among early members who have a deeper understanding of the system's context and history, thereby inhibiting effective participation from newer members or those with limited time.

Secondly, **the role of founders.** Except for Bitcoin, whose founder(s) remains anonymous and inactive, founders typically assume a crucial governance role, often acting as spiritual leaders or benevolent dictators. This dynamic, observed across many online communities predating Web3, poses a challenge for blockchain networks that aspire to a strategy of progressive decentralization.[64] It highlights the necessity for these networks to develop detailed founder exit and succession strategies to truly advance their decentralization goals.

Thirdly, **the impact of laws and regulations.** External actors such as policymakers, lawmakers, and regulators can significantly impact progressive decentralization. For instance, the United States Securities and Exchange Commission (SEC) considers the level of decentralization in cryptocurrency projects when determining if their issuance might qualify as a security issuance under US securities laws. The 'Howey Test' from the US Supreme Court's decision in SEC v. W.J. Howey Co. defines an investment contract as (a) an investment of money, (b) in a common enterprise, (c) with an expectation of profit, (d) derived primarily from the efforts of others.[65] A great variety of schemes could be classified as an investment contract. Many cryptocurrencies and Initial Coin Offerings (ICOs) issued and promoted by 'centralized entities' could meet this definition, thereby subjecting them to securities regulations.[66]

On the one hand, this scrutiny can push projects towards more decentralized structures to avoid regulatory burdens, influencing how they design their networks and distribute tokens. On the other hand, the Howey test, while designed to protect investors, can inadvertently hinder decentralization in blockchain projects. First, there is uncertainty regarding, for example, who constitutes the 'others' whose efforts result in profit for putative investors, making it difficult for blockchain systems to fit within traditional securities frameworks. Secondly, the compliance costs and risks associated with meeting SEC regulations can be prohibitive for smaller or nascent projects, discouraging them from pursuing innovative decentralized models. Additionally, projects may alter their token distribution strategies to avoid characteristics that might classify them as securities, such as the avoidance of profit-sharing mechanisms. This can restrict their ability to promote wider and more equitable ownership, a goal that may be seen as socially desirable. Collectively, these factors contribute to a conservative approach to decentralization, limiting innovation and the benefits that decentralization may have for blockchain communities.

Impact

Blockchain communities that genuinely seek to progressively decentralize must adopt precise and operational definitions of what decentralization means in the context of their blockchain system. Additionally, they will need to recognize and address re-centralizing tendencies both on-chain, such as those arising from consensus algorithms and token-weighted on-chain voting, and off-chain, including the tacit expertise required to participate in governance, the potentially significant influence of founders, and the impact of laws and regulations.

43 Jad Esber and Scott Duke Kominers, "Progressive decentralization: a high-level framework," a16z Crypto, Jan 12, 2023, https://a16zcrypto.com/posts/article/progressive-decentralization-a-high-level-framework/

44 Balázs Bodó and Alexandra Giannopoulou, "The Logics of Technology Decentralization – the Case of Distributed Ledger Technologies," in Routledge eBooks, 2019, 114–29, https://doi.org/10.4324/9780429029530-8.

45 Aaron Schneider, "Decentralization: Conceptualization and Measurement," Studies in Comparative International Development 38, no. 3 (September 1, 2003): 32–56, https://doi.org/10.1007/bf02686198.

46 Daniel Treisman, "Defining and Measuring Decentralization: A Global Perspective," SSCNet UCLA Social Sciences, (2002), https://www.sscnet.ucla.edu/polisci/faculty/treisman/Papers/defin.pdf

47 Jean-Paul Faguet, "Decentralization and Governance," World Development 53 (January 1, 2014): 2–13, https://doi.org/10.1016/j.worlddev.2013.01.002.

48 Buterin, "The Meaning of Decentralization."

49 ibid.

50 Balaji S. Srinivasan, "Quantifying Decentralization," Medium, June 20, 2018, https://news.earn.com/quantifying-decentralization-e39db233c28e.

51 Ashish Rajendra Sai et al., "Taxonomy of Centralization in Public Blockchain Systems: A Systematic Literature Review," Information Processing & Management 58, no. 4 (July 1, 2021): 102584, https://doi.org/10.1016/j.ipm.2021.102584

52 Dimitris Karakostas, Aggelos Kiayias, and Christina Ovezik, "SoK: A Stratified Approach to Blockchain Decentralization," arXiv (Cornell University), January 1, 2022, https://doi.org/10.48550/arxiv.2211.01291.

53 Bodo and Giannopoulou, "The logics of technology decentralization."

54 Braiins, "Bitcoin's Decentralization with Stratum V2," Braiins, June 29, 2020, https://braiins.com/blog/stratum-v2-bitcoin-decentralization

55 Tom Mitchelhill, "Vitalik Buterin on Fix for Ethereum Centralization: Make Running Nodes Easier," Cointelegraph, September 5, 2023, https://cointelegraph.com/news/vitalik-buterin-ethereum-centralization-issues-running-nodes-easier.

56 The Optimism Collective, "Introducing the Optimism Collective," Optimism Mirror, April 27, 2022, accessed April 25, 2024, https://optimism.mirror.xyz/gQWKlrDqHzdKPsB1iUnI-cVN3v0NvsWnazK7ajlt1fl.

57 OP Labs Team, "Optimism's Path to Technical Decentralization," OP Labs Blog, January 24, 2024, https://blog.oplabs.co/decentralization-roadmap/.

58 Polkadot, "Introduction to Polkadot OpenGov," Polkadot Wiki, accessed April 25, 2024, https://wiki.polkadot.network/docs/learn-polkadot-opengov; OneBlock, "OpenGov Is Launched on Polkadot!," Medium, June 29, 2023, https://medium.com/@OneBlockplus/opengov-is-launched-on-polkadot-c3e663f17867.

59 Polygon Labs, "Polygon 2.0: Governance," July 19, 2923, accessed April 25, 2024, https://polygon.technology/blog/polygon-2-0-governance.

60 Cardano, "Cardano Roadmap," Cardano Roadmap, accessed April 25, 2024, https://roadmap.cardano.org/en/.

61 Ibid

62 Tom Barbereau et al., "Decentralised Finance's Timocratic Governance: The Distribution and Exercise of Tokenised Voting Rights," Technology in Society 73 (May 1, 2023): 102251, https://doi.org/10.1016/j.techsoc.2023.102251; Rainer Feichtinger et al., "The Hidden Shortcomings of (D)AOs -- an Empirical Study of On-Chain Governance," arXiv.org, February 23, 2023, https://arxiv.org/abs/2302.12125.

63 For an example of a proposed way distribute token holdings over time in the Polkadot ecosystem, see: Web3 Foundation Team, "Decentralized Voices Program," Medium, February 7, 2024, https://medium.com/web3foundation/decentralized-voices-program-93623c27ae43.

64 Nathan Schneider, "Admins, Mods, and Benevolent Dictators for Life: The Implicit Feudalism of Online Communities," New Media & Society 24, no. 9 (January 7, 2021): 1965–85, https://doi.org/10.1177/1461444820986553.

IV. Governance Formalization

IV. Governance Formalization

"Achieving a careful balance between on-chain and off-chain governance practices allows for a blend of predictability and flexibility in decision-making processes."

Finding

In recent years, blockchain communities have experienced greater 'formalization,' or a surge in adopting online written documents that delineate blockchain rules and procedures. These documents play a crucial role in establishing the framework for off-chain and on-chain decision-making, essentially introducing what can be termed 'secondary rules.' However, despite these advancements, the blockchain governance landscape still grapples with a significant gap between these formalized rules and the implicit, often undocumented, practices that shape governance within many blockchain systems.

// Understanding Blockchain Constitutionalism 2.0:

The term 'constitution' can be used to refer to a collection of rules on how to make rules. In other words, rules for creating, modifying, and nullifying existing governance rules. This concept can be extrapolated into systems other than nation-states, such as blockchains. In this case, 'constitutions' can manifest on-chain and off-chain. The rules embedded in the blockchain protocol or smart contract make up for the **'on-chain constitution.'** The implicit and undocumented off-chain governance practices constitute the **'off-chain material constitution.'** The articulation of these implicit off-chain rules into written standardized documents can be referred to as the 'off-chain formal constitution.'

Blockchain Constitutionalism 2.0 refers to the phenomena of blockchain systems increasingly 'formalizing' their material constitution into readable documents.[67]

All interviewed blockchain communities have been progressively formalizing or documenting the procedures for governance decision-making. These written documents are typically hosted in GitHub repositories, Discord channels, or websites managed by founders, legal entities associated with the blockchain system, or other influential stakeholder groups. Examples of such documents are accessible through platforms like the Avalanche Foundation's GitHub, the Cardano website, the Cosmos Hub website, the Ethereum website, the Filecoin Foundation website, the Optimism Collective website, the OPerating Manual v0.3.8 on GitHub, the Polkadot website, the Polygon blog, the Tezos website, and the Zcash website. Notably, at the time of writing, the Optimism Collective has already adopted a single written document purposefully referred to as a 'Working Constitution,' while Cardano is currently in the process of adopting a 'constitution' as well. Bitcoin presents an interesting case regarding governance formalization. Lacking an active founder, the formalization of governance has not been necessarily 'planned,' but rather evolved organically over time. This process was particularly dynamic in the early stages but has shown signs of stagnation in recent years, which is evident in the declining adoption rate of Process Bitcoin Improvement Proposals (BIPs).

// Persisting Informal Practices and Information Asymmetry:

Despite the **transparency** inherent to transactions of public blockchain networks, this characteristic **doesn't necessarily extend to their governance.** Firstly, while formalizing governance is essential, it cannot entirely eradicate unofficial and undocumented governance practices. In numerous instances, various stakeholders wield significant decision-making authority over blockchain network operations, with some exerting influence behind the scenes without community knowledge or accountability. One area where informal practices often prevail is in handling security breaches or bugs, as detailed further in the report. Secondly, accessing written documentation isn't always straightforward or easily comprehensible for the broader blockchain community. This creates information disparities between newcomers and oldtimers, including founders and core developers.

// Legitimacy, Flexibility, and Predictability:

Generally, 'insiders' may perceive a blockchain system as 'legitimate' if they believe governance is conducted in a morally acceptable manner or serves the interests of the blockchain community.[68] Formalizing tacit and implicit norms into a structured 'constitution' can foster trust and garner support from community members by promoting accountability among all governance participants. However, the process of formalizing governance rules needs extensive and thoughtful consideration of the various governance mechanisms within a specific blockchain community.

When crafting a formal constitution, it is essential to strike a balance between flexibility and predictability in the governance system. On-chain governance, where decisions are made via token-weighted on-chain voting mechanisms or through punitive measures like 'slashing' in Proof-of-Stake networks, offers predictability but can be rigid and inflexible. Off-chain governance mechanisms, such as debates on governance forums, maintain flexibility but may lead to greater unpredictability or arbitrary changes. Achieving a careful balance between on-chain and off-chain governance practices allows for a blend of predictability and flexibility in decision-making processes.

Impact

Governance formalization can become an important opportunity for strengthening the legitimacy of blockchain systems. Yet, community members should remain aware of the delicate interplay between on-chain rules, formalized into blockchain code, and off-chain practices, which can never be completely and fully expressed on-chain. Implementing a hybrid of on-chain and off-chain rules makes blockchain governance more flexible and adaptable to the community's evolving needs while preserving the reliability and accountability of code-based mechanisms.

67 Morshed Mannan, Primavera De Filippi, and Wessel Reijners, "Blockchain Constitutionalism," in Oxford Handbook of Digital Constitutionalism, ed. Giovanni De Gregorio, Oreste Pollicino, and Peggy Valcke, forthcoming; Michael Zargham et al., "What Constitutes a Constitution?," Medium, February 27, 2024, accessed April 30, 2024, https://medium.com/block-science/what-constitutes-a-constitution-2034d3550df4.

68 De Filippi et al., "Report on Blockchain Technology & Legitimacy."

V. Governance Mechanisms

V. Governance Mechanisms

"Achieving a careful balance between on-chain and off-chain governance practices allows for a blend of predictability and flexibility in decision-making processes."

Finding

Certain governance areas within blockchain systems welcome contributions from various stakeholder groups. 'Rough consensus' and 'signaling and voting' represent two governance mechanisms for gathering input and making decisions. Blockchain communities utilize varying degrees of sophistication in these mechanisms and implement them independently or in conjunction, resulting in diverse decision-making processes for each scenario. The distinct characteristics of these mechanisms, alongside factors like the nature of the decision and the stakeholders involved, can give rise to more 'participatory' to more 'expedient' approaches to governance design.

// Terminology and Definitions:

In the previous section, we categorized governance mechanisms as either on-chain (ex-ante and ex-post) or off-chain, depending on where and how the decision-making process occurs. This section focuses solely on on-chain (ex-post) and off-chain mechanisms, setting aside ex-ante rules already baked into the blockchain code (e.g., consensus algorithms). Within this subgroup, we differentiate them as rough consensus, signaling, or voting based on their underlying ethos and structural processes.

Rough consensus is a qualitative and informal mechanism of gauging agreement in a group. It often involves extensive discussions, debates, and deliberation until there is a lack of strong or significant opposition to a proposal.[69] Unlike strict vote counts, rough consensus relies on a general sense of the group's opinion. Its ethos emphasizes collective agreement and collaborative problem-solving. This mechanism is not exclusive to blockchain systems; it was popularized in Internet governance by the Internet Engineering Task Force[70] and later extended to other open-source projects. Examples include the Linux Kernel community[71] and the Python community, which famously passed the Python Enhancement Proposals (PEP) 0 and PEP 1, serving as inspiration for early blockchain communities.

Signaling and voting represent more formalized and quantitative governance mechanisms, wherein participants explicitly indicate their preferences or choices regarding a proposal or issue within a specified time frame. Proposals are passed if they meet pre-established quorum and majority thresholds. The inherent ethos of signaling and voting is not necessarily to encourage opposing parties to jointly agree on a desirable outcome but rather to unambiguously measure the level of support for a particular proposal.

While these mechanisms are common in traditional governance structures, ranging from corporate boardrooms to national elections, blockchain technology and systems have led to the development of novel and more intricate signaling and voting designs. Although the terms are often used interchangeably, in this report, we distinguish between them based on the blockchain community's perception of the anticipated outcomes as either binding (i.e., the result ought to be enforced) or non-binding (i.e., the result does not need to be enforced).

In signaling, the outcomes are not considered binding but rather indicative. Signaling can happen on-chain, but it mostly occurs off-chain through third-party platforms. The reason is that in blockchain networks with high transaction fees, signaling acts as a filtering mechanism to streamline governance processes, ensuring that primarily those proposals with broad support advance to the formal voting stage, thereby optimizing governance costs.[72] **In contrast, voting outcomes are typically regarded as binding.** While off-chain voting is technically possible, in practice, it frequently occurs on-chain.

In this report, '**enforceability**' in a blockchain system is understood as implementing a governance decision determined through a given governance mechanism. Considering the complex and multi-layered nature of blockchain systems, enforceability can—but not always is, or needs to be—automatically executed by a blockchain protocol or smart contract. For example, in Tezos, on-chain voting not only aggregates preferences but also allows for outcomes to be self-executing by automatically integrating the results into the blockchain protocol code. However, merging code changes into the Bitcoin Core's GitHub repository in line with a Standards Track BIP adopted by off-chain rough consensus is also considered an act of 'enforcement.'

// Comparative Analysis of Governance Mechanisms Across Blockchain Networks:

As previously noted, blockchain systems may employ these two mechanisms, either in isolation or combined, across different governance areas, experimenting with various configurations depending on specific needs.

The Bitcoin community adopts many decisions through Bitcoin Improvement Proposals (BIP). The process for how BIPs work was laid out in 2011 through BIP-1, amended by BIP-2, technically the first 'secondary rule' or 'rule on how to make rules' to govern a blockchain network. There are three types of BIPs: Process BIPs describe or propose changes to the BIP process itself, or other processes within the Bitcoin community.

Informational BIPs are designed for general guidelines or information sharing and do not necessarily propose any changes to the Bitcoin protocol. Finally, Standards Track BIPs propose changes to the Bitcoin protocol, blockchain, or transaction validation method. Technically, anyone can be a BIP author and share it in the Bitcoin Core GitHub repository. If the BIP editor at the time, usually a well-known Bitcoin core developer, thinks it meets the content and formatting criteria, the BIP gets published. For a BIP to pass from 'drafted' to 'accepted,' it has to meet a **rough consensus**. In other words, it should face no stark opposition from community members. Over time, BIP authors have proposed **ad-hoc on-chain signaling mechanisms for miners** to express their support or rejection of a BIP by using, for example, the version field in the blocks they mine. While signaling was never deemed binding, it has played a crucial role in Standards Track BIPs, such as those driving the Segregated Witness (BIP-141) and Taproot (BIP-341 and BIP-342) soft forks.

Ethereum adopted a framework similar to Bitcoin's. In 2015, community members introduced their own 'secondary rule' via the Ethereum Improvement Proposal (EIP)-1, which followed a rationale and review process comparable to BIP-1 and BIP-2. In Ethereum, there are Informational EIPs, Meta (or Process) EIPs, and Standards Track EIPs. Initially, several editors, including Ethereum co-founder Vitalik Buterin, were tasked with overseeing the quality and clarity of proposals. Over time, as needs evolved, the composition of this team has grown and changed. Currently, EIPs progress from 'review' to 'last call' to 'final' stages through rough consensus. For Core EIPs—a type of Standards Track EIP—protocol core developers play a crucial role in reviewing and providing feedback.[73] Although no standardized signaling or voting mechanisms for EIPs exist, some have been proposed and utilized to resolve contentious debates. For instance, after the 2016 The DAO hack, the Ethereum community conducted on-chain voting to decide whether to implement a hard fork to reverse the hack transactions.[74] This voting was carried out through carbonvote, a platform enabling token holders to express their preference by sending a zero-value transaction from their Ethereum address to a YES or NO address and paying a transaction fee.[75] A supra-majority of approximately 85% of participating Ethereum addresses voted YES for a hard fork, which took effect on July 20, 2016.

The Zcash community has relied on **rough consensus** and, for some Zcash Improvement Proposals (ZIPs), **ad-hoc signaling mechanisms.** The Zcash's trademark agreement, one of the community's key governance documents, gives the Zcash Foundation and the ECC the exclusive right to legally determine what chain is called Zcash. This agreement, however, specifies that neither organization will approve or reject any decision that contradicts the 'clear consensus' of the Zcash community.

community proposals adhere to the process outlined in ZIP-0 and may be dismissed for several reasons, including if they starkly contravene the 'common expectations of a significant portion of the community,' though these expectations are not well defined. Over time, the community has also adopted 'community sentiment collection polls,' although the administration and framing of these polls by different governing bodies have sparked some controversy. For example, in 2019, to decide on 13 ZIPs related to development funding, the Zcash Foundation requested input from the representative community body known as the Zcash Community Advisory Panel (ZCAP) through the **off-chain signaling platform** Helios Voting Booth and from the Zcash miners through an **on-chain signaling** mechanism.[76]

Similarly, **Filecoin** stakeholders can submit a Filecoin Improvement Proposal (FIP) by following the guidelines outlined in FIP-0001. FIP-0001 advises FIP authors to first vet their proposals within the community, utilizing platforms like the Filecoin GitHub Repository's Issues section, the Filecoin Discourse Forum, and the Filecoin Community Chat. After drafting an FIP, authors are tasked with building community consensus. This process can involve noting opposing views, responding to technical concerns, and making necessary adjustments to ensure the FIP's acceptance. In August 2023, the Filecoin Foundation introduced the FIP-0001 v2 Initiative #799. This initiative aims to revise FIP-0001, deploy improved tools to facilitate the FIP process, and ensure greater alignment with community values.

In late 2023, the **Avalanche Foundation** proposed an Avalanche Community Proposal (ACP) process as a framework for **building consensus** around proposed changes to the Avalanche Network. As of the time of writing, there are four types of ACPS. The Standards Track ACP focuses on modifications to the design or functionality of the Avalanche Network, including changes to the peer-to-peer networking protocol, P-Chain design, Subnet architecture, or any alterations that influence the interoperability of Avalanche Network Clients (ANCs). The Best Practices Track ACP suggests design patterns or common interfaces that facilitate integration within the Avalanche Network or enhance interoperability among Subnets. The Meta Track ACP involves adjustments to the ACP process itself or proposes new methods for collaboration within the Avalanche Community. Lastly, the Subnet Track ACP targets specific changes or upgrades to individual Subnets. ACPs are scheduled for activation only if an 'overwhelming majority' shows support. The Avalanche Foundation retains a role in issuing (non-binding) recommendations on ACPs, but it is ultimately up to the Avalanche community to support an ACP by running a compatible ANC.

Some blockchain systems use rough consensus paired with signaling mechanisms. In the case of **Polygon** and its Governance 2.0 model, the **Polygon Improvement Proposals (PIP)** framework, which is fully functional on the Polygon PoS chain, serves as a platform for coordinating developments within the Polygon protocols.[77] The PIP framework is defined by PIP-1 and PIP-8. The main discussion space among community members for all PIPs is the Polygon Community Forum. Feedback from the forum is incorporated into the documented PIPs housed in the GitHub repository. Additionally, members of Polygon Labs and other stakeholders with technical knowledge gather in online calls such as Polygon Governance Calls, which serve as instances for addressing questions and suggestions about potential or in-review governance proposals.[78] The Polygon PoS Chain governance has also relied on off-chain signaling mechanisms. Traditionally, validators would conduct polls in a dedicated Discord channel to signal support or rejection of ideas.[79] In 2022, Polygon Labs announced they would use Snapshot as a tool for consensus gathering in areas such as offboarding offline validators.[80] Snapshot was used to conduct a poll on PIP-4: Validator Performance Management.

Various blockchain systems have developed advanced combinations of governance mechanisms.

For instance, within the **Cosmos Hub**, token holders have the ability to propose various changes such as the allocation of community pool funds, modifications to core on-chain parameters, chain version upgrades, or updates to an IBC client. Proposals undergo an off-chain peer review by community members before being pushed live on the testnet and mainnet. It is recommended that detailed documentation for these proposals be hosted on a censorship-resistant platform like IPFS. Before a proposal is up for an **on-chain vote**, it must gather a deposit of 250 ATOM tokens within a 14-day period. A quorum of 40% of the network's total voting power, represented by staked ATOM, is required for voting. Voting options include 'Yes,' 'No,' 'Abstain,' or 'NoWithVeto.' Proposals are approved with a simple majority of 'Yes' votes. However, if 'NoWithVeto' garners 33%, the proposal fails, and the proposer forfeits their deposit. Proposals that affect the community pool or parameters result in direct changes to the Hub. Additionally, Cosmos Hub employs an **on-chain signaling mechanism** known as Text Proposals, which records community sentiment and although non-binding, serves as a gauge of stakeholder positions.[81]

The governance model of the **Cardano** community is currently evolving and relies on two primary mechanisms. Firstly, there are the Cardano Improvement Proposals (CIPs) as outlined in CIP-1. These proposals detail changes to the Cardano ecosystem, processes, or environment and are hosted on the Cardano Foundation's GitHub Repository.

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The workflow for a CIP transitions from 'proposed,' to either 'active' or 'inactive' based on **rough consensus**. Each CIP must include a clear 'path to active' with measurable metrics to track implementation. These metrics help determine when projects or technologies are fully implemented, when protocol changes are live on the Cardano mainnet, and when ecosystem standards are noticeably adopted by the community. This pathway should also be supported by a detailed implementation plan. Essentially, CIPs must provide a specific reference or benchmark to indicate their **successful enforcement**. CIP Editors facilitate this process through public, recorded meetings available on the Cardano Foundation's YouTube channel. Secondly, the Funding Proposals (FPs) involve community-submitted proposals aimed at improving the ecosystem, such as allocating funds for platform development or creating new features. FPs are selected through an **on-chain voting** process managed by Project Catalyst, where any ADA holder can vote, with votes weighted by token holdings. Proposals with the highest support receive funding from the treasury. Additionally, CIP-1694 introduces significant changes by establishing two new governance bodies alongside existing Stake Pool Operators. These bodies are crucial in the ratification of 'governance actions' (distinct from CIPs) proposed by ADA holders via **on-chain voting**. These developments are part of Cardano's Roadmap Voltaire phase, focusing on enhancing governance structures.[82]

The **Polkadot** community transitioned from Governance V1 to Governance V2, also known as OpenGov. Under Governance V1, the primary mechanism for community decision-making was through 'referenda,' which are discussed off-chain and decided on-chain via a platform called **Polkassembly**, alongside Council motions. With the introduction of OpenGov, any DOT holder can draft a proposal, categorized based on implementation complexity and potential impact. This categorization aids in determining the suitable governance process for each proposal. Once a referendum is initiated, it enters a 'decision period' where votes can be cast as 'aye,' 'nay,' or 'abstain,' or votes can be split among these options. For a proposal to pass, it must meet the 'approval and support criteria' during the 'confirmation period,' or it is automatically rejected. Approved proposals progress to the 'enactment period,' where changes are implemented. Approval is gauged by the proportion of affirmative (aye) votes, adjusted for conviction, relative to the total vote weight. Support is calculated by summing affirmative and abstained votes (without adjustment for conviction) as a percentage of the total potential votes. 'Conviction' refers to conviction voting, where token holders can enhance their voting power by committing their tokens to a decision for a longer period.[83] Additionally, the Polkadot community relies on a Technical Fellowship, a self-governing expert body responsible for managing its membership, approving Requests for Comments (RFCs), and whitelisting proposals for Polkadot OpenGov.

The Fellowship also oversees network upgrades via runtime upgrades that the community subsequently approves. The collective decision of the Fellowship members, with votes weighted by rank, represents the considered opinion of the body.[84]

In April 2022, the **Optimism Collective** was launched, composed of 'communities, companies, and citizens,' and is overseen by the Optimism Foundation. The governance structure is bicameral. The Token House, operated by holders of the OP token, allows members to vote directly or delegate their voting rights to an OP Delegate. Currently, they oversee decisions on governance fund grants, protocol upgrades, inflation adjustments, director removal, treasury appropriations, and rights protection. The Citizens' House operates as 'an experiment in non-plutocratic governance,' utilizing a one-person, one-vote system. It is primarily responsible for retroactive public goods funding (RPGF), funded by network-generated revenue. The scope of its responsibilities is expected to expand over time.[85] Citizens are selected through a series of attestations that determine their eligibility. As of a July 2023 announcement, the Citizens' House will manage Citizenship Eligibility, with the Token House retaining veto power.[86] Historically, the expansion of Citizenship has been managed by the Optimism Foundation. In 2022, following a series of discussions among different stakeholder groups, it was proposed to **switch from Snapshot to on-chain voting** via Agora, enabling OP Delegates to represent the Token House in governance decisions.[87] According to the **OPerating Manual v0.3.8**, both Houses should enact governance through **formal proposals**. Most proposal types are initially discussed in the Governance Forum for community feedback, following a Standard Proposal Template. Subsequently, a governance administrator compiles these into a Voting Cycle Roundup, and stakeholders responsible for each proposal type—either OP Delegates or Citizens—are called to vote. Proposals are passed based on quorum, approval, and, for the Citizens' House, veto thresholds.

Finally, governance in **Tezos** is a multi-phase process that relies on **on-chain voting** over proposals for amending the economic protocol that, if approved, have their **outcomes automatically enforced**. The amendment process in Tezos involves a structured sequence of five periods spanning approximately two and a half months, with voting power tied to the number of XTZ tokens held by delegates. The process begins with the 'proposal period,' where delegates submit or upvote proposals. The most supported proposal that meets the quorum advances to the 'exploration period,' where delegates vote 'Yea,' 'Nay,' or 'Pass.' If a super-majority approves and quorum is met, it moves to the 'cooldown period' for further **off-chain scrutiny**. Next is the 'promotion period,' with another round of voting. If this also achieves a quorum and a super-majority of affirmative votes, the proposal enters the 'adoption period.'[88]

While the quorum threshold during the first voting was close to 80% of the stake, it has since been adjusted to ensure that the amendment process can continue even if some delegates stop participating.

// Legitimacy, Contextual Factors, and Trade-offs:

As previously mentioned, **the perceived legitimacy of a blockchain system's governance** often hinges on its alignment with moral principles and perceived benefits to the interests of its **members**. Therefore, careful consideration of the potential outcomes associated with various governance mechanisms is essential.[89]

The comparative analysis of blockchain systems uncovers a **complex landscape**, where understanding the trade-offs inherent in mechanisms like 'rough consensus' and 'signaling and voting' is a nuanced endeavor that defies broad generalizations. This intricate web of contextual factors, such as the nature of the governance decision and the participating stakeholders, profoundly shape the implications of relying on one or another mechanism. Despite these complexities, the explored governance mechanisms can **have different effects on governance and legitimacy.**

On the one hand, **rough consensus, while initially perceived as more 'participatory'** due to its allowance for input from non-token holders, grapples with the challenge of determining when a true 'consensus' is achieved.

This potential for ambiguity can lead to prolonged, unresolved discussions or the manipulation of public opinion by influential community members. Consequently, it's crucial to consider the potential pitfalls of relying on rough consensus for discussions regarding non-contentious issues among incentive-aligned stakeholders (e.g., adoption of technical standards among software developers) as it may yield vastly different outcomes than its application in broader community deliberations on more contentious matters (e.g., potential soft or hard forks discussed by the community at large).

On the other hand, signaling and voting generally offer more 'expedient' and measurable decision-making processes but are not without issues. When conducted on-chain through token-weighted systems, they inherently tend toward plutocracy. While on-chain signaling and voting may serve as effective mechanisms for governance areas where token-holders have significant stakes and demand higher expediency or transparency (e.g., decisions on treasury allocations), they may not be the optimal choice for decisions directly impacting non-wealthy stakeholders (e.g., policies on rewards for contributions).

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Impact

When designing governance frameworks, blockchain communities must consider the implications of adopting rough consensus versus signaling and voting as governance mechanisms. Whether used independently or combined in basic or advanced setups, these mechanisms can create specific incentives that may promote advantageous or detrimental behaviors, thus influencing the network's sustainability and resilience. These dynamics invariably shape stakeholders' perceptions of the legitimacy of the blockchain system.

69 Rough consensus does not require unanimous decision approval. Still, it is not considered 'achieved' if a bit less than half of the decision-makers clearly express disagreement. See: Bernie Jones, "A Comparison of Consensus and Voting in Public Decision Making," Negotiation Journal 10, no. 2 (April 1, 1994): 161–71, https://doi.org/10.1007/bf02184175.

70 Pete Resnick, "On Consensus and Humming in the IETF," Internet Engineering Task Force, June, 2014, https://datatracker.ietf.org/doc/rfc7282/

71 Greg Kroah-Hartman, "9 lessons from 25 years of Linux kernel development," Opensource.com, December 14, 2016, https://opensource.com/article/16/12/yearbook-9-lessons-25-years-linux-kernel-development

72 For examples on why we define signaling as non-binding, even when on-chain, see: Bitcoin Magazine, "Bitcoin Miners Are Signaling Support for the New York Agreement: Here's What that Means," Bitcoin Magazine, June 20, 2017, https://www.nasdaq.com/articles/bitcoin-miners-are-signaling-support-for-the-new-york-agreement:-heres-what-that-means

73 ethereum.org, "Introduction to Ethereum Governance," accessed April 25, 2024, https://ethereum.org/en/governance/.

74 There is an ongoing discussion on what "on-chain voting" is supposed to encompass. See: ZeusLawyer, "For Decentralized Governance on Ethereum, Why Is Snapshot Considered 'Off-chain' but Tally Considered 'On-chain'?," Stack Exchange, May 2, 2022, accessed April 30, 2024, https://ethereum.stackexchange.com/q/127331. In this report, on-chain voting involves issuing preferences through transactions in the blockchain, usually paying transaction fees, even if the final vote count and tally is done, off-chain and the results were deployed on a traditionally hosted website such as in the case of carbonvote back in 2016.

75 Bin Lu, "CarbonVote: A Gauge for Human Consensus," September 2016, accessed April 27, 2024, https://archive.devcon.org/archive/watch/2/carbonvote-a-gauge-for-human-consensus/?playlist=Devcon%202&tab=YouTube.

76 Zcash Foundation, "Zcash Dev Fund Community Sentiment Collection Poll," November 15, 2019, accessed April 26, 2024, https://zfnd.org/zcash-dev-fund-community-sentiment-collection-poll/.

77 Polygon Labs, "Polygon 2.0: Governance."

78 H_Rook, "The First Pillar: Protocol Governance," Polygon Community Forum, May 16, 2023, accessed April 26, 2024, https://forum.polygon.technology/t/the-first-pillar-protocol-governance/11972.

79 Mateusz, "Pre-PIP Discussion: Addressing Reorgs and Gas Spikes," Polygon Community Forum, December 7, 2022, accessed April 26, 2024, https://forum.polygon.technology/t/pre-pip-discussion-addressing-reorgs-and-gas-spikes/10623.

80 Polygon Labs, "Polygon Bolsters Validator Governance With Snapshot Voting," Polygon News, March 17, 2022, accessed April 26, 2024, https://polygon.technology/blog/polygon-bolsters-validator-governance-with-snapshot-voting.

81 Tendermint Inc., "Concepts," Cosmos SDK Documentation, accessed April 26, 2024, https://docs.cosmos.network/v0.45/modules/gov/01_concepts.html#proposal-types.

82 Cardano, "Cardano Roadmap."

83 Elizabeth Browning [Distractive], "OpenGov: What Is Polkadot Gov2," Moonbeam Network, December 15, 2022, accessed April 26, 2024, https://moonbeam.network/blog/opengov/.

84 Filippo, "Polkadot Technical Fellowship," Polkadot Wiki, last modified March 11, 2024, accessed April 26, 2024, https://wiki.polkadot.network/docs/learn-polkadot-technical-fellowship

85 The Optimism Collective, "Introducing the Optimism Collective."

86 The Optimism Collective, "The Future of Optimism Governance," Optimism Mirror, July 19, 2023, accessed April 26, 2024, https://optimism.mirror.xyz/PLrAQgE1EGRo7GRrFoztplFChnUZda4DFGW3dkQayxY.

87 lavande, "Transitioning to On-Chain Voting," Optimism Collective Forum, December 2022, accessed April 26, 2024, https://gov.optimism.io/t/transitioning-to-on-chain-voting/4193.

88 "The Amendment (and Voting) Process," Octez and Protocol Documentation, accessed April 26, 2024, https://tezos.gitlab.io/active/voting.html

89 De Filippi et al., "Report on Blockchain Technology & Legitimacy."

90 It is worth mentioning that while it is relatively accepted that on-chain signaling and voting are 'more transparent' than off-chain mechanisms, the pseudonymity of public blockchains may compromise anonymity, discouraging honest expression among participants wary of backlash and facilitating the proliferation of 'automated bribery protocols.' For more information about automated bribery protocols, particularly in the Decentralized Finance (DeFi) space, see: Liam J. Kelly, "DeFi Bribes Are on the Rise," Decrypt, January 13, 2022, accessed April 30, 2024, https://decrypt.co/90276/defi-bribes-are-on-the-rise.

VI. Security Measures and Breaches

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"Core developers and security teams remain among blockchain governance's most trusted stakeholders."

Finding

Preventive security measures in blockchain networks involve a range of strategies and technologies aimed at thwarting potential threats such as DDoS attacks, '51% attacks,' and vulnerabilities in smart contracts. These measures often rely on the expertise of in-house security teams or third-party contributors incentivized by bug bounty programs. Additionally, third-party security audits are commonplace across various blockchain ecosystems, ensuring an extra layer of protection. While some blockchain communities have established procedures or governance bodies to address unforeseen events, the handling of 'states of exception' continues to be a governance area that sparks controversy within these communities.

// Preventive Security Measures:

Preventive security measures comprise a variety of practices and technologies used to protect blockchain networks from specific threats and vulnerabilities. These include safeguarding the network from external attacks aimed at disrupting its operations, such as Distributed Denial of Service (DDoS) attacks,[91] evaluating the robustness of consensus algorithms against potential take-overs, such as through '51% attacks,'[92] or ensuring that smart contracts execute as intended without any room for exploits. The design and implementation of preventive security measures require input from tech-savvy individuals, either in-house security teams, third-party service providers, or external contributors submitting bugs or vulnerabilities, motivated by altruistic reasons or in anticipation of rewards.

Often, **in-house security teams** are set up and employed by the legal entities associated with a particular blockchain network. An example of this is the security team hired by the **Ethereum Foundation**.[93] This type of team is usually responsible for designing, implementing, and overseeing security measures, following responsible disclosure, response, and reporting processes. **Bitcoin** represents an interesting case of a blockchain community with no in-house "hired" security team. Still, the Bitcoin community has delineated a process for responsible disclosure of security bugs. Reports can be submitted by any stakeholder through encrypted emails to Bitcoin core developers or through the Bitcoin Core GitHub repository. These reports are handled by Bitcoin core developers, who usually disclose and report patches on the Bitcoin core website.[94]

Blockchain communities occasionally rely on **bug bounty programs** to incentivize people with technical expertise to identify potential threats and vulnerabilities before they become known to the world at large. For instance, the Ethereum Foundation uses a bug bounty platform that rewards bug reporters with up to 250,000 USD, depending on the severity of the issue. Avalanche also implemented a bug bounty program deployed on HackenProof, a "Web3 bug bounty platform for crypto projects," with potential rewards of up to 100,000 USD.

Similarly, the Tezos Foundation has set up a bug bounty program where anyone—except for Tezos core developers or contractors—can report a bug by submitting an encrypted email to the Foundation's security team, which rewards the author of valuable submission with a particular amount of XTZ.[95]

Another standard practice in the ecosystem is for blockchain systems to undergo **third-party security audits**. Notable blockchain networks such as **Avalanche**[96], **Cardano's IOHK,**[97] **Cosmos,**[98] **Filecoin,**[99] **Optimism,**[100] **Polkadot,**[101] **Polygon,**[102] **Tezos,**[103] and **Zcash**[104] announced their completion of such audits. Additionally, blockchain communities have established procedures or products and services specifically for auditing projects developed on their networks. An example of this is Cardano's CIP-52.

// Processes and Mechanisms for Unanticipated Events:

Even when blockchain communities invest a lot of effort and resources in preventive security measures, unanticipated events can still occur. Some blockchain communities have established specific governance processes that only become effective in the contingency of security breaches, such as hacks and attacks. These processes tend to increase the transparency of how unanticipated events are handled and may give the blockchain community a way to hold decision-makers to account. Still, the individuals directly involved in the decision-making processes during these emergencies retain considerable discretion. In September 2023, the **Optimism Collective** voted to establish a 'Security Council.' A few months later, the initial members proposed by the Optimism Foundation were ratified. In February 2024, the Collective launched the Council with a 2/2 multisig authorized to sign protocol upgrades for OP Mainnet, with the Optimism Foundation and the first Security Council as signers.[104] According to the Security Council Charter v0.1, this body oversees protocol updates and assigns roles to key network actors like sequencers, proposers, and challengers during normal operations. In emergency situations, the Council is tasked with ensuring network safety by proactively addressing issues such as bugs, defects, unplanned maintenance, or any other concerns that affect the security, stability, integrity, and availability of the OP Stack or any OP Chain. The Council may also take actions necessary for legal compliance, as advised by its members or the Optimism Foundation. While emergency measures can be enacted without formal governance approval, the Security Council is expected to provide a detailed and transparent retrospective to the community promptly, explaining the actions taken.

In the context of Polkadot, the new OpenGov introduced a Technical Fellowship to replace the Technical Committee and Council of its previous governance framework. In cases of emergency, the Technical Fellowship can whitelist proposals. Doing so lowers the thresholds and approval requirements since these proposals are submitted on a separate track with different configurations.

These proposals are only executed successfully if the Fellowship whitelists them, indirectly reducing the on-chain voting period. If these proposals are not whitelisted, they fail in execution.

As for **Polygon**, PIP-29 introduced a Protocol Council (initially called Ecosystem Council[105]), a 13-member governance body responsible for performing regular and emergency upgrades to the system's smart contracts. For 'regular' changes, decisions require a 7-of-13 majority vote, with a 10-day timelock delay to allow the community to exit before any change occurs. For 'emergency' changes, it requires a 10-of-13 majority vote, and changes are automatically implemented.

// Unanticipated Events and Informal Decisions:

Formalizing and publicizing processes for emergency procedures during unanticipated events is a relatively new trend. Until now, there have been controversial situations where founders, foundations, or developer teams have taken control during emergencies in ways that some community members have criticized.

The **Bitcoin** 'accidental' hard fork is one example. On March 11, 2013, a severe incompatibility issue between Bitcoin client 0.7 and 0.8 versions caused the main chain to fork into two separate chains. Once the problem was detected, some Bitcoin core developers quickly deliberated on the action in the #bitcoin-dev IRC channel.

There were two potential solutions: instruct miners and merchants to upgrade to the 0.8 version and stick to the newer chain or downgrade to the 0.7 version and stick to the older chain. One of the largest Bitcoin mining pools, BTC Guild, joined the conversation. Bitcoin core devs and BTC Guild decided that downgrading to 0.7 was the least risky solution and hoped miners would agree to do so, too. Afterward, core developer Peter Wuille posted on **bitcointalk.org** instructing miners, mining pools, miners, and merchants to downgrade their clients. The crisis was resolved in a matter of six hours.[106] Some critical voices in the Bitcoin community, such as Vitalik Buterin—who had not launched Ethereum yet—commended the work done to resolve the 2013 crisis. However, Vitalik argued that the instruction to downgrade to 0.7 may have been unnecessary. According to him, even if the core developers had done nothing, the Bitcoin network would have continued to work, albeit with some monetary loss. Echoing some worries felt across the community, Vitalik also pointed out that handling the accidental hard fork crisis may have left some feeling that "Bitcoin [was] clearly not at all the direct democracy that many of its early adherents imagine."[107] While he ultimately downplayed these fears, the episode revealed aspects of Bitcoin governance that may not have been so clear to the community, including the power concentrated in mining pools and the role played by Bitcoin core devs during unanticipated events.

The DAO hack and the process that led to the **Ethereum** hard fork is another example of an exceptional procedure to resolve a critical incident. The DAO, launched in April 2016, was an investor-driven venture capital fund managed as a decentralized autonomous organization (DAO). In June 2016, an attacker exploited a vulnerability in The DAO's smart contract code to drain about one-third of its funds—over $50 million worth of Ether at that time.[108] After the hack, the Ethereum community embarked on intense debates to decide the best course of action. Two of the options under consideration included accepting the hack's consequences, preserving the Ethereum blockchain's immutability, or hard forking the Ethereum blockchain to reverse and remediate the harm caused by the hack. Many stakeholders who held the principles of immutability and irreversibility dear, opposed the idea of a hard fork. Eventually, in July 2016, the decision was subject to an on-chain vote through the carbonvote platform.[109] Approximately 85% of the participating Ethereum addresses (which amounted to 5.5% of the total Ether supply) voted in favor of the hard fork. This decision led to the emergence of a separate blockchain network, Ethereum Classic (ETC), which rejected the hard fork and continued on the original Ethereum blockchain. Critics of the hard fork saw the decision to fork as a demonstration of centralized power, where a few core developers and the Ethereum Foundation had significant influence in a decision affecting the Ethereum network as a whole.[110]

Similarly, in 2021, **Polygon** had to introduce a hard fork to resolve a critical vulnerability in the PoS genesis contract discovered by two whitehat hackers and reported via the blockchain security and bug bounty platform Immunefi. Over 9.27 billion MATIC were at risk, representing nearly the entirety of the token's total supply of 10 billion MATIC. According to an article by Polygon Labs, the Polygon core team and Immunefi experts addressed the critical vulnerability with an 'Emergency Bor Upgrade,' informing validators and the full node community to update their software. Within 24 hours, around 80% of the network transitioned to the new client, successfully preventing network disruptions. The security resolution process followed a 'silent patches' policy, which mandates reporting critical bug fixes several weeks after implementation to avoid risks of exploitation during the patching process. While some validators voiced concerns about their nodes falling out of sync, they did not seem to have criticized the upgrade or its implementation.[111] The article, which detailed the security concerns behind their decision, may have helped garner support and understanding from various stakeholders regarding the actions taken.

The examples above show that when blockchain systems don't have formalized governance processes for emergencies described in public documentation nor make efforts to clearly inform about the steps and rationale that had to be followed to address the emergency, exceptional interventions are likely to be opposed more firmly by community members.

As it happens in nation-states during 'states of exception,' influential actors can leverage unanticipated events to further their own political (or economic) interests. For this reason, a proper formalization of emergency procedures is necessary for legitimate intervention. This formalization ensures transparency, accountability, and a clear framework for decision-making, reducing the potential for abuse of power and ensuring that interventions align with the interests of the broader community.

Impact

To maintain community trust, ensuring the security of blockchain networks requires adopting formal and well-understood processes for handling external threats while reducing the likelihood of decision-making centralization for personal gain. Achieving this balance demands a fusion of specialized technical knowledge and an understanding of stakeholders' needs and incentives to define the parameters under which 'states of exception' can, if any, be invoked within a blockchain ecosystem.

91 A Distributed Denial of Service (DDoS) attack on a blockchain network is a significant threat, though it's less common compared to traditional networks due to the inherent design of blockchain technology. To learn more about this topic, see: Rob Behnke, "How Blockchain DDoS Attacks Work," October 19, 2021, https://www.halborn.com/blog/post/how-blockchain-ddos-attacks-work.

92 A '51% attack' on a blockchain network refers to a situation where a single entity or group gains control of more than 50% of the network's mining power, hash rate, or stake. With this level of control, the attacker can exclude or modify the ordering of transactions, which can enable them to double-spend coins, block transactions, or even rewrite parts of the blockchain retroactively.

93 Security Research Team, "Secured #3: Security Teams, Protecting the Ethereum Consensus-layer," Ethereum Foundation Blog, April 14, 2022, accessed April 26, 2024, https://blog.ethereum.org/2022/04/14/secured-no-3.

94 "Issues - Contribute to Bitcoin Core," Bitcoin.org, accessed April 27, 2024, https://bitcoin.org/en/bitcoin-core/contribute/issues

95 Tezos Foundation, "Security Policy & Bug Bounty," accessed April 27, 2024, https://tezos.foundation/security/security-policy-bug-bounty/.

96 Avalanche, "Has the Avalanche® Code Been Audited? Where Are the Audit Reports?," Avalanche Support, accessed April 27, 2024, https://support.avax.network/en/articles/5462273-has-the-avalanche-code-been-audited-where-are-the-audit-reports.

97 Abdulkarim Abdulwahab, "Cardano IOHK Says Marlowe Has Been Audited Both Internally and Externally," The Crypto Basic, May 30, 2023, accessed April 27, 2024, https://thecryptobasic.com/2023/05/30/cardano-iohk-says-marlowe-has-been-audited-both-internally-and-externally/.

98 Jessy Irwin, "Audits, Audits, Everywhere," Interchain Ecosystem Blog - Medium, March 5, 2019, accessed April 27, 2024, https://blog.cosmos.network/audits-audits-everywhere-everything-you-need-to-know-about-application-security-and-the-cosmos-76130f69aa60.

99 Filecoin, "Audit Reports," Filecoin Spec, July 1, 2023, accessed April 27, 2024, https://spec.filecoin.io/appendix/audit_reports/.

100 OpenZeppelin Security, "Optimism Smart Contracts Audit," OpenZeppelin (blog), November 24, 2021, accessed April 27, 2024, https://blog.openzeppelin.com/optimism-smart-contracts-audit.

101 Polkadot, "XCMv2 Audit Completed by Quarkslab," April 8, 2022, accessed April 27, 2024, https://polkadot.network/blog/full-audit-of-xcmv2-completed-by-quarkslab.

102 Anna Baydakova, "Tezos Hires 'Big Four' Firm PwC to Conduct External Audit," CoinDesk, September 13, 2021, accessed April 30, 2024, https://coindesk.com/markets/2018/07/24/tezos-hires-big-four-firm-pwc-to-conduct-external-audit/.

103 "2018 Security Audit Results Overview," Zcash, accessed April 27, 2024, https://z.cash/2018-security-audit-results-overview/

104 The Optimism Collective, "Introducing the Optimism Collective's Security Council," Optimism Mirror, February 13, 2024, accessed April 27, 2024, https://optimism.mirror.xyz/f20gj4Mv3DWdqQEduk5J85VVN254SaQtP0zV_v-8IYs.

105 Polygon Labs, "Polygon 2.0: Governance."

106 Arvind Naranayan, "Analyzing the 2013 Bitcoin fork: centralized decision-making saved the day," Freedom to Tinker, July 28, 2015, https://freedom-to-tinker.com/2015/07/28/analyzing-the-2013-bitcoin-fork-centralized-decision-making-saved-the-day/

107 Vitalik Buterin, "Bitcoin Network Shaken by Blockchain Fork," Bitcoin Magazine, March 13, 2013, https://bitcoinmagazine.com/technical/bitcoin-network-shaken-by-blockchain-fork-1363144448

108 Quinn DuPont, "Experiments in Algorithmic Governance," in Routledge eBooks, 2017, 157–77, https://doi.org/10.4324/9781315211909-8.

109 Lu, "CarbonVote: A Gauge for Human Consensus."

110 "Arvicco, "A Crypto-Decentralist Manifesto," Ethereum Classic Blog, July 11, 2016, accessed April 27, 2024, https://ethereumclassic.org/blog/2016-07-11-crypto-decentralist-manifesto.

111 Polygon Labs, "All You Need to Know About the Recent Network Upgrade," Polygon News, December 29, 2021, https://polygon.technology/blog/all-you-need-to-know-about-the-recent-network-upgrade.

Conclusion

This report, a collaborative effort between BlockchainGov and Project Liberty's Institute, has illuminated the intricate and evolving landscape of governance dynamics of blockchain networks as core components of the Web3 ecosystem. The governance taxonomy built for the purposes of this report has provided a structured lens through which to view the multifaceted nature of blockchain governance, from the foundational layers of blockchain architecture to the detailed mechanisms of governance decision-making. The multidisciplinary and comparative analysis of Avalanche, Bitcoin, Cardano, Cosmos, Ethereum, Filecoin, Optimism, Polygon, Polkadot, Tezos, and Zcash led to the formulation of key insights regarding the creation of legal entities, power distribution dynamics, insights on planned versus actual decentralization, the recent surge in governance formalization, affordances behind different governance mechanisms, and controversies regarding security measures and breaches. The content of these insights, while having merit on their own, is interrelated, shedding light on the complex interactions that shape governance within the blockchain ecosystem.

We hope that the insights and reflections provided in this report will serve as valuable resources for those involved in designing, implementing, and evolving the governance frameworks of blockchain networks. The challenges identified in this report—such as the need for clearer definitions of decentralization, the management of power concentration, and the integration of formal and informal governance practices—point to areas where further research and innovative solutions are needed. By continuing to engage with these challenges, blockchain communities can enhance the resilience and robustness of their governance structures and collectively enact the principles underpinning the Web3 vision.

Bibliography

Abdulwahab, Abdulkarim. "Cardano IOHK Says Marlowe Has Been Audited Both Internally and Externally." The Crypto Basic, May 30, 2023. Accessed April 27, 2024. https://thecryptobasic.com/2023/05/30/cardano-iohk-says-marlowe-has-been-audited-both-internally-and-externally/.

Alchemy. "Polygon ZK Rollups: Everything You Need to Know," May 18, 2022. Accessed April 29, 2024. https://www.alchemy.com/overviews/polygon-zk-rollups.

Alston, Eric. "Constitutions and Blockchains:Competitive Governance of Fundamental Rule Sets." Case Western Reserve University School of Law Scholarly Commons, October 27, 2020. Accessed April 30, 2024. https://scholarlycommons.law.case.edu/jolti/vol11/iss1/6.

Alston, Eric. "Governance as Conflict: Constitution of Shared Values Defining Future Margins of Disagreement." MIT Computational Law Report (2022), https://law.mit.edu/pub/governanceasconflict/release/1.

Arvicco. "A Crypto-Decentralist Manifesto." Ethereum Classic Blog, July 11, 2016. Accessed April 27, 2024. https://ethereumclassic.org/blog/2016-07-11-crypto-decentralist-manifesto.

Atik, Jeffery, and George Gerro. "Hard Forks on the Bitcoin Blockchain: Reversible Exit, Continuing Voice." Stanford Journal of Blockchain Law & Policy, June 23, 2018. Accessed April 30, 2024. https://stanford-jblp.pubpub.org/pub/hard-forks-bitcoin/release/2.

Avalanche. "Has the Avalanche® Code Been Audited? Where Are the Audit Reports?" Avalanche Support. Accessed April 27, 2024. https://support.avax.network/en/articles/5462273-has-the-avalanche-code-been-audited-where-are-the-audit-reports.

Banerjee, Ananda. "What Is the Howey Test and How Does It Impact Crypto?" BeInCrypto, April 3, 2023. https://beincrypto.com/learn/howey-test/.

Barbereau, Tom, Reilly Smethurst, Orestis Papageorgiou, Johannes Sedlmeir, and Gilbert Fridgen. "Decentralised Finance's Timocratic Governance: The Distribution and Exercise of Tokenised Voting Rights." Technology in Society 73 (May 1, 2023): 102251. https://doi.org/10.1016/j.techsoc.2023.102251.

Baydakova, Anna. "Tezos Hires 'Big Four' Firm PwC to Conduct External Audit." CoinDesk, September 13, 2021. Accessed April 30, 2024. https://coindesk.com/markets/2018/07/24/tezos-hires-big-four-firm-pwc-to-conduct-external-audit/.

Behnke, Rob. "How Blockchain DDoS Attacks Work," October 19, 2021. https://www.halborn.com/blog/post/how-blockchain-ddos-attacks-work.

Bitcoin.org. "Issues - Contribute to Bitcoin Core." Accessed April 27, 2024. https://bitcoin.org/en/bitcoin-core/contribute/issues.

Bitcoin Magazine, "Bitcoin Miners Are Signaling Support for the New York Agreement: Here's What that Means." Bitcoin Magazine, June 20, 2017, https://www.nasdaq.com/articles/bitcoin-miners-are-signaling-support-for-the-new-york-agreement:-heres-what-that-means

Bodó, Balázs, and Alexandra Giannopoulou. "The Logics of Technology Decentralization – the Case of Distributed Ledger Technologies." In Routledge eBooks, 114–29, 2019. https://doi.org/10.4324/9780429029530-8.

Braiins, "Bitcoin's Decentralization with Stratum V2." Braiins, June 29, 2020, https://braiins.com/blog/stratum-v2-bitcoin-decentralization

Brekke, Jaya Klara, Kate Beecroft, and Francesca Pick. "The Dissensus Protocol: Governing Differences in Online Peer Communities." Frontiers in Human Dynamics 3 (May 26, 2021). https://doi.org/10.3389/fhumd.2021.641731.

Browning, Elizabeth [Distractive]. "OpenGov: What Is Polkadot Gov2." Moonbeam Network, December 15, 2022. Accessed April 26, 2024. https://moonbeam.network/blog/opengov/.

Buterin, Vitalik. “An Incomplete Guide to Rollups.” Vitalik Buterin’s Website, January 5, 2021. Accessed April 29, 2024. https://vitalik.eth.limo/general/2021/01/05/rollup.html.

Buterin, Vitalik. “Bitcoin Network Shaken by Blockchain Fork.” Bitcoin Magazine, March 13, 2013, https://bitcoinmagazine.com/technical/bitcoin-network-shaken-by-blockchain-fork-1363144448

Buterin, Vitalik. “The Meaning of Decentralization.” Medium, July 24, 2018. Accessed April 30, 2024. https://medium.com/@VitalikButerin/the-meaning-of-decentralization-a0c92b76a274.

Cardano. “Cardano Roadmap.” Cardano Roadmap. Accessed April 25, 2024. https://roadmap.cardano.org/en/.

Cardano’s Monetary Policy, see: Cardaniansio, "Understanding Cardano Monetary Policy," Cexplorer.io, Sep 11, 2023, https://cexplorer.io/article/understanding-cardano-monetary-policy

De, Nikhilesh, and Danny Nelson. “Filecoin Price Drops After SEC Asks Grayscale to Withdraw Application to Make Trust Reporting.” CoinDesk, May 18, 2023. Accessed April 30, 2024. https://www.coindesk.com/policy/2023/05/17/filecoin-price-drops-after-sec-asks-grayscale-to-withdraw-fil-trust-application/.

De, Nikhilesh. “SEC Chair Gensler Declines to Say if Ether Is a Security in Contentious Congressional Hearing.” CoinDesk, April 19, 2023. Accessed April 30, 2024. https://www.coindesk.com/policy/2023/04/19/sec-chair-gensler-declines-to-say-if-ether-is-a-security-in-contentious-congressional-hearing/.

De Filippi, Primavera, and Benjamin Loveluck. “The Invisible Politics of Bitcoin: Governance Crisis of a Decentralised Infrastructure.” Internet Policy Review, 2016. https://hal.science/hal-01382007.

De Filippi, Primavera, Mannan Morshed, Nabben Kelsie, Cossar Sofia, Merk Tara, Kamalova Kamilya. “Report on Blockchain Technology and Polycentricity.” Forthcoming.

De Filippi, Primavera, Morshed Mannan, Jack Henderson, Tara Merk, Sofia Cossar, and Kelsie Nabben. “Report on Blockchain Technology & Legitimacy.” Social Science Research Network, January 1, 2022. https://doi.org/10.2139/ssrn.4300502.

De Filippi, Primavera, Morshed Mannan, Kelsie Nabben, Sofia Cossar, Jamilya Kamalova, Tara Merk, Silke Noa, Marco Crepaldi, and Joshua Dávila. “Blockchain Constitutionalism: The Role of Legitimacy in Polycentric Systems.” EUI Robert Schuman Centre, October 2023. https://blockchaingov.eu/wp-content/uploads/2023/11/EUI-Conference-June-2023-FINAL.pdf

De Filippi, Primavera, Morshed Mannan, Wessel Reijers, Paula Berman, and Jack Henderson. “Blockchain Technology, Trust & Confidence: Reinterpreting Trust in a Trustless System?” Social Science Research Network, January 1, 2022. https://doi.org/10.2139/ssrn.4300486.

De Filippi, Primavera and McMullen Greg, “Governance of blockchain systems: Governance of and by Distributed Infrastructure.” Blockchain Research Institute and COALA, (2018), https://hal.science/hal-02046787/document.

DuPont, Quinn. “Experiments in Algorithmic Governance.” In Routledge eBooks, 157–77, 2017. https://doi.org/10.4324/9781315211909-8.

Esber, Jad and Kominers Scott Duke. “Progressive decentralization: a high-level framework.” a16z Crypto, Jan 12, 2023, https://a16zcrypto.com/posts/article/progressive-decentralization-a-high-level-framework/

ethereum.org. “Introduction to Ethereum Governance.” Accessed April 25, 2024. https://ethereum.org/en/governance/.

Faguet, Jean-Paul. “Decentralization and Governance.” World Development 53 (January 1, 2014): 2–13. https://doi.org/10.1016/j.worlddev.2013.01.002.

Faustino, Sandra, Inês Faria, and Rafael Marques. “The Myths and Legends of King Satoshi and the Knights of Blockchain.” Journal of Cultural Economy 15, no. 1 (May 25, 2021): 67–80. https://doi.org/10.1080/17530350.2021.1921830.

Feichtinger, Rainer, Robin Fritsch, Yann Vonlanthen, and Roger Wattenhofer. "The Hidden Shortcomings of (D)AOs -- an Empirical Study of On-Chain Governance." arXiv.org, February 23, 2023. https://arxiv.org/abs/2302.12125.

Ferdous, Md Sadek, Mohammad Jabed Morshed Chowdhury, Mohammad A. Hoque, and Alan Colman. "Blockchain Consensus Algorithms: A Survey." arXiv.org, January 20, 2020. https://arxiv.org/abs/2001.07091.

Filecoin, "Audit Reports," Filecoin Spec, July 1, 2023, accessed April 27, 2024, https://spec.filecoin.io/appendix/audit_reports/.

Filippo. "Polkadot Technical Fellowship." Polkadot Wiki. Last Modified March 11, 2024. Accessed April 26, 2024. https://wiki.polkadot.network/docs/learn-polkadot-technical-fellowship.

H_Rook. "The First Pillar: Protocol Governance." Polygon Community Forum, May 16, 2023. Accessed April 26, 2024. https://forum.polygon.technology/t/the-first-pillar-protocol-governance/11972.

Han, Rong, Zheng Yan, Xueqin Liang, and Laurence T. Yang. "How Can Incentive Mechanisms and Blockchain Benefit With Each Other? A Survey." ACM Computing Surveys 55, no. 7 (December 15, 2022): 1–38. https://doi.org/10.1145/3539604.

Hinman, William. "SEC.gov | Digital Asset Transactions: When Howey Met Gary (Plastic)." U.S. Securities And Exchange Commission, June 14, 2018. Accessed April 30, 2024. https://www.sec.gov/news/speech/speech-hinman-061418.

Hirschman, Albert O. "Exit, Voice and Loyalty: Responses to Decline in Firms, Organizations, and States." The Journal of Finance 25, no. 5 (December 1, 1970): 1194. https://doi.org/10.2307/2325604.

Irwin, Jessy. "Audits, Audits, Everywhere." Interchain Ecosystem Blog - Medium, March 5, 2019. Accessed April 27, 2024. https://blog.cosmos.network/audits-audits-everywhere-everything-you-need-to-know-about-application-security-and-the-cosmos-76130f69aa60.

Jameson, Hudson. "What Is an Ethereum Core Developer?" Hudson Jameson, June 22, 2020. Accessed April 30, 2024. https://hudsonjameson.com/2020-06-22-what-is-an-ethereum-core-developer/#:~:text=Definition,layer%2C%20such%20as%20client%20code.

Jones, Bernie. "A Comparison of Consensus and Voting in Public Decision Making." Negotiation Journal 10, no. 2 (April 1, 1994): 161–71. https://doi.org/10.1007/bf02184175.

Karakostas, Dimitris, Aggelos Kiayias, and Christina Ovezik. "SoK: A Stratified Approach to Blockchain Decentralization." arXiv (Cornell University), January 1, 2022. https://doi.org/10.48550/arxiv.2211.01291.

Kelly, Liam J. "DeFi Bribes Are on the Rise." Decrypt, January 13, 2022. Accessed April 30, 2024. https://decrypt.co/90276/defi-bribes-are-on-the-rise.

Kim, Christine. "The Ethereum Governance Process." Uploaded by ETHGlobal, September 29, 2023. Accessed April 30, 2024. https://www.youtube.com/watch?v=2T4h-r9wu44.

Kroah-Hartman, Greg, "9 lessons from 25 years of Linux kernel development." Opensource.com, December 14, 2016, https://opensource.com/article/16/12/yearbook-9-lessons-25-years-linux-kernel-development.

lavande. "Transitioning to On-Chain Voting." Optimism Collective Forum, December 2022. Accessed April 26, 2024. https://gov.optimism.io/t/transitioning-to-on-chain-voting/4193.

Leporati, Alberto, "Studying the Compounding Effect: The Role of Proof-of-Stake Parameters on Wealth Distribution." In Proceedings of the Fifth Distributed Ledger Technology Workshop (DLT 2023), ed. Paolo Mori, Ivan Visconti and Stefano Bistarelli, (2023), https://ceur-ws.org/Vol-3460/papers/DLT_2023_paper_2.pdf.

Lopp, Jameson. "Who Controls Bitcoin Core?" Cypherpunk Cogitations, May 5, 2023. https://blog.lopp.net/who-controls-bitcoin-core/.

Lu, Bin. “CarbonVote: A Gauge for Human Consensus,” September 2016. Accessed April 27, 2024. https://archive.devcon.org/archive/watch/2/carbonvote-a-gauge-for-human-consensus/?playlist=Devcon%202&tab=YouTube.

MacDonald v. Dynamic Ledger Sols., Inc., Case No. 17-cv-07095-RS (N.D. Cal., 2017).

Mannan, Morshed, Primavera De Filippi and Wessel Reijers. “Blockchain Constitutionalism.” Oxford Handbook of Digital Constitutionalism, ed. Giovanni de Gregorio, Oreste Pollicino and Peggy Valcke, forthcoming.

Mateusz. “Pre-PIP Discussion: Addressing Reorgs and Gas Spikes.” Polygon Community Forum, December 7, 2022. Accessed April 26, 2024. https://forum.polygon.technology/t/pre-pip-discussion-addressing-reorgs-and-gas-spikes/10623.

Mechanism Institute. “Airdrops.” Mechanism Institute Library. Accessed April 28, 2024. https://www.mechanism.institute/library/airdrop.

Mitchelhill, Tom. “Vitalik Buterin on Fix for Ethereum Centralization: Make Running Nodes Easier.” Cointelegraph, September 5, 2023. https://cointelegraph.com/news/vitalik-buterin-ethereum-centralization-issues-running-nodes-easier.

Nabben, Kelsie. “Cryptoeconomics as Governance: An Intellectual History From ‘Crypto Anarchy’ to ‘Cryptoeconomics.’” Internet Histories 7, no. 3 (March 3, 2023): 254–76. https://doi.org/10.1080/24701475.2023.2183643.

Naranayan, Arvind. “Analyzing the 2013 Bitcoin fork: centralized decision-making saved the day.” Freedom to Tinker, July 28, 2015, https://freedom-to-tinker.com/2015/07/28/analyzing-the-2013-bitcoin-fork-centralized-decision-making-saved-the-day/

Octez and Protocol Documentation. “The Amendment (and Voting) Process.” Accessed April 26, 2024. https://tezos.gitlab.io/active/voting.html.

OneBlock. “OpenGov Is Launched on Polkadot!.” Medium, June 29, 2023. https://medium.com/@OneBlockplus/opengov-is-launched-on-polkadot-c3e663f17867.

OpenZeppelin Security. “Optimism Smart Contracts Audit.” OpenZeppelin (blog), November 24, 2021. Accessed April 27, 2024. https://blog.openzeppelin.com/optimism-smart-contracts-audit.

OP Labs Team. “Optimism’s Path to Technical Decentralization.” OP Labs Blog, January 24, 2024. https://blog.oplabs.co/decentralization-roadmap/.

Polkadot. “Introduction to Polkadot OpenGov.” Polkadot Wiki. Accessed April 25, 2024. https://wiki.polkadot.network/docs/learn-polkadot-opengov.

Polkadot. “XCMv2 Audit Completed by Quarkslab,” April 8, 2022. Accessed April 27, 2024. https://polkadot.network/blog/full-audit-of-xcmv2-completed-by-quarkslab.

Polygon Labs. “All You Need to Know About the Recent Network Upgrade.” Polygon News, December 29, 2021, https://polygon.technology/blog/all-you-need-to-know-about-the-recent-network-upgrade.

Polygon Labs. “Polygon 2.0: Governance,” July 19, 2923. Accessed April 25, 2024. https://polygon.technology/blog/polygon-2-0-governance.

Polygon Labs. “Polygon Bolsters Validator Governance With Snapshot Voting.” Polygon News, March 17, 2022. Accessed April 26, 2024. https://polygon.technology/blog/polygon-bolsters-validator-governance-with-snapshot-voting.

Wandmacher, Ralf. “Tokenomics.” In Cryptofinance and Mechanisms of Exchange, 113–23. Springer, 2019. https://doi.org/10.1007/978-3-030-30738-7_7.

Resnick, Pete. “On Consensus and Humming in the IETF.” Internet Engineering Task Force, June, 2014, https://datatracker.ietf.org/doc/rfc7282/

Sai, Ashish Rajendra, Jim Buckley, Brian Fitzgerald, and Andrew Le Gear. "Taxonomy of Centralization in Public Blockchain Systems: A Systematic Literature Review." Information Processing & Management 58, no. 4 (July 1, 2021): 102584. https://doi.org/10.1016/j.ipm.2021.102584.

Schädler, Lukas, Michael Lustenberger, and Florian Spychiger. "Analyzing Decision-making in Blockchain Governance." Frontiers in Blockchain 6 (August 21, 2023). https://doi.org/10.3389/fbloc.2023.1256651.

Schneider, Aaron. "Decentralization: Conceptualization and Measurement." Studies in Comparative International Development 38, no. 3 (September 1, 2003): 32–56. https://doi.org/10.1007/bf02686198.

Schneider, Nathan. "Admins, Mods, and Benevolent Dictators for Life: The Implicit Feudalism of Online Communities." New Media & Society 24, no. 9 (January 7, 2021): 1965–85. https://doi.org/10.1177/1461444820986553.

Securities and Exchange Commission v. Binance Holdings Limited, BAM Trading Services Inc., BAM Management US Holdings Inc., and Changpeng Zhao, Civil Action Case 1:23-cv-01599 Document 1, (D.D.C., 2023), https://www.sec.gov/files/litigation/complaints/2023/comp-pr2023-101.pdf.

Securities and Exchange Commission v. Ripple Labs, Inc., Case 1:20-cv-10832-AT-SN Document 874, (USDC SDNY, July 2023), https://www.nysd.uscourts.gov/sites/default/files/2023-07/SEC%20vs%20Ripple%207-13-23.pdf

Security Research Team. "Secured #3: Security Teams, Protecting the Ethereum Consensus-layer." Ethereum Foundation Blog, April 14, 2022. Accessed April 26, 2024. https://blog.ethereum.org/2022/04/14/secured-no-3.

Shannon, Victoria. "A 'more Revolutionary' Web." The New York Times, May 23, 2006. Accessed April 30, 2024. https://www.nytimes.com/2006/05/23/technology/23iht-web.html.

Srinivasan, Balaji S. "Quantifying Decentralization." Medium, June 20, 2018. https://news.earn.com/quantifying-decentralization-e39db233c28e.

Tendermint Inc. "Concepts." Cosmos SDK Documentation. Accessed April 26, 2024. https://docs.cosmos.network/v0.45/modules/gov/01_concepts.html#proposal-types.

Tezos Foundation. "Security Policy & Bug Bounty." Accessed April 27, 2024. https://tezos.foundation/security/security-policy-bug-bounty/.

The Optimism Collective. "Can I run a verifier?," OP Mainnet Help Center, June 2023, accessed April 29, 2024, https://help.optimism.io/hc/en-us/articles/4413155125403-Can-I-run-a-verifier.

The Optimism Collective. "Introducing the Optimism Collective." Optimism Mirror, April 27, 2022. Accessed April 25, 2024. https://optimism.mirror.xyz/gQWKlrDqHzdKPsB1iUnI-cVN3v0NvsWnazK7ajlt1fI.

The Optimism Collective. "Introducing the Optimism Collective's Security Council." Optimism Mirror, February 13, 2024. Accessed April 27, 2024. https://optimism.mirror.xyz/f20gj4Mv3DWdqQEduk5J85VVN254SaQtP0zV_v-8IYs.

The Optimism Collective. "Introduction." OP Stack Specification. Accessed April 29, 2024. https://specs.optimism.io/introduction.html#:~:text=The%20sequencer%20is%20the%20primary,oversight%20of%20the%20Optimism%20Foundation.

The Optimism Collective. "The Future of Optimism Governance." Optimism Mirror, July 19, 2023. Accessed April 26, 2024. https://optimism.mirror.xyz/PLrAQgE1EGRo7GRrFoztplFChnUZda4DFGW3dkQayxY.

Treisman, Daniel. "Defining and Measuring Decentralization: A Global Perspective." SSCNet UCLA Social Sciences, (2002), https://www.sscnet.ucla.edu/polisci/faculty/treisman/Papers/defin.pdf

Van Pelt, Rowan, Slinger Jansen, Djuri Baars, and Sietse Overbeek. “Defining Blockchain Governance: A Framework for Analysis and Comparison.” Information Systems Management 38, no. 1 (March 9, 2020): 21–41. https://doi.org/10.1080/10580530.2020.1720046.

Voshmgir, Shermin and Zargham Michael. “Foundations of Cryptoeconomic Systems.” Research Institute for Cryptoeconomics, Vienna, Working Paper Series 1 (2019), https://assets.pubpub.org/sy02t720/31581340240758.pdf.

Web3 Foundation Team. “Decentralized Voices Program.” Medium, February 7, 2024. https://medium.com/web3foundation/decentralized-voices-program-93623c27ae43.

Werbach, Kevin. “The Siren Song: Algorithmic Governance by Blockchain.” Social Science Research Network, September 24, 2018. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3578610.

Wood, Gavin. “ÐApps: What Web 3.0 Looks Like.” Insights Into a Modern World Blog, April 17, 2014. Accessed April 30, 2024. https://gavwood.com/dappsweb3.html.

World Wide Web Foundation. “History of the Web.” Accessed April 30, 2024. https://webfoundation.org/about/vision/history-of-the-web/.

Zargham, Michael, Eric Alston, Kelsie Nabben, and Ilan Ben-Meir. “What Constitutes a Constitution?” Medium, February 27, 2024. Accessed April 30, 2024. https://medium.com/block-science/what-constitutes-a-constitution-2034d3550df4.

Zargham, Michael, and Kelsie Nabben. “Aligning ‘Decentralized Autonomous Organization’ to Precedents in Cybernetics.” Social Science Research Network, January 1, 2022. https://doi.org/10.2139/ssrn.4077358.

Zcash. “2018 Security Audit Results Overview.” Accessed April 27, 2024. https://z.cash/2018-security-audit-results-overview/.

Zcash Foundation. “Zcash Dev Fund Community Sentiment Collection Poll,” November 15, 2019. Accessed April 26, 2024. https://zfnd.org/zcash-dev-fund-community-sentiment-collection-poll/.

ZeusLawyer. “For Decentralized Governance on Ethereum, Why Is Snapshot Considered ‘Off-chain’ but Tally Considered ‘On-chain’?” Stack Exchange, May 2, 2022. Accessed April 30, 2024. https://ethereum.stackexchange.com/q/127331.

Ziolkowski, Rafael, Geetha Parangi, Gianluca Miscione, and Gerhard Schwabe. “Examining Gentle Rivalry: Decision-Making in Blockchain Systems.” 52nd Hawaii International Conference on System Sciences (HICSS 2019), 2019. https://doi.org/10.5167/uzh-160377.

Governance Dynamics Matrix

This is the model matrix that was used to research and analyze every 11 blockchain networks selected in this report

Organizational Profile							
Year	Founder	Tech Stack Layer	Animating Purpose	Funding Model	Legal Personhood	Environment: Law	Environment: Market

Governance Surfaces		
On-Chain Constitution	Off-Chain Material Constitution	Off-Chain Formal Constitution

Governance Areas						
Short description of governance area						
Secondary Rules	Standards and interopera-bility	Block Production	Monetary Policy	Treasury Management	Contributions reward policies	Security Measures and Breaches

Governance Frameworks					
Entry and Exit	Mechanism	Enforcement	Participation Incentives	Internal Dispute Resolution	Amendability

Governance Trends			
Power Distribution	Governance Scope	Governance Complexity	Governance Formalization

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Please quote as: De Filippi, Primavera, Sofia Cossar, Morshed Mannan, Kelsie Nabben, Tara Merk, and Jamilya Kamalova. “Report on Blockchain Governance Dynamics.” A collaborative effort between Project Liberty Institute and BlockchainGov, May 2004.

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