GOVERNANCE OF BLOCKCHAIN-BASED DECENTRALIZED APPLICATIONS: EVIDENCE FROM MULTIPLE CASES

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ABSTRACT

Blockchain enables reimaging organizational interactions and provides novel avenues to enforce agreements and foster cooperation, which set it apart from traditional and other digital governance mechanisms. These peculiarities pave the way for the dawn of non-hierarchical organizations characterized by highly decentralized decision-making processes. At the forefront of this evolution are Decentralized Applications (DApps): trustless systems on peer-to-peer networks without central oversight. Amidst growing interest, the specific business ramifications and governance structures of DApps remain underexplored. Our study delves into how blockchain reshapes governance in DApps and the realization of decentralized governance. Leveraging on a multiple case study, we examined the governance models, the extent of decentralization, and the forward-looking governance projections of 7 DApps. Our findings illuminate the dynamics of power distribution in DApps, revealing decision-makers, the spread of stakeholder power, and the mechanisms for making and implementing pivotal decisions within decentralized frameworks. Theoretical and empirical implications are discussed.

Keywords*: Blockchain, governance mechanisms, DApps, decentralization*

1. INTRODUCTION

The nascent literature on decentralization (Chen et al., 2021) spans disciplines, attracting scholars from political analysts to computer scientists, notably in management (Hoffman et al., 2020). This interest reflects the growing recognition of decentralization as a pivotal organizational principle in an era of increasing complexity and rapid change (Hsieh & Vergne, 2022). Decentralization challenges traditional hierarchies by distributing authority and decision-making across nodes within a system (Chen & Bellavitis, 2020), enabling more agile responses to challenges and opportunities (Lumineau et al., 2021).
While the principles of decentralization are appreciated, specifics like its function in different contexts, benefits, limitations, and best practices are debated (Chen & Bellavitis, 2020; Vergne, 2020). Blockchain technology has energized these discussions, presenting solutions for creating decentralized systems with implications beyond cryptocurrency (Lumineau et al., 2021; Zhan et al., 2022; Kumar et al., 2022; Massaro, 2021). Blockchain facilitates consensus and cooperation without traditional hierarchical boundaries (Hsieh & Vergne, 2022), enabling self-organization and collective decision-making (Aste et al., 2017).

DApps represent a departure from centralized digital services (Angelis & Silva, 2019) and embody a shift toward trustless systems where no single party controls everything (Werbach, 2018). Despite DApps' potential to reshape organizational structures and governance, scholarly investigation into their governance is still nascent, lacking depth in

addressing their unique challenges and opportunities (Leiponen et al., 2022). This gap has significant implications for users, developers, investors, and policymakers.
Our research examines how blockchain influences DApp governance and what practical decentralization looks like within these entities. Recognizing the lack of empirical studies in this complex domain, we adopt a multiple case study methodology. We selected seven representative DApps based on active user metrics, grounding our findings in widely-used solutions.
This exploration aims to enrich academic discourse on blockchain and organizational strategy, providing empirical evidence and theoretical refinement to a growing field. It also offers practical insights for industry professionals and policymakers navigating blockchain-enabled governance structures. As such, our research is driven by an inquiry that is both timely and consequential: *Which are the factors that influence decision-making processes within DApps? How do these factors impact the effective decentralization of DApps' governance?*

2. THEORETICAL BACKGROUND

2.1 EVOLUTION OF DECENTRALIZATION: FROM POLITICS TO BLOCKCHAIN AND DAPPS

The concept of decentralization spans various disciplines, carrying different connotations (Kim, 2008). Initially central to political science due to its implications for governance and power distribution (Mill, 1861; Tocqueville, 1835), it later transitioned into computer science with distributed computing systems (Hoffman et al., 2020). This shift aimed to enhance systems' efficiency and stability (Saltzer et al., 1984) and influenced the internet's architecture. In the 1990s and early 2000s, peer-to-peer (P2P) networks further democratized digital content distribution by eliminating the need for central servers (Schollmeier, 2001).
The advent of blockchain marked a milestone in decentralization, introducing decentralized consensus in a trustless environment (Nakamoto, 2008). Despite its potential, most literature has focused on speculative discussions about blockchain's characteristics or hypothetical solutions (Hsieh & Vergne, 2022). Thus, there is a pressing need for empirical research on blockchain's practical applications beyond its technical aspects.
DApps, or Decentralized Applications, exemplify blockchain governance at the application level. Originating from P2P networks like Tor and BitTorrent (Voshmgir, 2019), DApps run on blockchain platforms, featuring a user interface (front-end) and operational processes (back-end). The DApps space is rapidly expanding across sectors like finance, gaming, and social media, showcasing blockchain's benefits of immutability, security, and transparency (Blockchain & Web3 Observatory, 2023).
However, this growth also presents governance challenges. Effective governance structures that balance decentralization with efficiency and stakeholder alignment are essential (Bellavitis et al., 2023). Issues include voter apathy, power concentration among few token holders (De Filippi & Loveluck, 2016), and the rigidity of smart contract-based governance, which complicates protocol amendments in response to evolving needs or unforeseen circumstances (Atzori, 2015).

2.2 GOVERNANCE OF BLOCKCHAIN AND DAPPS

In blockchain governance, academic discourse reflects both convergent and divergent views, highlighting the field's complexity. There is a consensus on the multifaceted nature of blockchain governance, but interpretations and approaches vary significantly.

A critical theme in studies by De Filippi and Loveluck (2016), De Filippi and McMullen (2018), and Petersen (2022) is the tension between algorithmic governance and human intervention. These works recognize that blockchain's promise of decentralized autonomy through algorithmic governance is compelling but constrained by its rigidity and inability to adapt to unforeseen scenarios. This limitation reflects a deeper challenge in balancing coded rules' inflexibility with human contexts' fluidity.

The literature also presents varied perspectives on centralization in blockchain systems. Halaburda and Mueller-Bloch (2019) advocate for some centralization in early blockchain development, asserting that centralized control can stabilize nascent networks. Their view resonates with permissioned blockchains, where decentralization is controlled through off-blockchain agreements. In contrast, Ziolkowski et al. (2020) and Trump et al. (2018) suggest a differentiated approach to understand decentralization in various blockchain applications. Contributions by Goldsby and Hanisch (2022) and Lumineau et al. (2021) provide frameworks for diverse governance mechanisms but reveal a gap in DApp-specific governance needs.

Most studies focus on blockchain infrastructure, often overlooking governance challenges at the application level. This oversight signals the need for more research on governance within individual DApps. The literature frequently falls short in addressing all dimensions of blockchain governance, underscoring the necessity for a comprehensive framework that includes administrative, infrastructural, and application-level governance in DApps. Without this, the dialogue on blockchain governance remains incomplete, potentially hindering the development of effective governance models reflective of the decentralized ethos and practical application-level needs.

3. METHODOLOGY

3.1 RESEARCH DESIGN

The central objective of this paper is to understand the DApps governance mechanisms and to investigate the extent to which these mechanisms embody the principles of decentralization. To this end, the multiple case study method emerges as a coherent research design.

As articulated by Yin (2018), the multiple case study approach is particularly effective when addressing 'how' and 'why' questions, as it allows for an in-depth exploration within the real-life context that these phenomena manifest. The selection of a multiple case study method is further fortified by the phenomenon-driven imperatives of the research. As noted by Eisenhardt and Graebner (2007), when the phenomenon under scrutiny is emergent rather than established, the insights often lie in the thick description and contextual exploration that only a case-based approach can afford. This methodological choice aligns with the exploratory nature of our research. It allows a holistic and multifaceted examination of DApps governance, accommodating the complexity and dynamism that characterize this field. By disentangling various instances of governance structures across different DApps, this study endeavors to uncover patterns, derive insights, and build a nuanced understanding that quantitative methods may not reveal.

3.2 SAMPLING AND SETTING

To establish the criteria for case selection and identify the target population of DApps for analysis, we utilized DappRadar, a comprehensive DApp database.

We then applied a theoretical sampling approach, guided by Eisenhardt (1989), to select cases. Our primary filter targeted DApps with decentralized governance structures, as

indicated by secondary sources. We also concentrated on projects beyond the initial development phase to ensure robust evidence. After filtration, we contacted the management teams or founders to assess their willingness to participate in interviews, identifying seven distinct cases.
This research centers on DApps offering financial services within Decentralized Finance (DeFi). The rationale is twofold: first, DeFi represents a mature and rapidly advancing application of DApps, providing a robust context for examining governance structures (Schär, 2020; WEF, 2021). Second, DeFi's inherent complexities, such as regulatory compliance, security, and user protection, present unique governance challenges (Auer & Claessens, 2018).

3.3 DATA COLLECTION

To mitigate potential biases and enhance the robustness of our insights, we employed a multifaceted evidence-gathering strategy (Eisenhardt, 1989; Eisenhardt & Graebner, 2007). Our data sources were twofold: primary and secondary. Primary data were gleaned from semi-structured interviews, while secondary data comprised reports, whitepapers, posts on social networks, online news articles, and DApp-related websites.
The primary data corpus was built from 7 semi-structured interviews to members of core teams developing each Dapp. These interviews corresponded to distinct Dapps and were executed over the period from May to September 2022. Each interview started with a brief overview provided by the informants, describing both the DApp in question and their specific role within its ecosystem. Subsequently, we delved into the structured questions designed to dissect the nuances of DApp governance. The research adopted an iterative data collection methodology. This dynamic approach was pivotal in uncovering emerging patterns, as insights from earlier interviews could inform and refine subsequent data collection (Gioia et al., 2013). Consequently, we adapted the interview protocol responsively to follow the trail of knowledge as outlined by our informants.

3.4 DATA ANALYSIS

To align with the established protocols for multiple case study theory development, we engaged in both within-case and cross-case analyses, as advised by Eisenhardt (1989) and Eisenhardt & Graebner (2007). Initially, the primary data were meticulously examined by two authors of the team, who also incorporated secondary data to triangulate findings, a method recommended by Jick (1979).
Following this, we applied an inductive approach to our analysis (Saldana, 2009). This entailed a rigorous coding of the interview transcripts, during which we surfaced preliminary concepts. With these initial insights, we advanced to a cross-case examination. By applying a replication logic, we sought to detect patterns across different cases. This step facilitated the aggregation of individual codes into higher-level, second-order themes.
Once we engaged in cross-case analysis, our process became iterative: we oscillated between examining case details, refining our understanding of emerging concepts and dimensions, and consulting relevant academic literature to hone the definitions of our constructs, determine appropriate levels of abstraction, specify construct measurements, and elucidate theoretical linkages (Gilbert, 2005).
This disciplined focus allowed us to distil a robust set of constructs that held up under rigorous analysis.

4. FINDINGS

4.1 COMMUNICATION CHANNELS AND CONSENSUS BUILDING

As stated in the literature, blockchain involve political and social dimensions that cannot be adequately addressed by relying solely on technological tools and algorithmic governance. Such approaches lack the flexibility needed to face unforeseen circumstances and often neglect the human factor and broader involvement. The improvement and development of DApps, along with the underlying code base, require consensus-seeking and human intervention to adapt to evolving needs and market dynamics.
To implement decisions in DApps, specific proposals must be developed. Governance processes typically begin off the blockchain on various communication channels, allowing community members and development teams to interact freely. These discussions serve various purposes, including exchanging ideas, seeking consensus on DApp improvements, gauging community sentiment, and approving or rejecting formal processes. Once discussion topics are refined, some DApps move motions to off-chain voting platforms, where token holders can cast their votes for or against proposed changes. Since the voting happens off-chain, the outcome primarily serves as a signaling system, as there is no code execution involved:

"For the governance, what the community can do is post something in the forum, and then it can eventually be turned into a proposal. It needs a three-day discussion period, then it goes to Snapshot for voting. But first it's a non-binding discussion on the forum, because we need, and we want to promote the debate first." (Yearn)

Decisions regarding the operational structures and development of the DApp must align with the interests of various stakeholders. However, these decisions, although they can often come from anyone's proposals, often involve specific knowledge and proprietary information held by development teams. This knowledge gap can create a disparity between the development teams and the broader community. Many decisions necessitate specialized technical or economic expertise that may not be possessed by the average token holder:

"Token holders can raise proposals, however, the technology itself, which is the core of 1Inch, is too complicated for essentially anyone from the community to understand. So, the core things that are driving 1Inch forward, hopefully to success, are happening within the foundation only, because all the engineers are contributors to the 1Inch foundation." (1Inch)

With a few exceptions, the information asymmetry often leads the community to primarily focus on elementary aspects or those related to a few specific areas, such as token allocations and protocol fees, in its discussions. What frequently occurs is that the community suggests ideas without first organizing them into a problem or identifying viable, data-driven solutions. These factors, in turn, tend excluding community members from the process of formulating complex decisions:

"We also need to understand what the main thing that bothers the community is or that actually they care about. Essentially what 99% of the community care about is the price of the token. So, when they care about 1Inch token price, they don't really care about the technology because it's already good for them, since they are already using it. I would say that 90% of the proposals from the community are heavily 1inch token oriented." (1Inch)

Despite being scattered, unstructured, and non-binding, ideas arising from various stakeholders are often taken into consideration by the core teams. However, in most cases, they just serve as inputs for their decisions. Development units typically engage in

separate conversations from the rest of the community to identify necessary changes and determine how addressing the issues experienced:

"If the proposal comes from the community, it usually happens on Discord. But if the new proposal comes from the contributors that are part of the yTeams it's going to happen in Telegram. The yTeams have groups where they talk about stuff, and they decide." (Yearn)

Consequently, what is observed is that token holders are primarily presented with yes-
Given the current governance structures, token holders and DApps participants tend having a decision-making power that they are unable to fully exercise. Instead, they often rubber stamp centrally made decisions or exercise veto power when granted by the governance system in place.
To fully involve the community and the token holders in the governance of DApps, proper processes need to be implemented to encourage constructive and transparent discussions. This enables stakeholders to coordinate and identify necessary or desired changes. The governance debate should transition into a consensus-seeking exercise aimed at achieving an optimal compromise. Communication channels should compel participants to focus on the underlying reasoning, causes, theories, and data rather than engaging in polarizing contests over specific token integrations, creation of new pools, setting of fees, or other parameters that may divert attention from the big picture and important issues.
Proposition 1: *The governance system of a DApp should have well-functioning structures through which stakeholders are provided with the proper data and knowledge supporting decision making.*

4.2 LEADERSHIP CENTRALIZATION AND STAKEHOLDER DISPARITY

Off-chain decisions are usually overseen by a central entity, often the company or core team behind the application. This is because off-chain decisions, unlike those executed through smart contracts on the blockchain, involve interactions with the non-crypto world. Matters requiring engagement beyond the crypto sphere cannot be solely governed by code. Compliance with national and supranational regulations, such as registering intellectual property rights and brand ownership, may necessitate the involvement of a legal entity or another business organization in these decision-making processes.
Even in DApps that lack a legal entity representing them, it is typically the core team that handles relationships with external organizations, both outside the blockchain and with other blockchain protocols, unless the partnership explicitly involves the governance token. However, although off-chain governance is not a formal process and does not directly impact the DApp, it remains foundational to the decision-making process:

"Today the Maker Foundation is currently no longer in control of the treasury of the project and other things like that. But it still owns some intangible assets like IP and such, and some trademarks" (MakerDAO)

The governance mechanisms employed by DApps to distribute decision-making powers often rely on voting systems to determine the acceptance or rejection of a given policy or change. Voting power is contingent on the amount of governance tokens an individual holds or locks into a contract for a specified period. Consequently, wealthier token holders can wield more influence on decisions, and the community, usually entitled to a significant share of the tokens, would ostensibly play a substantial role, especially in the voting process. However, the execution of decisions and the implementation of desired changes into executable "spells" are primarily carried out by the core team. Despite the potential for anyone to develop a contract, token holders often lack the capacity to develop features themselves and lack the authority to compel the development team to do so:

"We want to open the smart contract side and invite all kinds of external builders, but currently after they build the contract, our team members still need to help them to merge the codes into the code base and then to allow users to use it on the Interface." (Furucombo)

Indeed, even if a proposal were to be ratified through a DApp vote, without executable code or smart contracts ready to be deployed and enforced, it would not bring immediate change and would merely serve as a signaling system. The same logic applies to off-chain voting as well. This is why, in on-chain governance, proposals are typically voted on only after the code has been written and, in some cases, audited, ensuring that they automatically translate into effective protocol advancements. The development teams also function as the workforce of the applications, managing operational responsibilities, administering groups, developing the code, setting the roadmap, and usually managing the budgets to achieve defined goals:

"We usually work with auditors as a centralized entity. When we develop code, we work with auditors to check the code we contribute. […] the company can deploy something and it's up to the DAO to accept the smart contract, whether it goes into the DAO ecosystem or not" (Curve)

The implementation of decisions and executive power are often concentrated in the hands of the core teams, which are also in charge of overseeing operational tasks. De facto, the community has the ability to influence outcomes and have an impact on policy-making, but the involvement of the token holders in governance systems does not necessarily imply that they are able to execute decisions or participate in maintaining the code base, defining and performing operating tasks and routines, as well as core business activities. We also finds that in DApps with a higher degree of decentralization, token holders delegate authority and responsibilities to core teams to run the operations and take autonomous action on behalf of the community, whereas in less decentralized DApps, the team retains direct control of the execution and does not necessarily need to confront token holders with their work. Thus, we conclude that:

Proposition 2: *Core teams responsible of DApp development are inherently more influential than other stakeholders, even in highly decentralized DApps.*

4.3 INCENTIVES

In DApps, it is particularly important to introduce incentives for the core teams so that they benefit from the improvement and growth of the DApp, given that they are the primary contributors to its development and hold a higher influence in governance. The cases demonstrate that incentives for the core team are well-structured. They primarily consist of monetary rewards of two types: salaries paid by the DApp treasuries, which collect fees charged to users, or directly receiving a portion of the app revenues, and tokenomics. To distribute decision-making power, the DApp founders mint governance tokens and then distribute them through various mechanisms and initiatives. A share of native tokens is usually kept by the core team, and eventually, a portion can be sold to external investors to raise capital:

"Developers received an initial token allocation and have reserved a percentage of the future token emissions. It is not all distributed initially so that they do not lose the incentive to work on the project; the incentives are made to ensure the core team keeps developing" (SpookySwap)

Members of core teams frequently hold a considerable portion of the governance tokens, thus wielding significant voting power. To reduce risks of conflict of interest, the incentive systems are designed to ensure that teams are engaged in developing and growing the DApp in a way that aligns with the interests of the entire ecosystem.

The absence of incentives directed toward governance activities could be one of the reasons explaining the general lack of community participation and engagement in governance discussions and decision-making procedures:

"Recently what we've seen is that you actually have to make a lot of effort for the users to actively participate in DAO and this is super understandable because token holders have also other things to care about and might not understand clearly why should they bother and spend time and do some voting" (1inch)

Certain DApps, like Curve, incentivize users who lock their tokens to gain voting power and enforce penalties for early unlocking. This approach tends fostering a more engaged community, even though the incentive is not directly linked to participation itself. Once users have locked their tokens and have limited alternatives, they may be more inclined to actively engage in the governance system. On the other hand, MakerDAO does not provide incentives for passive token holders; instead, it compensates contributors actively involved in governance, promoting a dynamic exchange of ideas and discussions:

"The 50% of trading fees going to the DAO gets distributed to those who have voting power. So it's not sitting in treasury for voting for different purposes. It's just going to those who have voting power. (Curve)

The community often lacks incentives to participate in governance beyond the opportunity to engage in the decision-making process. In cases where incentives are provided, token holders may be required to lock their assets for specified periods to access rewards and voting power. The absence of strong incentives can result in a concentration of influence among a few powerful token holders, as those with limited voting power may find the opportunity costs of engaging in governance too high. Delegation, especially when combined with disincentives for non-participation, could enhance community voice and influence. Time-locking tokens with penalties for early withdrawal serves a similar purpose, encouraging decision-makers to vote in the best interest of the ecosystem for long-term value appreciation. Overall, we can conclude that:

Proposition 3: *Distribution of decision-making powers needs to come with properly set, balanced and aligned incentives to ensure each participant to the DApp has an interest in its success.*

5. DISCUSSION

5.1 THEORETICAL CONTRIBUTIONS

The findings reveal the multi-layered nature of governance in DApps, challenging conventional paradigms and highlighting the complex interplay between decentralized ideals and pragmatic necessities. This section illuminates the theoretical and practical implications, connecting foundational concepts and extending understanding. Our exploration shows the complexities in implementing blockchain-based decentralized governance and offers insights into decentralization principles in practice and the role of various actors. By synthesizing our findings with existing literature, we elucidate the nuanced dynamics in blockchain governance.

Our study introduces a nuanced perspective on blockchain decentralization, viewing it as a continuum rather than a binary state. This shift challenges traditional perceptions and suggests that decentralization in blockchain involves various degrees of centralized control mixed with decentralized decision-making. This continuum perspective is crucial for understanding blockchain's transformative potential and aligns with the observations

of several scholars who note diverse applications and impacts of blockchain across industries.
Recognizing decentralization as a continuum contributes to a sophisticated understanding of blockchain governance, implying that blockchain's impact varies by use case and decentralization degree. This insight is crucial for designing and implementing blockchain solutions, highlighting the importance of context-specific approaches.
Our findings also reveal that algorithmic governance in DApps requires a nuanced approach, blending algorithmic systems with human oversight. This hybrid governance model deviates from the libertarian ethos associated with blockchain technology, suggesting that purely autonomous governance is impractical.
This approach provides a realistic perspective on blockchain's capabilities and limitations, advocating a balanced governance model. Our research underscores the significant role of off-chain decision-making by core teams, highlighting the need for human judgment and discretion in addressing nuanced challenges within DApps.

5.2 IMPLICATIONS FOR PRACTICE

Our research into the governance of Decentralized Applications (DApps) offers critical insights for blockchain technology practitioners. These findings illuminate the complex dynamics within DApps, highlighting the interplay between decentralized mechanisms and the pragmatic necessities of human oversight and centralized coordination, especially in the early stages of DApp development.
A key takeaway is the importance of hybrid governance models in DApps. Such models combine algorithmic governance's efficiency and impartiality with human judgment's flexibility and nuanced understanding. This approach is essential for handling complex scenarios and unforeseen challenges that pure technological protocols might not adequately address. For practitioners, this means creating and participating in governance structures that transcend tech-driven systems' limitations. The demarcation between on-chain and off-chain decision-making processes is another critical aspect.
Our findings suggest that DApp ecosystems need to clearly outline which decisions can be implemented autonomously on-chain and which require off-chain deliberation and human input. This clarity is vital for managing stakeholder expectations and ensuring complex decisions receive the necessary attention. In stakeholder engagement, our study underscores the need for robust communication platforms. Developing interactive forums and discussion boards is crucial for facilitating meaningful participation in governance debates. Overall, DApp governance requires a nuanced blend of decentralized ideals and practical necessities. Practitioners must create governance models that are technologically innovative, inclusive, responsive, and sustainable, contributing to the effective governance and long-term success of DApps in the blockchain ecosystem.

6. LIMITATIONS AND FUTURE RESEARCH

This study provides substantial insights into DApp governance but has limitations that open avenues for future research. A primary limitation is the focus on DeFi DApps, which may not fully capture governance dynamics in other blockchain domains. The evolving nature of blockchain technology and diverse applications suggest that DeFi findings might not be universally applicable. Future studies should explore governance mechanisms in a broader range of DApps, including non-financial applications, to provide a comprehensive understanding of decentralized governance.
Additionally, the reliance on a case study approach, while providing depth, may limit the generalizability of the findings. Future research could employ quantitative methods to

validate and extend the qualitative insights gained from this study. Large-scale surveys or experimental designs could offer statistical evidence to support or refine the conclusions drawn from these case studies.

Lastly, the current research predominantly focuses on internal governance mechanisms within DApps. An exploration of how these decentralized applications interact with external regulatory frameworks and traditional governance structures would provide critical insights into the integration and co-evolution of decentralized and centralized governance models.

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