Exploring off-chain voting and blockchain in decentralized autonomous organizations

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Abstract

Purpose – The current scenario shows increased adoption of off-chain voting applications in decentralized autonomous organizations (DAOs) to avoid complexity and costs for user engagement in their governance. This paper aims to comprehend the trends and patterns within the DAO community with off-chain voting systems and blockchain usage.

Design/methodology/approach – This exploratory study uses a two-pronged quantitative approach, combining descriptive statistical analysis and fuzzy-set qualitative comparative analysis. Input data from different DAO proposals and votes were analyzed.

Findings – Results indicate that the 179 DAOs analyzed account for 26,538 proposals and 1,268,474 followers of the entire Snapshot base in January 2023, showing high concentration in engagement. The preferred social media communication channels are Twitter and GitHub, showing a decrease of Ethereum as a main chain, with Polygon and Binance Smart Chain already accounting for 22%. Basic voting can lead to greater user involvement in the voting process.

Research limitations/implications – This study complements the traditional governance theory perspective and advances in the emerging literature on DAOs and blockchain with an empirical analysis.

Practical implications – As blockchain technology gains increasing adoption, comprehending trends and patterns within the DAO community becomes pivotal in identifying opportunities and challenges for innovation and improvement.

Social implications – Findings can facilitate the development of improved governance models and decision-making processes for DAOs, leading to a more robust and sustainable ecosystem.

Originality/value – This study presents a broader IT-based governance foresight via blockchain while providing an understanding of the voting process, technology features and governance mechanisms for social community engagement and decision-making in DAOs.

Keywords Decentralized autonomous organizations, Blockchain, Voting, Off-chain,
Decision-making, Governance

Paper type Research paper

1. Introduction

The rise and dissemination of blockchain technology allowed new paradigms regarding how organizations create new value channels and explore its benefits in security, trust, and transparency in different manners and levels of depth (Lafioune & St-Jacques, 2020; Ramos & Queiroz, 2022; Saurabh, Rani, & Upadhyay, 2023). Meanwhile, organizations in the form of an online social network within a set of rules are being built from scratch with these aspects as core values to pursue a shared common purpose called decentralized autonomous organizations (DAOs). A DAO is a collective governance where communities organize themselves, relying on decentralized infrastructure. These organizations are changing how businesses are conducted and how people work (Glaveski, 2022; Saurabh et al., 2023). The DAOs are estimated to exceed the economic value managed in US$5tn by 2025 (Geschickter, 2022). By January 2023, the data analytics tool DeepDAO shows a total treasury of US$13bn managed over 2,325 DAOs (DeepDAO, 2023).

A DAO is a new form of organization design that comes up with governance rules written in the blockchain. In the blockchain economy, a DAO sets a reexamination in Information Technology (IT) governance through incentives, accountability and decision rights (Beck, Müller-Bloch, & King, 2018). Furthermore, a new perspective of governance via IT establishes Peer-to-Peer (P2P) alignment and autonomy in this algorithmic organization (Mini, Ellinger, Gregory, & Widjaja, 2021). For these organizations, transparency and decentralization that remove the necessity of intermediary parties in transactions enable trust-free systems (Hawlitschek, Notheisen, & Teubner, 2018), meaning that transactions are public to be verified and audited, and the same happens to the decision-making power among the community through a consensus mechanism.

The decentralized governance of the DAOs shows significant differences compared to centralized platforms, such as ownership from shareholders to community members, management from corporate to community leadership and control from top-down to bilateral, respectively (Gol, Avital, & Stein, 2019). This decentralized nature also means no central authority to resolve disputes, making reaching a consensus among members difficult. However, the inexistence of transparent and effective governance in decision-making can lead to organizational inefficiencies and failures.

Members' engagement in the voting system is vital for the DAO's functioning. In the past years, a high transaction cost threatened the decision of the DAOs to establish the on-chain voting system only since it would require everyone on each vote to pay a costly fee due to the blockchain's network congestion (Wang *et al.*, 2019). The difference between on-chain and off-chain refers to transactions inside or outside the blockchain network. Off-chain solutions have gained new relevance in reducing transaction costs and slowness compared to on-chain solutions. It is relevant to note that new approaches to extend the blockchain benefits into off-chain applications are an area of interest in building more secure environments (Liu et al., 2022). To address this issue, voting processes in DAOs nowadays usually start in the off-chain model. After completing the votes and consensus of the proposal, all the related details are registered in the on-chain, and the transaction cost is paid only once. Voting steps, transaction cost, and process speed are a few parts of the autonomous principle of a DAO, and it is essential to research the performance of these off-chain mechanisms for community decision-making in this context (Goldberg & Schär, 2023; Hanisch, Goldsby, Fabian, & Oemichen, 2023; Park, Ureta, & Kim, 2023; Santana & Albareda, 2022).

As the field of DAOs is still in its infancy, many explorations have yielded compelling insights across a variety of domains, including health care (Mateus & Sarkar, 2023) and finance (Bellavitis, Fisch, & Momtaz, 2023; Mini et al., 2021), shedding light on the diverse forms and structures of DAOs (Hsieh, Vergne, Anderson, Lakhani, & Reitzig, 2018;

Wang et al., 2019). Despite this, there remains a significant gap in the scholarly discourse regarding a coherent conceptual framework and shared understanding of DAOs (Hassan & De Filippi, 2021; Santana & Albareda, 2022), particularly concerning the fundamental concepts of autonomy and decentralization (Hassan & De Filippi, 2021; Santana & Albareda, 2022). In this relatively underexplored area, several research avenues remain to be explored.

First, there is a dearth of studies examining the experience and engagement of users within DAOs. A thorough examination of the impact of off-chain mechanisms on member engagement and experience during voting is needed. Factors such as user-friendliness of interfaces and accessibility of off-chain voting models are crucial to determine such systems' feasibility and adoption rates (Goldberg & Schär, 2023; Hanisch et al., 2023). In addition, a greater understanding of the long-term sustainability of off-chain solutions for community decision-making within DAOs is necessary (Goldberg & Schär, 2023; Hanisch et al., 2023). It entails an exploration of the viability and resilience of off-chain mechanisms over extended periods, considering factors such as scalability, security and adaptability to evolving governance needs.

Thus, this article aims to contribute to comprehending the trends and patterns within the DAO community with off-chain voting systems and the blockchain. More specifically, we explored the off-chain voting system of 179 DAOs powered by the Snapshot application that uses the InterPlanetary File System (IPFS), providing an overview of the properties of the voting system and understanding how a group of individuals chooses the outcome from a given set of options, and how it represents an engagement with the proposals. The article contributes to the academic literature on DAO governance, providing a more comprehensive understanding of the role of digital presence in DAOs with off-chain voting systems and helping identify best practices for enhancing proposal generation and overall success.

2. Literature review

2.1 Governance mechanism: traditional × DAO

Due to its wide range of practices, actors and mechanisms, defining governance is complex. It involves not only government or formal institutions but also non-state actors, networks, and processes (Balc, Ilies, Cioban, & Cuza, 2013). Therefore, having a flexible and broad understanding of governance is essential.

To understand this new form of organization at the governance level, comparing traditional corporate governance and DAO governance mechanisms is initially more accessible. As organizational governance mechanisms intend to promote efficient decision-making, accountability and control (Zattoni, Dedoulis, Leventis, & Van Ees, 2020) based on several dimensions, we compare the nuances between these contexts, considering that DAOs are evolving models. As Table 1 illustrates, we compare the traditional and new forms of governance by highlighting the differences in mechanisms like transparency, accountability, board of directors, risk management, ethics and corporate governance.

Organizations must adapt their strategies and structures to today's rapidly changing competitive business landscape. It refers to the duality from the stability of the traditional to the fluidity of DAO governance mechanisms, moving away from rigid hierarchies toward more flexible networks, using improvised processes rather than relying solely on specialized knowledge, and prioritizing lateral communication across the entire organization rather than vertical lines of command (Schreyögg & Sydow, 2010).

Considering another point of view, highly regulated markets may tend more toward stability while fostering innovation regulations since it may affect firms in terms of

Table 1. Governance mechanism: traditional × DAO

Mechanism	Traditional	DAO
Transparency	Achieved through financial reporting and disclosure requirements (Bebchuk, Cohen, & Hirst, 2017)	Transparency is inherent due to the use of blockchain technology, which ensures transparent and immutable record-keeping (Böhme, Christin, Edelman, & Moore, 2015)
Accountability	Enforced through regulatory bodies, legal frameworks, and shareholder rights (Siew Yee, Sharoja Sapiei, & Abdullah, 2018)	Enforced through smart contracts (Chohan, 2017)
Board of directors	Composed of independent directors who oversee the organization (Hermalin & Weisbach, 2007)	Decision-making is decentralized, and shareholders participate directly through voting mechanisms or consensus protocols (Larimer, 2013)
Risk management	Internal/external auditor independence and definition of limits of authority for management (Mohd Noor, Rasli, Abdul Rashid, Mubarak, & Abas, 2022)	Relies on mechanisms such as auditing and community oversight to mitigate risks (Zetzsche, Buckley, Arner, & Föhr, 2019)
Ethics and corporate	Emphasizes behavior and corporate culture through codes of conduct and ethics policies (Crombie, 2008)	Participants are independent in their cooperation intentions (Virovets & Obushnyi, 2020)

Source: Authors' own work

performance for some segments, such as the financial with the P2P lending platforms (Yang, 2022).

2.2 An overview of decentralized autonomous organizations
In a DAO, blockchain technology is embedded in the organizational architecture in a symbiotic manner (Ying-Ying & Wadhwa, 2021). This distributed ledger enables features like a shared transaction database, consensus-based updates, unique cryptographic signatures and tamper-proof auditability. As a result, an institutional structure might shift to a computationally controlled form. The blockchain is a transparent and tamper-resistant digital record-keeping system with a decentralized architecture, eliminating the need for intermediaries.

By validating direct P2P digital asset transactions without intermediaries, a new type of transaction can be developed, consisting of a distributed ledger that processes transactions chronologically over a network of computers to create an immutable chain, always following consensual protocols, unlike traditional transactions (Murray, Kuban, Josefy, & Anderson, 2021). While smart contracts are codes in the blockchain, they require determining all potential outcomes before any action, which challenges the traditional economic notion of the contract's incompleteness. Consequently, human decision-making and off-chain technologies are used to handle the unknown and establish most governance mechanisms, including platform control, work control and work coordination (Gol et al., 2019).

While it may be helpful to standardize the governance of DAOs' processes, it may also limit innovation. Therefore, organizations using DAOs' mechanisms might frequently need new governance structures.

Additionally, human collaboration is required to identify opportunities, define automated rules, recruit human resources and do many other tasks in a DAO (Virovets & Obushnyi, 2020). Using different voting methods to coordinate these activities is a good way for DAOs to be flexible enough to attend to their communities, and access to data and information significantly impacts the quality of decision-making.

2.3 Unleashing decentralized autonomous organization governance: decentralized decision-making

Members of a DAO can participate in the governance process without incurring the costs and complexities associated with on-chain transactions by using the off-chain voting system. Understanding the factors influencing voting behavior and off-chain voting systems becomes increasingly important as DAOs gain prominence (Wu, Yang, Xia, & Rong, 2021).

Keeping good communication and collaboration efficiency is a hot topic in DAOs. A smaller voting group or delegating votes across stakeholders could improve several decision-making steps that sometimes require specialist knowledge or a quick decision. In the initial steps, hybrid voting occurs while adopting off-chain voting for more flexibility and efficiency. Afterward, the registered results are sent to the main chain. These mechanisms allow DAOs and stakeholders to create more resilient communities (Böhme, Christin, Edelman, & Moore, 2022) because of the increased decision traceability.

Voting mechanisms are very use-case-dependent, and there is no predefined one-size-fits-all solution. To experiment with different voting mechanisms, flexible and modular governance systems are essential (Wang et al., 2019). Off-chain and on-chain votes can be aggregated using platforms like Snapshot, enabling seamless integration of various voting methods (Table 2).

Snapshot is a platform that leverages the IPFS to manage and distribute data associated with DAOs and their proposals. IPFS is a cutting-edge, distributed, decentralized file storage system that enables users to share and store files across a peer-to-peer network, eliminating the need for a centralized server.

2.4 Off-chain voting system and transparency: snapshot and InterPlanetary File System integration

IPFS acts as a globally distributed file system, assigning each file a unique hash. Using this hash, users can access the file from any IPFS node possessing it (Hale, 2020). IPFS provides decentralized access to DAO-related data without relying on a single point of failure.

Snapshot uses IPFS to promote transparency and collaboration among DAO members (Schröder, Brangewitz, & Platenius, 2020). All DAO members can access proposal documents, voting records, and other information using IPFS.

Spaces in Snapshot are distinct communities or groups involved in the DAO's decision-making process, organized around specific topics. Proposals range from small changes to significant decisions submitted by DAO members. Before going to a vote, they need community support. Snapshot's off-chain voting system records votes outside the blockchain and then submits results to the blockchain. On-chain voting costs and delays are minimized (Zamyatin et al., 2019).

Snapshot stores proposal data, including title, description, voting period and options, on IPFS. Hashing on the main chain is a unique identifier and reference to IPFS-stored proposal data, ensuring tamper-proof records.

Off-chain systems typically record votes via a website or integrated plugins. Results are tallied in a centralized database after members cast their votes. Results are submitted to the blockchain and recorded on the DAO's ledger after the voting period ends. Members of a

Table 2. Proposal voting type

Voting type	Description
Single choice	Each voter may select only one choice
Approval	Each voter may select any number of choices
Quadratic	Each voter may spread voting power across any number of choices. Results are calculated quadratically
Ranked choice	Each voter may select and rank any number of choices. Results are calculated by the instant-runoff counting method
Weighted	Each voter may spread voting power across any number of choices
Basic	Single choice voting with three choices: for, against or abstain
Custom	Logic based on the custom algorithm code

Source: Authors' own work

DAO can participate in decision-making efficiently and cost-effectively through off-chain voting (Azzi, Chamoun, & Sokhn, 2020). Governance participation is equal regardless of location or technical expertise (Grilo & Rosado, 2019).

3. Methodology approach

This exploratory study uses a two-pronged quantitative approach, combining descriptive statistical analysis and qualitative comparative fuzzy ensemble analysis (fsQCA) to investigate the dynamics of off-chain voting in the DAOs using Snapshot data (Snapshot, 2023). By leveraging recent advancements in quantitative and set-theoretical methods, this research aims to provide a comprehensive understanding of the voting process, capturing general trends and specific configurations that drive decision-making in decentralized organizations.

The Snapshot database was the data source, accessed via the Graph API. Raw data from spaces, proposals, and votes was generated through a NodeJS language application, allowing multiple extractions to bypass the output limit per request. The following step was in data preparation from a JSON format to consolidate the output in files and transform them into a table while defining the relevant fields of the analysis. This step took several tasks due to the output formation required for reading the relevant fields imposed by the application interface (Table 3).

Manual development of new metadata tables was undertaken to elucidate the significance of compound structured fields and provide context for each matter. Preprocessing steps were implemented to generate data clusters, streamlining the analysis of each topic related to off-chain voting in DAOs. This involved calculating formulas and employing data visualization techniques. The most engaged and active DAOs were selected based on the highest number of followers and proposals simultaneously, decided in a ranking.

It is relevant to mention that spaces, proposals and votes were analyzed separately based on their respective output and preprocessed data, meaning irrelevant deviations between them for the overall understanding.

As to the fsQCA configuration analysis approach, the data sets were prepared to analyze the outcome based on the causal condition fields related to the research objectives. These fields were crisp and fuzzy data calibrated, establishing the threshold for full membership, crossing point and non-membership. The standard analysis ran the truth tables with filtered registers with a consistency of 0.7 (Ragin, 2008). We presented the intermediary solution,

Table 3. Snapshot data source

Spaces		Proposals		Votes	
Field	Extracted	Field	Extracted	Field	Extracted
id: String!	Yes	id: String!	Yes	id: String!	Yes
Name: String	Yes	Ipfs: String	Yes	Ipfs: String	Yes
Private: Boolean	Yes	Author: String!	Yes	Voter: String!	Yes
About: String	Yes	Created: Int!	Yes	Created: Int!	Yes
Avatar: String	Yes	Space: Space	Yes	Space: Space!	Yes
Terms: String	Yes	Network: String!	Yes	Proposal: Proposal	Yes
Location: String	Yes	Symbol: String!	Yes	Choice: Any!	Yes
Website: String	Yes	Type: String	Yes	Metadata: Any	No
Twitter: String	Yes	Strategies: [strategy]!	Yes	Reason: String	Yes
Github: String	Yes	Validation: Validation	Yes	App: String	Yes
Coingecko: String	Yes	Plugins: Any!	No	vp: Float	Yes
Email: String	Yes	Title: String!	Yes	vp_by_strategy: [float]	Yes
Network: String	Yes	Body: String	Yes	vp_state: String	Yes
Symbol: String	Yes	Discussion: String!	Yes		
Skin: String	Yes	Choices: [string]!	Yes		
Domain: String	Yes	Start: Int!	Yes		
Strategies: [strategy]	Yes	End: Int!	Yes		
Admins: [string]	No	Quorum: Float!	Yes		
Members: [string]	Yes	Privacy: String	Yes		
Filters: SpaceFilters	No	Snapshot: String	Yes		
Plugins: Any	Yes	State: String	Yes		
Voting: SpaceVoting	Yes	Link: String	Yes		
Categories: [string]	No	App: String	Yes		
Validation: Validation	Yes	Scores: [float]	No		
voteValidation: Validation	Yes	Scores_by_strategy: Any	No		
Treasuries: [treasury]	No	Scores_state: String	Yes		
followersCount: Int	Yes	Scores_total: Float	Yes		
proposalsCount: Int	Yes	Scores_updated: Int	Yes		
Parent: Space	No	Votes: Int	Yes		
Children: [space]	No				
Guidelines: String	Yes				
Template: String	Yes				

Source: Authors' own work

delineating each path's central and contributing causal conditions. A counterfactual analysis is used to determine their classification, aided by the three distinct solutions generated: the complex, parsimonious and intermediary solutions (Ragin, 2008). Conditions featured solely in the parsimonious solution are labeled *central conditions*, whereas those exclusive to the intermediary solution are regarded as *contributing conditions* (Misangyi & Acharya, 2014).

4. Results

The sample data presented in Table 4 is drawn from a specific subset of DAO spaces to scrutinize the most active and engaged entities within DAOs rather than encompassing all spaces. This deliberate choice of focusing on the most active and engaged DAOs is crucial, enabling a more thorough examination of the DAO ecosystem. These selected spaces are expected to offer a representative snapshot of the overall behavior and activity within DAOs

Table 4. DAOs, proposals and followers

Item	Total database			Selection sample	
	Total	% Total		Total	% Total
DAOs	12,843	100		179	1,39
Proposals	81,577	100		26,538	32,53
Followers	2,316,460	100		1,268,474	54,76

Notes: Registers from Snapshot. DAOs selection based on the most followers and proposals simultaneously
Source: Authors' own work

(Li & Liang, 2021), thereby enhancing the ability to identify patterns and trends pertinent to the broader DAO community.

The analysis of the space digital communication within different DAO spaces suggests that Twitter is the most popular platform for digital communication among DAOs, with 125 instances recorded, representing 69.83% of the total communication. GitHub follows closely with 87 instances (48.60%), while Coingecko and website spaces have 72 (40.22%) and 64 (35.75%) instances, respectively. On the other hand, email is the least popular means of digital communication for DAOs, with only one instance recorded, representing only 0.56% of the total communication.

Overall, the data imply that social media platforms like Twitter and GitHub are the most preferred digital communication channels for DAOs, while email is the least preferred. This scenario could be because social media platforms allow for easy and quick communication, making them more suitable for DAOs. Additionally, social media platforms have larger user bases, potentially increasing the reach of DAOs' communication.

Regarding the main chain used by DAOs in the sample, the Ethereum Mainnet was the most popular main chain used by DAOs, with 116 DAOs (64.80%). This phenomenon is unsurprising, as Ethereum is one of the most adopted blockchain platforms with a prominent developer and user community. The second most popular main chain used by DAOs in the sample selection was Polygon Mainnet, with 21 DAOs (11.73%). Polygon is a blockchain platform for Ethereum that aims to increase transaction throughput and reduce gas fees, and it has gained popularity among developers and users in recent years.

Binance Smart Chain Mainnet was the third most popular main chain used by DAOs in the sample selection, with 19 DAOs (10.61%). Binance Smart Chain is a blockchain platform developed by Binance that aims to provide benefits such as Polygon Mainnet, which offers faster and cheaper transactions compared to Ethereum. Other leading chains used by DAOs in the sample selection include Fantom Opera, Avalanche, Arbitrum One, Optimism Mainnet, Gnosis Chain, Ethereum Testnet Görli, Energy Web Chain, Klaytn Baobab Testnet, Metis and Moonbeam.

With the growing embrace of blockchain technology across various industries and applications, this phenomenon underscores the competitive landscape within the blockchain industry. It emphasizes the imperative for continuous innovation and enhancement to align with the ever-changing requirements of users (Purwaningsih, Muslikh, Suhaeri, & Basrowi, 2024).

The QCA results in Table 5 reveal two pathways associated with elevated proposal levels in the data set. Path 1 highlights DAOs characterized by a significant number of followers as a central condition, even without an online presence on platforms. Despite this, these DAOs still exhibit a higher frequency of proposals, constituting 14% of the cases with a consistency

Table 5. Configurational paths for high level of proposals

Condition	Path1	Path2
Follower	●	●
Website	○	●
Twitter		●
Github	○	○
CoinGecko	○	●
Email	○	○
Raw coverage	0.148	0.017
Unique coverage	0.148	0.017
Consistency	0.842	0.974
Solution coverage	0.170	
Solution consistency	0.854	

Notes: ● = core causal contributing condition (present); ○ = core causal contributing condition (absent); ● = contributing causal conditions (present); ○ = contributing causal conditions (absent)
Source: Authors' own work

of 84%. Conversely, Path 2 indicates the existence of DAOs with a substantial following and proposal activity, where a presence on Coingecko and a dedicated website are central conditions, along with Twitter as a contributing factor. Notably, these DAOs lack an email or GitHub repository. This specific configuration accounts for 1.6% of the cases, demonstrating a high consistency of 97%.

The absence of Twitter as a factor in the first path underscores the intricate interplay between digital presence and the generation of proposals in DAOs (Hanisch et al., 2023). These paths shed light on the various combinations of conditions that could result in a higher number of proposals within a DAO off-chain voting system. The findings indicate that digital presence impacts the proposal count for DAOs employing off-chain voting systems. Diverse combinations of online presence factors are suggested to contribute to increased proposal numbers, with a robust follower base identified as a consistent factor in both scenarios.

The proposal's activity and engagement within the DAO ecosystem were analyzed following the selected sample of spaces for the analysis. The result indicates a diverse range of project ideas and shows a positive sign for the organization's health.

Regarding voting type, single-choice voting is the most used in proposals by DAOs, with a frequency of 87.92%. Single-choice voting is simple and easy to understand, making it a popular choice for organizations with diverse memberships. Basic and weighted voting are the most used types, with frequencies of 5.66% and 3.82%, respectively.

Approval, ranked-choice and quadratic voting are less commonly used, with frequencies of 1.20%, 0.78% and 0.62%, respectively. These types of voting may be more complex or require more understanding from the voters, which could explain their lower usage rates.

Quadratic voting is still emerging, as adopted by the DAOs, promising to solve issues associated with traditional voting mechanisms, such as the tyranny of the majority and the under-representation of minority interests. Custom voting has the lowest frequency at just 0.01%. This scenario could be because custom voting requires more effort and resources to design and implement and may only be necessary for some DAOs.

Concerning the total number of proposals per DAO, there is a high concentration among a few DAOs, with the top three spaces CakeVote.eth, Snapshot.dcl.eth and Pancake with 1,000 proposals or more, representing 4.17% of the total (Figure 1). One possible reason for this
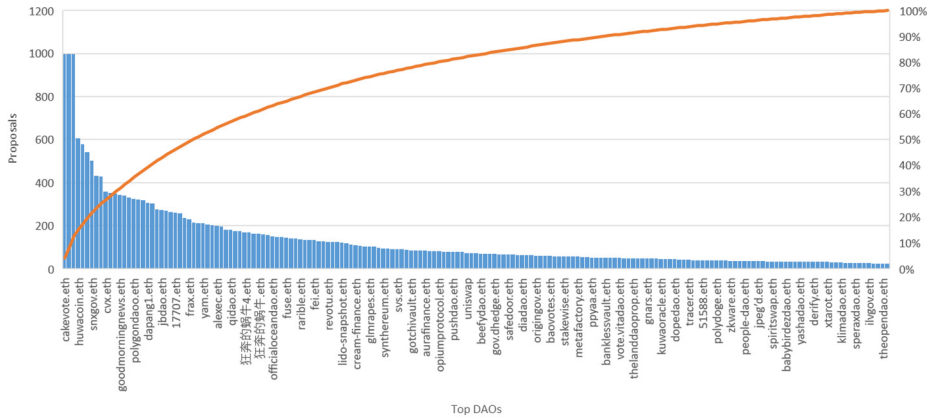
Note: Top DAOs with proposals registered

Figure 1. Proposals in DAOs and Pareto

concentration is that these DAOs are well-established and have a large user base, which allows them to generate a high volume of proposals. Additionally, they positioned themselves as trusted and reliable platforms, which attracted more users and further increased the number of proposals.

The other DAOs in the list have significantly fewer proposals, with most having less than 1% of the total. Possible reasons include being newer, having a smaller user base, or having more specific goals that generate fewer proposals.

With an average of 14.4 days to vote on proposals, the DAOs make decisions quickly, which is a positive factor in agility and the ability to respond quickly to opportunities and challenges.

There is a high concentration of votes in only a few proposals, suggesting one side of the engagement and participation from members of the DAOs. This result could also lead to community misrepresentation depending on the matter of the proposal or qualified knowledge to vote accordingly. The finding is that the average number of votes per proposal is 221.6. Overall, the concentration of voting in proposals highlights the importance of network effects and the benefits of building a solid and engaged community in the success of a DAO to achieve more distributed participation.

5. Discussion

This research aimed to understand trends and patterns in DAO communities with off-chain voting systems. An overview of the off-chain voting system of 179 DAOs powered by Snapshot is provided, along with an understanding of how a group of individuals decide what outcome to pursue from a set of options, representing engagement with proposals.

The single-choice voting type is present in more than 80% of proposals. A more accessible and unstructured approach may be suggested. It suggests that the "majority wins model" is more prevalent than different methods, such as the preference ranking discussed in social choice theory.

The research contributes to understanding the governance dynamics of DAOs, which introduces a new organizational structure with significant implications for decision-making,

transparency, and community engagement (Hsieh et al., 2018). Research is needed to guide the formulation of effective governance models for blockchain technology and DAOs. Innovating and improving governance mechanisms begins with discovering trends and patterns within the DAO community.

Regarding the first research gap relating to the impact of off-chain mechanisms on members' engagement and experience in the voting process, the results demonstrate that although the off-chain voting system promotes decentralized governance, decisions are entirely channeled by the characteristics of blockchain technology. This result corroborates those found by Beck et al. (2018) that, despite the promise of DAOs to deliver more decentralization and decision power to communities, in a certain sense, what happens is quite the opposite since the transactional character of the voting process provides the means for heavily centralized decisions processes and control (Harsono, 2023).

However, this analysis stimulates deeper investigation, primarily because of the high concentration of engagement on just a few proposals, which could lead to community misrepresentation depending on the topic of the proposal or the knowledge qualified to vote appropriately. While Hanisch *et al.* (2023) emphasize that establishing and building digital relationships is essential for digital governance, and Chen, Tong, Tang, & Han (2022) mention that governance decisions strongly influence the overall attractiveness of the network, building high levels of digital relationships in DAOs seems to be challenging, possibly because of the intense focus on the structured voting system.

Valuable insights were gained through collaboration when addressing the second research gap concerning the long-term sustainability of off-chain solutions for community decision-making within DAOs. The abundance of proposals by DAO members often results in a prolonged decision-making process due to the time required for voting, thereby limiting internal delegation autonomy and potentially leading to suboptimal governance performance. Despite the undeniable enhanced disclosure and transparency offered by DAOs, there is a noticeable absence of consolidated communication channels. Again, DAOs seem prone to emphasize transactional relationships with little room for relational interaction support, which additional channels should provide.

While Twitter emerges as a prominent platform for general discussions about the organization outside the voting system, providing increased visibility and open communication, the study reveals that many proposals do not originate on Twitter. In pursuing inclusive governance rules, this study emphasizes the importance of voice (discussions with others regarding what actions should be taken) and over-reliance on voting mechanisms (Heap, Tsutsui, & Zizzo, 2020).

Within the corporate governance layer of a DAO, the development of IT applications is intricately linked with the infrastructure, resembling the collaborative nature of open-source projects managed by a community without centralized ownership (Rikken, Janssen, Kwee, Bolívar, & Scholl, 2019). The digital community GitHub emerges as the second most influential social network for a DAO, aligning with this perspective.

In this scenario, it is reasonable to conclude that despite the benefits associated with blockchain and DAO-driven governance, adopting this approach does not necessarily ensure a fully decentralized organizational governance process. As highlighted by Goldberg & Schär (2023), while governance systems and ownership layers based on blockchain are essential elements, they alone do not guarantee establishing a neutral metaverse infrastructure. The risk lies in the potential centralization and concentration of voting power, which could result in dependencies leading to rent-extraction behaviors and retention issues.

The research results help shape governance models and improve decision-making processes for DAOs, thus promoting a more resilient and sustainable ecosystem. The study's

elucidation of trends and patterns within the DAO community provides invaluable knowledge for researchers, practitioners and policymakers involved in blockchain governance and decentralized systems.

6. Conclusion

The study of the off-chain voting ecosystem within DAOs has provided significant insights into the decision-making process, especially segment analysis. According to the findings, Twitter and GitHub are popular digital communication channels among DAOs, along with Ethereum Mainnet, Polygon Mainnet and Binance Smart Chain Mainnet. Considering the concentration of proposals in a select group of DAOs, fostering a strong and engaged community is crucial to ensure success.

Furthermore, basic voting with a high volume of votes substantially affects proposal outcomes compared to other approaches. Understanding trends and patterns within the DAO community is becoming increasingly important in identifying opportunities and challenges for innovation and improvement. Due to community members' ownership of digital tokens associated with organizational governance, DAOs mitigate the agency problem of self-interest (Santana & Albareda, 2022).

The current context of Open AI is a case where the relevance of a DAO managed by the community could represent more robust governance. As one of the most important artificial intelligence research and deployment companies, they raised concerns about transparency and leadership, from questionable board decisions to adding a for-profit approach to hybrid governance. In this case, revenue was compared with the initially stated mission to provide open code and safe AI implementation. The impact of voting methods on proposal outcomes can also inform investment strategies for blockchain technology investors. Projects or tokens associated with DAOs demonstrating effective decision-making through high-volume voting may be more appealing.

Using the study findings, one can develop better governance models and decision-making processes, enhancing ecosystem resilience and sustainability. There are, however, some limitations to this research. Due to Snapshot's GraphAPI output limits, the sample size, limited to DAOs with the highest followers and proposals, may not represent the entirety of Snapshot data from DAOs.

Expanding the sample size and including a broader range of DAOs could address these limitations. The impact of social and cultural factors on DAO decision-making may also provide valuable insights into enhancing decentralized organizational governance. Social dynamics within DAOs and their impact on voting outcomes have the potential to refine and optimize the governance of decentralized organizations, contributing to their maturation and advancement. Experts can also analyze the challenges of governance through digital technologies. Research on digital governance accountability is also essential.

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